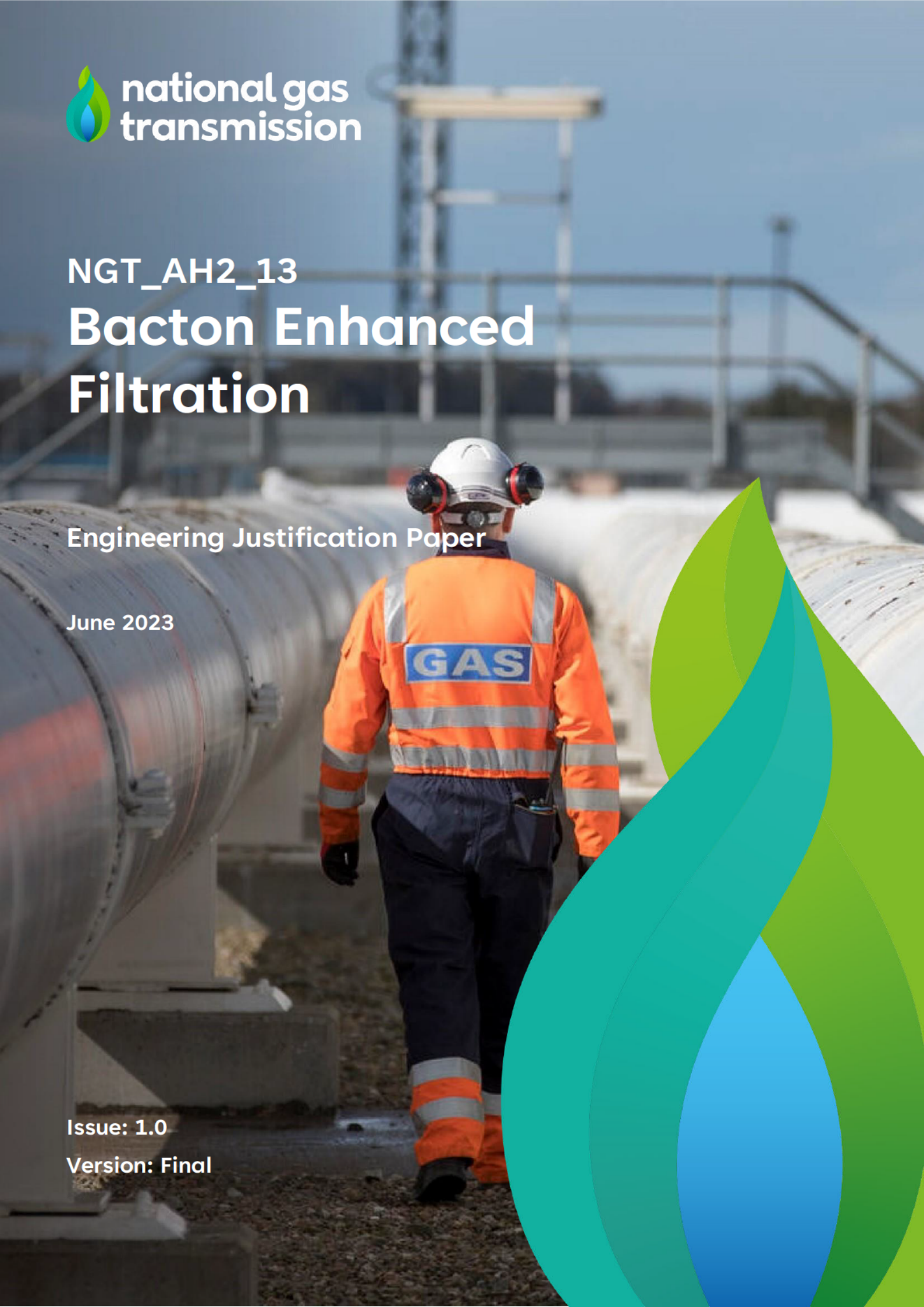
national gas transmission

NGT_AH2_13

Bacton Enhanced Filtration

Engineering Justification Paper

June 2023



Issue: 1.0

Version: Final

Table of contents

1. Executive Summary

This Engineering Justification Paper has been re-submitted in support of the full cost book submission seeking funding for Feeder Filtration works at Bacton. The EJP in January 23' was submitted on the basis it was for the need case and option with view that the Jun 23' submission would follow with full detailed costs to a +15/-5% accuracy. Detailed updated costing is provided for our preferred Option 1 only. Other Options have been scaled according to the Option 1 delta between Jan-Jun 23 included in the cost book. As such the cost estimation accuracy for those options remains -+30%. Programme for delivery is still being refined in order to meet our own challenge on accelerated delivery, therefore spend profile in RIIO-2/3 may change as programme is developed.

In parallel to this cost submission NGT are working on a technical addendum which provides additional information for Ofgem to consider regarding this investment. That addendum was discussed at a recent DESNZ and Ofgem tripartite meeting and will include:

- Independent report on Black dust – explains more about the phenomenon being experienced, how it is likely to continue to be an issue and how to manage it.

- Bacton Exit capacity strategy paper – [redacted]

- Feeder Utilisation analysis supporting the Feeder 2 and Feeder 4 option.

- Additional supplementary technical information that validates the preferred option is most practical and achieves the best balance of risk vs cost.

Due to timings of this submission the addendum will fall after the 30th of June and will be discussed in person at the earliest convenience followed up by an additional tripartite meeting.

Ofgem will also note that [redacted] in this submission when compared back to the Jan 23' position. This has been narrated in the cost book and it is our view this is within the estimate tolerance banding that would be appropriate for a project at this stage as more detail has been developed during the conceptual stage.

Why are submitting this report?

1.1. National Gas Transmission (referred to in this regulatory submission as 'NGT'), is submitting this Engineering Justification Paper to enable Ofgem to assess the costed preferred option for this investment to mitigate material ingress into the Bacton Terminal. This has impacted on the site's ability to manage ongoing security of supply flows which have been disrupted by the presence of solid debris.

1.2. This submission follows the submission of our needs case and option selection paper in January 2023, and has been submitted to seek cost approval for our preferred option.

1.3. NGT have also taken this opportunity to re-iterate that the proposed preferred investment within this paper aligns to what would constitute to an ALARP engineering solution for mitigating dust on Feeder 02 & 04. Additional supporting information has been provided in the form of:

- 'Black dust theory' report commissioned by NGT via ROSEN
- Recent review of dust incidents that correspond with operational events
- Full review of residual risks to NGT, INT and the wider gas industry along with NGT's position

1.4. This report is submitted in accordance with the National Transmission System Gas Transporter Licence Condition 3.14 Asset Health Re-opener, Price Control Deliverable Reporting Requirements and Methodology Document and RIIO-T2 Re-opener Guidance and Application Requirements Document.

What is the Driver for this Investment?

1.5. Filtration is currently installed at Bacton Terminal on incomers to remove solid debris from gas entering from upstream Shell and Perenco Gas Terminals, however there is no filtration installed on the feeders which connect Bacton Terminal to the wider NTS.

1.6. Across 2022 a number of interruptions were experienced by our downstream customers, impacting on the security of supply from UK to Europe during a period of unprecedented uncertainty within the European gas supply landscape.

1.7. We enacted short-term operational mitigations by double filtering NTS gas flowing it back through our Terminal bypass pipework and into one of several incomer filtration systems, predominantly used to filter gas entering the Terminal from upstream United Kingdom Continental Shelf (UKCS). Double filtering involves NGT filtering gas before it is discharged to our downstream customers. Along with filtration of incomer gas, undertaking this operation ensures c75% of gas is filtered before being discharged to Interconnector Ltd. This results in a reduced but continued risk exposure of solid particles and interruptions.

1.8. Our operational mitigations are best endeavours and result in significantly more frequent filter maintenance. Undertaking this additional maintenance increases health, safety and environmental risk burden due to the type of materials collected (NORM, Benzene and Pyrophoric Dust) and large volumes of gas required to be safely vented. Across 2022 in total an estimated 51 days of additional filter maintenance has been conducted.

1.9. Double filtering incomers are rotated in line with operational requirements. Upstream operators require outages for their connected assets to these incomers which cannot be facilitated by NGT due to undertaking double filtration activities. Investment to reduce the frequency of filter maintenance ensures optimised asset management by NGT and upstream operatives which ultimately provides better value to consumers.

1.10. This risk exposure impacting on security of supply for both imports and exports from the Terminal and the operational risks incurred through double filtering operations are unsustainable, therefore have resulted in this investment proposal being created.

1.11. Across financial year 2022, an incremental revenue of [redacted] has been generated from April to December from the release of Exit Capacity at the Bacton Exit Point. The incremental revenue reflects the difference between the forecast Bacton Exit capacity revenues that were utilised in our charge setting processes to recover our allowed revenue and the total revenue generated year to date at the Bacton Exit Point.

1.12. Transportation charges are set by NGT in accordance with our Licence and are derived in relation to the set price control formulae which determines the Allowed Revenue that NGT can earn from the transportation of gas. Should NGT earn more or less than the allowed revenue in any formula year, an adjustment will be made in the relevant future year. Any over recovery could result in lower auction reserve prices with the potential to lead to lower shipper costs. As such incremental revenue generated at the Bacton Exit point compared to the forecast used in charge setting would either result in an over recovery and reduce the exit capacity reserve price or reduce the under recovery and reduce any increase in the exit capacity reserve price.

1.13. NGT through operating an efficient network to meet the needs of the market, particularly at the Bacton exit point, with high levels of asset availability can effectively support high utilisation which ultimately provides value for money to customers and ultimately for consumers through lower charges.

1.14. Our filtration investments at Bacton will help ensure that we achieve this efficient network.

The Importance of Bacton to the NTS – Today & Future

1.15. Bacton is a site of strategic importance due to supplying up to one third of the UK gas demand on a winter day whilst importing and exporting to and from Europe via two interconnectors. The Terminal was originally designed as an importation terminal but has connected customers with both import and export operations.

1.16. Due to the European geopolitical situation, exports from the UK to Europe has been the predominant mode of operation across calendar year 2022. Export flows have exceeded the baseline obligated capacity through efficient operation of Bacton Terminal and wider NTS assets, with flows c25% in excess of this capacity through the release of non-obligated capacity. It is generally good practice to release non-obligated capacity where operationally possible.

1.17. Forward price curves show the UK National Balancing Point (NBP) market operating at a discount over the European Zeebrugge Trading Point (ZTP) and the Dutch Title Transfer Facility (TTF) prices, which potentially supports macro long term exports. This results in Bacton Terminal having a pivotal role in ensuring security of supply in both directions depending on the prevailing market condition and needs.

1.18. Our Bacton Investment Strategy details our approach for managing both short-term and long-term risks at the site. Our Bacton Phase 1 (Short Term) strategy ensures we have certainty on the Terminal operation requirements for operation out to 2035 and the investments required to facilitate this. Our investment within this EJP forms part of the Phase 1 Accelerated investment area due increasing risk exposure as a result of operational developments.

Optioneering

1.19. We have conducted a full options assessment for seeking the removal of materials from the gas entering Bacton Terminal. This included reviewing commercial, operational and asset options to mitigate the transportation of solid material within Bacton Terminal.

1.20. Optioneering was split into two parts, Part 1 considered options to enhance the filtration installed within our existing filter banks. Part 2 considered options to manage the risk of material entering the Terminal from the NTS.

1.21. For Part 1, due to the standardisation of vessel technology on the site and the spaces within the existing incomer filtration banks, our preferred option is the installation of three additional filter vessels to be fitted within Perenco A1 Incomer. Analysis was undertaken on the vessels available on the site which identified a vessel that could be revalidated. Costs presented in this paper reflect the revalidation of one vessel and the procurement of two new vessels. This has been progressed at financial risk given the risk and low materiality of the investment. In addition, spare filter baskets were also procured, increasing the flexibility on site to undertake filter maintenance.

1.22. For Part 2 NGT undertook an assessment process considering a full range of options including operational mitigations, commercial options, and a range of asset options both within the Terminal and at other sites on the network.

1.23. Options identified at this stage looked to mitigate the downstream disruptions whilst maintaining Security of Supply to Europe. No option was discounted at this time and initially all five feeders (Feeders 2, 3, 4, 5 & 27) were within the scope of this assessment.

1.24. A long list of 13 options was created, with workshops undertaken to review the opportunities, benefits and limitations of each option. Quantitative and qualitative data was used to undertake an assessment of the long list. For asset options (eight of the 13) a range of selection criteria were utilised to determine the suitability of the shortlisted options including:

- Performance Criteria (e.g., % of gas filtered)
- Cost Criteria (Capex and Opex)
- Construction Criteria (Duration of Construction, Space for Option)
- Operations Criteria (Impact on Terminal Operations)

1.25. The results from this assessment are shown below:

		Performance			Cost	Construction					Operations		
Option	Detail	Filtration Duty	GSM(R) Compliance	Entry Flow Capability Feeder 2 & 4 (RAG)	Capex Cost £m	Brownfield / Greenfield	Planning Permission	Development & Build Duration (Timeframe)	Constructability	Disruption to Site & Feeder Operation (Outages)	Expected Frequency of Filter Maintenance	Personnel Health & Safety Risk	Shortlist
Magnetic Filters	nsta l innovative Magnetic Filters with self-cleaning.	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
Filtration on Ring Main	To filter gas from any route (i.e. ncomer or Feeder connection).	25-50% NTS Export Gas F ltered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
Filters on Feeder connections (Above)	Filters on Feeders 2 3 4 5 & 27.	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
	Filtration on Feeders 2 4 & 27	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						Y
	Separate Filtration on Feeders 2 & 4 (2x 3 = 6 Filters)	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						Y
	Common Filtration on Feeders 2 & 4 (5 Filters)	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						Y
	Separate Filtration on Feeders 2 & 4 (2 Filters)	>100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						Y
	Common Filtration on Feeders 2 & 4 (3 filters)	>100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						Y
Filters on Feeder connections (Below)	Filters on Feeders 2 3 4 5 & 27.	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
	Filtration on Feeders 2 4 & 27	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
	Separate Filtration on Feeders 2 & 4 (2x 3 = 6 Filters)	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
	Common Filtration on Feeders 2 & 4 (5 Filters)	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
	Separate Filtration on Feeders 2 & 4 (3 Filters)	>100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
	Common Filtration on Feeders 2 & 4 (3 filters)	>100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
Filters located outside the site on Terminal Extension		100% NTS Export Gas Filtered				Greenfield - Planning permission required (2 year lead time)	Planning Permission Required						N
Filters installed at Block Valves on Feeder 2 4 e.g. Suffield BV or Erpingham BV		25-50% NTS Export Gas F ltered				Greenfield - Planning permission required (2 year lead time)	Planning Permission Required						N
Filters installed at Kings Lynn		100% NTS Export Gas Filtered				Brownfield	Permitted Development						N

1.26. From the assessment, five options were progressed to the shortlist with one additional operational option also progressing to the shortlist "Continued Double Filtration Operational Mitigations" as a counterfactual.

1.27. These shortlisted options are summarised as follows:

Short List Options Table
1 – Separate Filtration Feeders 2 & 4 (6 Filters)
2 – Common Filtration Feeders 2 & 4 (5 Filters)
3 – Separate Filtration Feeders 2 & 4 (4 Filters)
4 – Common Filtration Feeders 2 & 4 (3 Filters)
5 – Common Filtration Feeders 2, 4 and 27 (9 Filters)
6 – Continued Double Filtration Operational Mitigations (Counterfactual)

1.28. Each of these shortlisted options were developed, costed and benefits and limitations assessed. Common Filtration options have limitations such as reducing operational resilience through removing existing backup flow routes to supply Interconnector Ltd and requiring filters to be lifted over live gas pipework. It is NGT policy for this to always be avoided therefore both common filtration options were discounted.

1.29. Options 1-5 should reduce the frequency of filter maintenance required at the site and therefore reduce the health and safety and environmental risks whilst managing upstream security of supply risks.

1.30. The table below shows an overview of the costs for each of the shortlisted options.

Option Cost Comparison Table (18/19 Prices)	Project Start Date	Project Finish Date	Total Cost (18/19)	Cost Accuracy
1 – Separate Filtration Feeders 2 & 4 (6 Filters)	July 2023	[redacted]	[redacted]	-5+15%
2 – Common Filtration Feeders 2 & 4 (5 Filters)	July 2023	[redacted]	[redacted]	-+30%
3 – Separate Filtration Feeders 2 & 4 (4 Filters)	July 2023	[redacted]	[redacted]	-+30%
4 – Common Filtration Feeders 2 & 4 (3 Filters)	July 2023	[redacted]	[redacted]	-+30%
5 – Separate Filtration Feeders 2, 4 and 27 (9 Filters)	July 2023	[redacted]	[redacted]	-+30%
6 – Continued Double Filtration Operational Mitigations	N/A	N/A		

Preferred Option

1.31. Our Preferred Option decision has been based on qualitative and quantitative engineering and cost assessments of the available options.

1.32. For Part 1 (Incomer Filtration) our preferred option is the installation of two new and one reconditioned class 600 horizontal vessel. The installation of these vessels enhances the filtration installed on the existing filter banks ensuring flexibility in managing gas quality from our upstream customers. Our cost request for this element of the project is [redacted].

1.33. For Part 2 (Feeder Filtration) our preferred option is Option 1 Separate Filtration on Feeders 2 & 4 (2x 3 = 6 Filters) and our EJP seeks cost approval for this option, [redacted] (18/19

prices). Two new dry gas filtration systems are proposed to be installed on the existing No 2 and No 4 Feeders allowing gas from the NTS to be filtered prior to entering the Terminal.

1.34. A cost breakdown for this preferred Feeder Filtration option can be seen in the table below (18/19 prices).

Element / Deliverable	FY22	FY23	FY24	FY25	FY26	Total Cost
EPC Estimate	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
EPC PM	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
EPC Site Establishment	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
NGT Direct Company Costs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
NGT Indirect Company Costs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Contractor Risk	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
NG Project Risk (Direct)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
NG Project Risk (Indirect)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
EPC Estimate	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
EPC PM	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Cumulative	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	

1.35. The preferred option manages the risk of interruptions to exports from the Bacton Terminal, impacting security of supply, enables management of the health and safety risks associated with filter maintenance and provides resilience to Terminal operations through sub-optimal operation.

1.36. The table below shows the spend profile across the RIIO-T2 & RIIO-T3 periods for cost of our preferred options.

£m (18/19 prices)	2022/23	2023/24	2024/25	2025/26	2026/27	Total
Feeder Filtration	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Incomer Filtration	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	**24.649**

Conclusion and Next Steps

1.37. Based on the outcome of the options assessment and considering the criticality of Bacton Terminal to the Security of Supply to both the UK and Europe and the impact of interruptions to this supply, the installation of additional filter vessels on our incomers and the installation of new filtration assets on Feeders 2 & 4 is our Preferred Option, and our EJP has requested cost approval for this preferred option as presented above.

1.38. Ofgem are invited to assess and approve the two preferred options presented within this EJP, ahead of a funding request in June 2023 through the Asset Health Re-opener. This shall be submitted, in line with Special Condition 3.14, which will request an adjustment to the value of the NARMAHOt term. This is summarised, along with other investments, within

section 9 of the Asset Health Overarching Document provided as Product 1 of the January 2023 Asset Health Re-opener Submission.

1.39. Whilst this investment mitigates the risk of solid debris ingress from disrupting our downstream customers and from entering the National Transmission System (NTS) which has the potential to result in disruptions to Network Offtakes and the build-up of material within our pipeline system, the paper has also presented some of the challenges experienced at the site in relation to liquid filtration.

2. Summary Table

Name of Project	Bacton Filter Enhancement
Scheme reference/ mechanism or category	[redacted]
Primary Investment Driver	Enhancement to existing Terminal Filtration to ensure European Security of Supply
Output references/type	Delivery of Enhanced Filtration onto Feeder 2 & 4 at Bacton Terminal Installation of additional filters onto Terminal Incomers Procurement of Filter Basket spares Bacton
Project Initiation Year	2022/23
Project Close Out Year	[redacted]
Total Installed Cost Estimate (£m)	£24.649m
Cost Estimated Accuracy (%)	-5/+15%
Project Spend to date (£m)	[redacted]Conceptual Design Study for Feeder Filtration [redacted]Incomer vessel procurement and installation
Price Basis	2018/2019
Current Project Stage Gate	4.2/4.3 – Conceptual Design & Long Lead item Procurement
Reporting Table	RRP Table 6.2 (Projects) and table 6.1 (CAPEX_Summary)
Outputs included in RIIO T1	No
Outputs included in RIIO T2	No

Table 1: Project Summary Table

3. Project Status and Request Summary

Overview

3.1. A site of strategic importance, Bacton can supply up to one third of UK gas demand on a winter day whilst importing and exporting gas to and from Europe via two interconnectors, Interconnector Ltd and Balgzand Bacton Line (BBL).

3.2. Driven by major disruption of European gas supplies from Russia and geo-political challenges affecting transmission routes, unprecedented demand for exports from Bacton Terminal during financial year 2022/23 further highlighted the strategic importance of the site.

3.3. The presence of dust in the NTS is a historic and known issue, this is reflected in the various agreements including Interconnector Agreements. These contains a series of controls (in particular the Velocity Protocol Agreement) to minimise material delivery to customers including Interconnector Ltd. Due to the inherent risk of dust in the NTS, filters are installed across compressor stations, regulators, and exit points on the NTS. Even with these measures, across 2022 several outages have occurred because of material build up within NGT filters and customers' filters at Bacton Terminal, leading to interconnector Ltd interruptions.

3.4. NGT has implemented several operational measures to mitigate the effects of material ingress to downstream customers. However, these measures reduce the efficiency and resilience of the site, increase the health & safety risk to site operatives, maintenance burden, and minimise the Terminal's ability to manage upstream incidents. These are not sustainable operating conditions.

3.5. NGT is seeking funding to proceed with a project to reduce solid debris being transported through Bacton Terminal to customers.

3.6. A range of potential investments have been considered to enhance the filtration on site and to improve the efficiency and resilience of the site, reduce maintenance burden and reduce the additional management oversight to ensure the site continues to meet all safety, regulatory and contractual obligations.

Project Status

3.7. Since September 2022, NGT have appointed an Option Selection Consultant [redacted] to support conceptual design development against a range of options to mitigate liquid and solid material ingress at the site.

3.8. Initial conceptual design study options have been evaluated and assessed against a range of option selection criteria metrics including cost, performance and operational impacts.

Request Summary

3.9. NGT are undertaking a range of actions to mitigate solid debris ingress into the Terminal. We have commenced several investments at funding risk, including conducting enhancements to the United Kingdom Continental Shelf (UKCS) incomer filtration, procuring additional spare filter baskets and developing options to install filtration onto Feeder 2 & Feeder 4 at the site.

3.10. Total project costs for the options presented is £24.649m, split between, [redacted] for installation of filtration onto Feeder 2 & Feeder 4, [redacted] for installation of additional vessels onto Incomers, modifications to the Line Vu system and for the procurement of spare filter baskets to speed up filter maintenance.

3.11. This submission follows the submission of our needs case and option selection paper in January 2023, and has been submitted to seek cost approval for our preferred option. This document has been submitted in line with Special Condition 3.14, which requests an adjustment to the value of the NARMAHOt term.

4. Problem Statement

Why are we doing the work and what happens if we do nothing?

4.1. At this sensitive time for European supplies, NGT are supporting the needs of the United Kingdom and European Gas Markets by working with the Department for Business, Energy and Industrial Strategy (BEIS) and Ofgem to maximise exports to Europe from Bacton Terminal. NGT has experienced a range of instances at the site where solid material and liquids have been transported to our downstream customers resulting in interruptions to European exports.

4.2. In response to the highly complex and dynamic geopolitical environment, European Parliament passed regulation for EU countries to have a mandatory minimum level of gas in storage facilities at 80% by 1st November 2022 . With European LNG gasification facilities operating towards maximum capacity, the UK National Transmission System (NTS) has been used as a transportation route with United Kingdom Continent Shelf (UKCS), LNG and Norwegian supplies entering the NTS to be transported to Bacton for onward transmission to Europe. The volume of LNG, Norwegian and UKCS gas exported via the interconnectors at Bacton Terminal has vastly exceeded 5-year highs as shown in Figure 1.

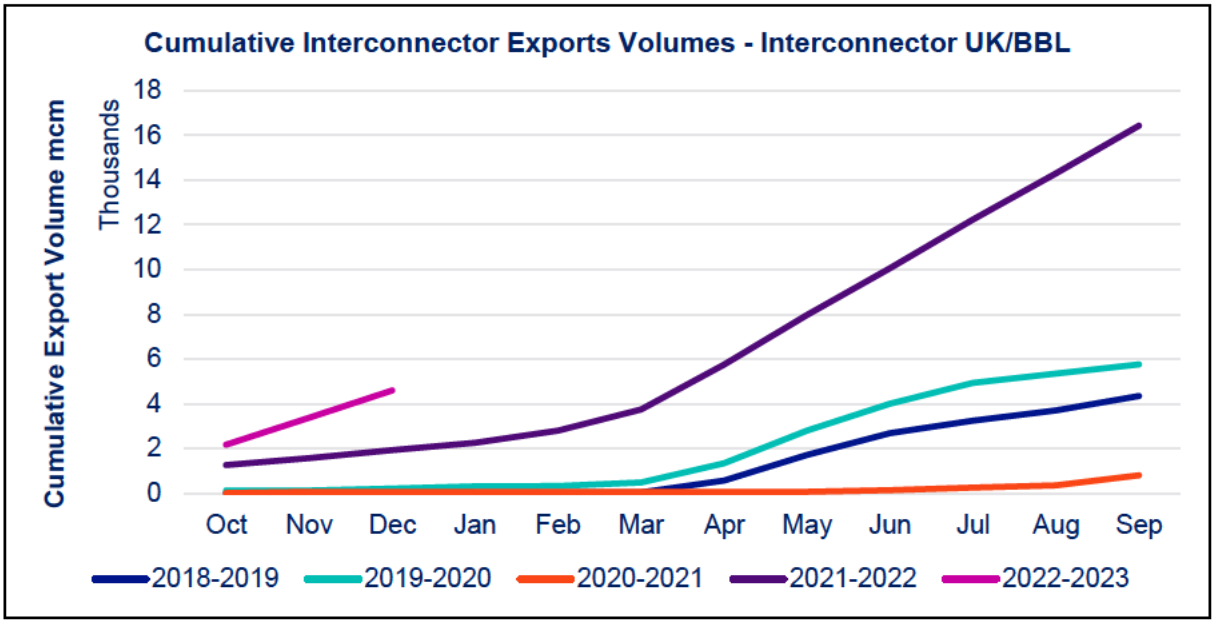


Figure 1 Volume Supplied to BBL/IUK Interconnector for Export

4.3. Since March 2022, European exports via Bacton Terminal have considerably increased and remained at these sustained levels. Gas year 2021/22 was unprecedented and gas year 2022/23 has commenced at even higher rates.

Needs Case Drivers

4.4. NGT facilitates European exports at Bacton through a range of exit capacity products at the Bacton Interconnector Exit Point. In October 2021, Interconnector Ltd and BBL Capacity Exit

points were combined into a single Bacton Interconnector Exit Point, with the following products:

- Obligated Non-Interruptible (Firm Capacity)
- Non-Obligated Non-Interruptible
- Interruptible

4.5. The baseline Firm Capacity defined within NGT's license for Bacton IP Exit is 651.68GWh/d (59.24mscm/d).

4.6. In addition to Firm Capacity, Non-Obligated Non-Interruptible capacity can be released to enable shippers to maximise exports to Europe in support of European security of supply. Non-Obligated Capacity is considered for release where there is an evidenced market need for additional capacity and the NTS has capability to support this. A capability assessment is undertaken prior to release of non-obligated capacity at any point, such as the Bacton IP Exit point, in order to sufficiently assess constraint risks.

4.7. The decision to release Non-Obligated capacity is assessed on a daily basis by the Gas Network Control Centre (GNCC) based on prevailing network conditions utilising a set decision making process, utilising latest supply/demand/outage data. It is generally good practise to release non-obligated capacity where operationally possible.

4.8. Recently, 150GWh/d (13.6mscm/d) of Non-Obligated Non-Interruptible capacity has been released daily which has enabled shippers to utilise BBL & Interconnector Ltd to flow ~25% above the obligated capacity. Capacity is open to shippers operating on both Interconnector Ltd and BBL.

4.9. A summary of sold capacity is shown in Figure 2, against the flows experienced on the day in mscm/d.

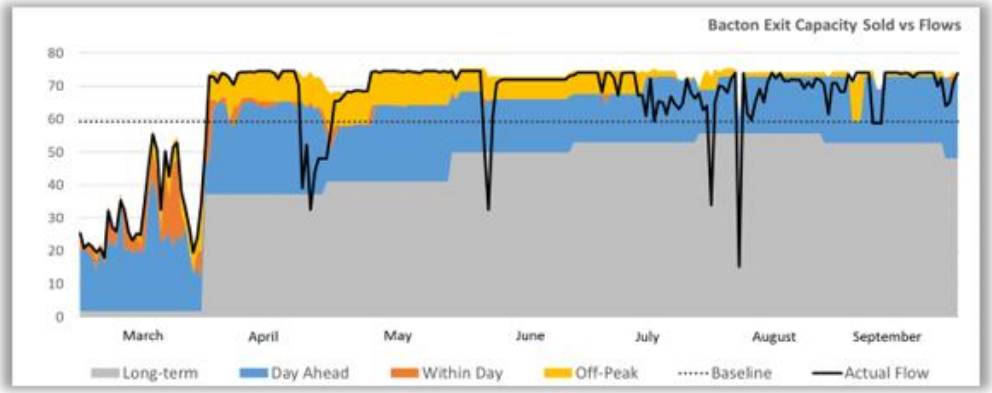


Figure 2 Bacton Exit Capacity Sold vs Flows

4.10. This data shows on average flows have been ~25% in excess of obligated baseline level. The unprecedented volumes of exports have resulted in the increase of occurrences of material ingress into Bacton Terminal across 2021 & 2022. Both liquids and solid materials have been removed from site filtration which have entered the Terminal from upstream customers and from the wider NTS.

4.11. The build-up of materials within site filtration has led to interruptions to our filter assets to facilitate cleaning. Our downstream customer (Interconnector Ltd) also experienced interruptions due to needing to undertake their own filter maintenance which led to interruptions in flow and customer complaints being raised to NGT. This has had an impact on European and UK Security of Supply facilitated through both Interconnectors.

4.12. Figure 3 shows flows exported by Interconnector Ltd since January 2022, with several interruptions shown. These interruptions lasted between 4 days and 17 days to remove the build-up of materials, change filters and check integrity of systems. This results in significant disruption to the balance of supply transports by this intercontinental transmission routes

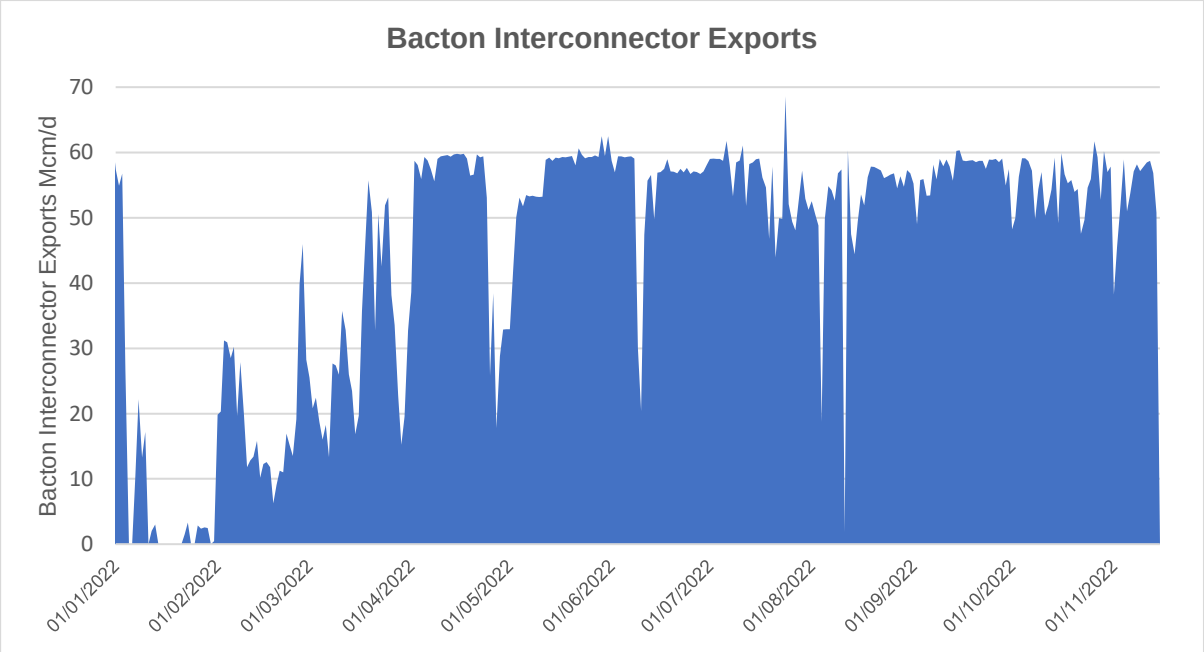


Figure 3 Interconnector Ltd Exports

4.13. NGT as National Transmission System Operator is required to ensure that gas supplied to downstream customers is free from solids and liquids in line with Gas Safety (Management) Regulations (GS(M)R)1 Part I requirements. In relation to materials, the following is defined within these regulations; shall not contain solid or liquid material which may interfere with the integrity or operation of pipes or any gas appliance (within the meaning of regulation 2(1) of the 1994 Regulations) which a consumer could reasonably be expected to operate.

[1] Gas Safety (Management) Regulations 1996

4.14. Network Entry Agreements (NEAs) with upstream parties also define the composition parameters of entry gas in line with GS(M)R Part I Requirements under normal conditions.

4.15. At Bacton Terminal, gas quality equipment is installed on incomers and feeders to ensure gas entering and leaving the site remains within parameters specified in GS(M)R, NEAs and Interconnection Agreements. Filtration equipment is also installed on the Terminal incomers to remove liquids from UKCS gas entering the Terminal, however no solids filtration is situated at the site.

4.16. If we were to do nothing, then it is likely that there would be continued material ingress and transportation through Bacton Terminal leading to persistent outages to interconnector operations with the potential to impact security of supply not only from gas flowing from the UK to Europe but also to gas flowing into the UK through these interconnectors. NGT have implemented operational mitigations as a best endeavour approach, but this has significant operational burden and does not filter all of the gas being transported to Interconnector.

Current Operations

4.17. To proactively manage the situation and mitigate the build-up of materials, NGT initiated the following actions as explained in this section:

- Implemented interim operational process to flow gas from NTS through incomer filters via Ring Main (Double Filtration).
- Completed additional filter maintenance associated with increased flows.
- Reviewed availability of spares for filters and the required quantity of spare filter baskets.
- Established new framework with local company (in Great Yarmouth) for cleaning soiled filters to reduce turnaround time and increase asset availability.
- Sent off samples of material for analysis.
- Installed additional line view cameras (Line Vu) on incomers to assist with validation of liquid occurrences.
- Reviewed recent in-line inspections (ILI runs) conducted on Feeder 2 in May 2021 and Feeder 27 in 2019.
- Isolated Feeder 4 in May 2022 due to contamination concerns and undertook In-line inspection cleaning / assurance runs in November 2022 aligned with Interconnector Ltd outage.
- Considered alternative ways of working, technology and innovative possibilities.

Double Filtration

4.18. Since April 2022, NGT has been 'double filtering' gas supplied to Interconnector Ltd through Feeder 2 & Feeder 4 to remove contaminants from the gas stream. Other than during operational interventions, double filtration has been running 24/7.

4.19. Double filtration is the process of conducting additional filtration on gas prior to it being discharged to Interconnector Ltd, who also then filter the gas.

4.20. Figure 4 shows one potential path (Yellow dotted line) for double filtered volumes to be routed through the Bacton Terminal site as follows:

- Gas from Feeder 2 enters the Terminal and passes through Gas Quality & Metering (GQ&M) assets located where it connects to the terminal.
- Gas is comingled within the ring main with UKCS gas entering through Perenco (in this example) incomers (but with the option depending on operational availability to instead also use Shell incomers).
- Gas is filtered through the incomer filtration streams onto manifold for onwards transmission to the Interconnector Ltd and / or BBL. Flow Control valves are opened 100% to not disrupt flows through the valve.

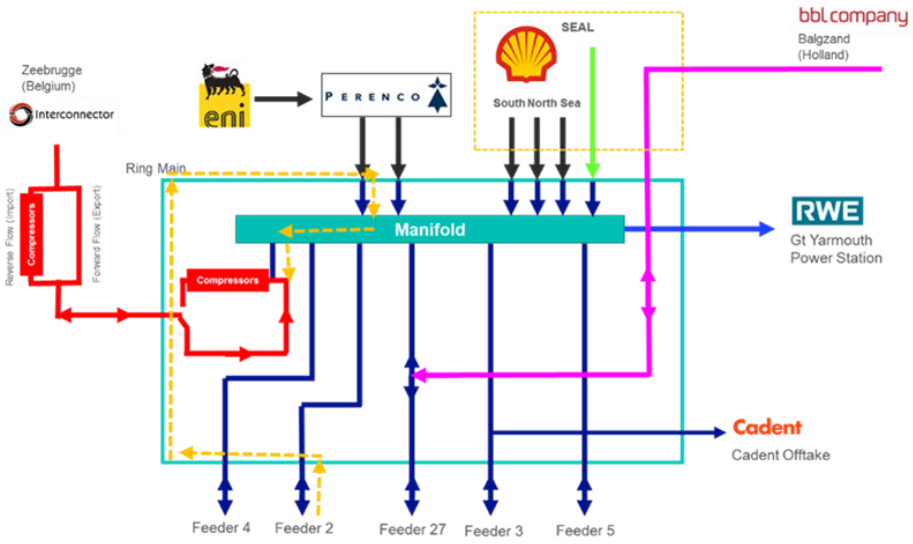


Figure 4 Example Double Filtration flow path

4.21. The specific incomer utilised for double filtration is varied dependent on operational requirements of upstream customers (Shell & Perenco) and our own maintenance activities. To date, double filtering has occurred through utilisation of Perenco A1, Perenco A2, Shell S1 and Shell S2 incomers.

4.22. Based on the capacity of the assets we can double filter up to [redacted], however due to varying numbers and sizes of installed filters across the incomers the quantity varies.

4.23. To accommodate [redacted], a reduction in flow along Feeder 27 is required which has adverse implications on supply to BBL and their export pressures. Double filtering operations also cannot occur on gas transported through Feeder 27, predominantly utilised for BBL exports when the Terminal is exporting, without impacting on compression at King's Lynn, therefore is only achieved through Feeders 2 & 4.

4.24. [redacted] The graph below, Figure 5 utilises historical flows from April 2022 to show the volumes filtered at the Terminal through double filtering operational routes and existing incomer filtration banks.

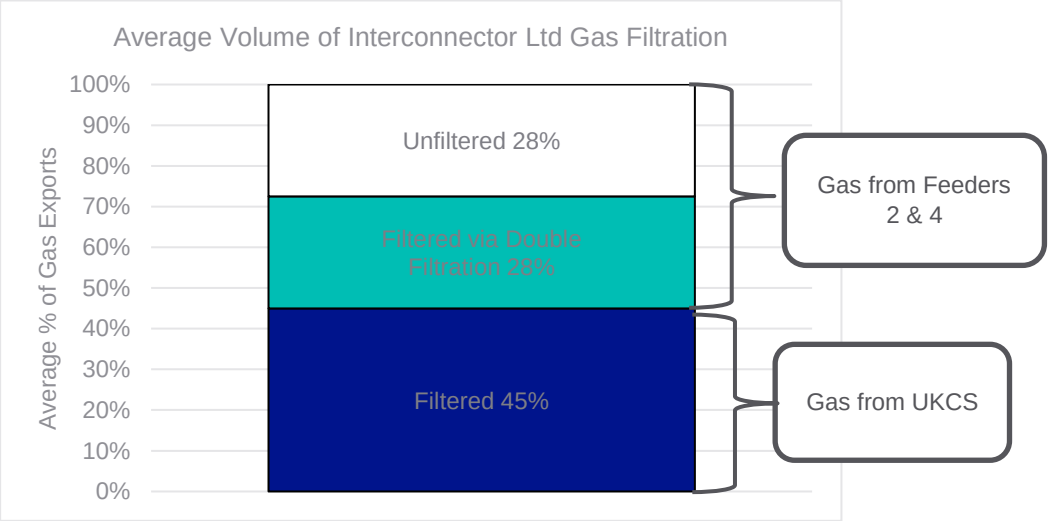


Figure 5 Terminal Filtered and Unfiltered Export Volumes

4.25. Therefore, our double filtering operation only partly mitigates the problem, with a proportion (c 28%) of the Interconnector Ltd export gas unfiltered, which has the potential to result in downstream filter binding resulting in outages which impact on European Security of Supply.

4.26. Our double filtering mode of operation is a best endeavours approach. As it requires the Terminal to operate differently to the established operating model it is inherently inefficient and requires additional management oversight to ensure the site continues to meet all safety, regulatory and contractual obligations. In addition, it requires the utilisation of King's Lynn compressor to ensure exit point pressures are met. If King's Lynn compression is unavailable or experiences short-term trip outages, then pressure reduces which, in turn, reduces the amount of gas that can be double filtered.

4.27. Our default Terminal operating strategy is to have a spare incomer available to manage and mitigate upstream process incidents. Therefore, using one of the incomers to double

filter removes this redundancy, increasing the risk of out of spec gas entering the Terminal and NTS and/or supply curtailment consequently impacting security of supply.

Points 4.28 to 4.31 are additional information requested by Ofgem as part of the January 23' submission SQ process.

4.28. In addition to the more recent double filtration operation (April 2022 to Present) there have been three historic instances of double filtration over the requested period, one instance in 2013, one in October 2015 where double filtration occurred across the majority of the month and another occurrence in 2019. Double filtration was also requested by our customers in May 2020 but this could not be facilitated due to incomer availability.

4.29. Bacton Site Operations will make the decision to commence double filtration arrangements based on the local operational conditions. The decision lies with the Bacton Control Room team (Shift Team) and Terminal Manager/Terminal Engineers. The decision is taken based on the prevailing supply and demand position, the level of maintenance works within the terminal impacting on the level of resilience and the operation of our upstream customers.

4.30. The assets were not designed specifically for double filtration configuration and therefore through operating in this configuration this limits our ability to operate and maintain the terminal. E.g., If UKCS incomer outages are required to facilitate maintenance, or outages are agreed with our upstream customers to facilitate maintenance then the ability to utilise spare incomers is assessed to avoid security of supply risks or supply constraints.

4.31. Engagement will occur between the local Bacton Control Room and GNCC to ensure there is no implication on NTS velocities, however ultimately the decision is made locally within the Bacton Control Room team. Decisions made are recorded within the shift logs which has been interrogated to provide the information below.

4.32. Double filtering operations also impact maintenance activities. NGT needs to conduct significantly more frequent filter maintenance under this operation with financial, operational and health & safety implications.

4.33. In addition, as a result of NGT double filtration activities, upstream operators have been asked to postpone their own maintenance. This has been due to the unavailability of this spare incomer and our inability to reconfigure the Terminal. This increases operational risk to process plant with the potential to impact on security of supply to the UK.

4.34. Double filtration accelerates asset wear, (Isolation valves, filter vessel access hatch door seals) which may lead to assets needing to be intervened upon or replaced earlier than originally forecast, driving out of phase maintenance and asset replacement costs.

4.35. Double filtering operations have significant site operational burden, maintenance consequences, health and safety consequences and environmental impacts and is not a sustainable mode of operation to manage this risk.

Maintenance / Filter Changes

4.36. One of the consequences of the supplementary flow and associated build-up of material within filters is the increased frequency of maintenance beyond the baseline plan (functional checks scheduled every year as per T/PR/MAINT/2 Part 3 policy).

4.37. Figure 6 shows the filter maintenance activities carried out across 2022 on the incomers utilised to conduct double filtering. It highlights the baseline planned filter maintenance activities and the additional activities undertaken as a result of differential pressure readings being identified across the filter bank – indication that materials have been collected within the filter baskets.

		2022											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Filter	A1												
	A2												
	S1												
	S2												

Key	
	Baseline Planned
	Additional (Not Planned)
	Planned (Additional)

Figure 6 Scheduled vs Unscheduled Filter Maintenance

4.38. Across calendar year 2022, we have completed 11 filter bank maintenance tasks on Perenco A1, Perenco A2, Shell S1 and Shell S2 incomers, of which only two were planned. These additional filter maintenance activities were driven from reading a high differential pressure across the filter bank, signifying a build-up of materials within the filters (filter binding).

4.39. Filter maintenance is undertaken across the whole filter bank, e.g. across all 5 filters in Perenco A1, rather than as individual filters due to location of isolation points. In order to achieve a double block and bleed isolation we need to go back to the valve located on the incomer of the filter bank. Therefore, this isolates the whole incomer for the duration of the filter maintenance.

4.40. Since filter maintenance isolates the whole incomer, filter maintenance tasks are carefully planned with our upstream customers. Maintenance can only be undertaken when we have availability of our incomer assets, and our upstream customers have availability of their assets to switch between incomers.

4.41. To complete the filter maintenance, operatives are required to work in a high process hazard environment, near to high pressure gas assets. Current maintenance procedures require the gas inventory within the filter bank is vented to atmosphere which requires the installation of additional assets and extends the duration of the filter maintenance. The size of each isolation envelope is significant and to safely obtain the isolation, the work involves

undertaking Major Accident Hazards (MAH) scenario type activities (as noted in Bacton Terminal's COMAH Safety Case) and have safety critical tasks for operatives to follow to manage such risks. The increased frequency NGT are currently undertaking filter maintenance work increases the risk of a MAH scenario and a domino incident onsite. There is also a risk of loss of containment of a filter vessel closure with the additional maintenance work, exposure to NORM, Benzene, Volatile Organic Compounds (VOCs) and pyrophoric dust.

4.42. On average, two operatives are required to complete filter maintenance activities, time that could be spent undertaking asset integrity checks or maintaining operational assets. Actual filter maintenance takes on average one day per vessel to complete. However, in addition to this time it takes two to three days to apply the isolation to the filter bank and one day to recompress the filter bank.

4.43. Additional filter maintenance over and above our policy position (every two years) results in significant additional operational burden to the operation of the site and has diverted site operatives from other activities at the site.

4.44. Table 2 Filter Maintenance Durations provides an estimate for the duration of filter maintenance as per the filters installed on the filter banks.

Incomer	Filters	Est Duration of Filter Maintenance (Assuming 2 days for isolation)	Additional Maintenance Days across 2022
Perenco A1	2	5 Days	10 Days
Perenco A2	5	8 Days	24 Days
Shell S1	2	5 Days	5 Days
Shell S2	3	6 Days	12 Days
Shell S3	3	6 Days	0 Days
Shell S4	3	6 Days	0 Days
Total			**51 Days**

Table 2 Filter Maintenance Durations

4.45. There are also environmental impacts to filter maintenance due to venting of gas within the bank to atmosphere. On average [redacted] carbon is estimated to be released upon each filter bank maintenance activity.

4.46. For the regulatory period of RIIO-2, Ofgem expects our focus to be on decarbonising the energy network, with there being a strong influence from the UK Government to reduce carbon emissions to meet legally binding commitments (Net Zero by 2050). Venting is considered a high impact area and targeting the reduction of this will help achieve these targets.

4.47. NGT through our Environmental Action Plan, submitted with our RIIO-2 Business Plan, identified a range of commitments to demonstrate how we, as a business, intend to reduce our impact on the environment. One commitment was to reduce our carbon emissions by 2026.

4.48. The focus on methane emissions, such as the recent Global Methane Pledge agreed at COP26, to which the UK is a signatory, has increased the urgency to reduce all greenhouse gases (especially methane) in the context of climate change. Since NGT submitted its RIIO-2 business plan, the focus on methane emissions has grown significantly and hence NGT wishes to reduce emissions in all contexts where possible, including the impacts from its filter maintenance.

4.49. Filter maintenance activities have considerable risks associated with them due to operatives working near high pressure assets but also requires the handling of potentially hazardous materials. Pyrophoric dust, Benzene, Naturally Occurring Radioactive Materials (NORM), Glycol & Volatile Organic Compounds (VOCs) have all been identified within the recovered materials within the filter baskets which present a range of hazards, requiring full personal protective equipment (PPE) and breathing apparatus to be worn throughout the operation, as shown in Figure 7.

- Pyrophoric dust contains combustible materials that ignite instantly upon exposure to oxygen. Low quantities of this have been found within the recovered material. Fire hoses are used to dampen down materials as it is removed from the filter baskets, with materials put within sealed bags to remove the oxygen before material is removed from site.

- Low levels of NORM are found within the collected materials in existing filters. These need to be safely captured and disposed of by Radiation Protection Supervisor (RPS) operatives on site in line with legislative requirements.

Figure 7 Filter Maintenance Activities

4.50. There are additional risks including environmental risks associated with the runoff of materials into the ground of waterways, and the risk of asphyxiation, requiring the use of breathing apparatus. Nitrogen is used to purge the filter system to atmosphere. Nitrogen displacing the oxygen within confined spaces results in risks to operatives completing the maintenance activities. Breathing apparatus as shown is utilised to manage this risk, however there are still inherent risks to this operation. More frequent activities result in increased risk exposure to site operatives.

4.51. In addition to operational inefficiencies and health and safety risks from maintenance there are also increased financial costs from more frequent maintenance. Filter baskets are sent away to be cleaned by specialist contractor at considerable cost. [redacted] has been spent on the nine additional maintenance tasks within 2022 (~[redacted] per maintenance task).

4.52. More frequent filter maintenance, driven from double filtration has significant health, environmental and MAH risks that are intolerable for NGT to sustain in the medium to long term.

Material Analysis

Points 4.53 to 4.68 are additional information requested by Ofgem as part of the January 23' submission SQ process.

4.53. As part of the project development process, we commenced with the needs case assessment. Initially this resolved around collating and assessing information in relation to the material identified with our network.

4.54. It is worth highlighting that the design philosophy of the National Transmission System is one of filtering onto the system and filtering off it, with scrubbers located on a number of our compressor stations to mitigate liquid ingress from our wet seal compressors.

- Our assessment of the needs case considered the following areas:
- How and when the build-up of solids occurred in the pipeline, is it corrosion of the pipelines or has it come from connected parties.
- What are the likely sources of the solids
- Have solid materials affected other sites on the NTS
- What is the material make up of the solid material.

How and when the build-up of solids occurred in the pipeline, is it corrosion of the pipelines or has it come from connected parties?

4.55. Our assessment of the problem commenced at Bacton due to this being the location of the significant disruption, however this then broadens out into the immediately connected NTS assets and then further out into the network. There is no evidence for gross solids contamination from connected parties ([redacted] The upstream processing terminals typically recover the higher hydrocarbons (natural gas liquids) by condensation and inject liquid glycol to dry the gas. These processes will inherently scrub any significant quantities of solids that may be present in the gas stream.

4.56. The filters at Bacton see very little solid build up when filtering UKCS gas. Overall, it can be said with a high degree of confidence that we aren't seeing large quantities of solids from connected parties.

4.57. It is our policy to conduct chemical sampling of all material collected at Bacton Terminal. Trend analysis was completed on this data to understand the predominant properties (dosage) of the collected material within our samples, this being Iron, and Benzene.

4.58. Data was also analysed from the last In-line inspections completed on Feeders 2, 4 & 27. Our methodology for In-line inspections involves utilising a range of gauge, cleaning and intelligent Pipeline Inspection Gauges (PIGs) to assess the internal condition of our pipelines. Reports from the inspections completed prior to 2022 provided no evidence for gross corrosion of the internal surface of the pipework including any loss of wall material that could affect the integrity of the pipework on any of the three feeders utilised for bulk export transmission.

4.59. However, the very earliest sections of feeder, such as Feeder 2 & 4, were fabricated using line pipe that has a red internal coating, under CM/2 specification. These sections will contain significant quantities of mill scale (oxides of iron generated during the fabrication of the pipe in the mill including material associated with the profiling of the edges of the plate prior to welding the seam and slag from the seam welding process itself). This material would not necessarily have been removed from the line pipe during the on-site fabrication of the feeder at the time of installation (generally more than 50 years ago) and is likely to be displaced by periodic high flows.

What are the likely sources of the solids?

4.60. There are multiple potential sources of the solids within the pipeline system:

4.61. 1) The individual sections of line pipe (each a few metres long with the maximum length dictated by the capacity of the pipe mill and transport considerations) have to be field welded together to form the pipeline. Prior to welding, the ends of each section have to be bevelled to the correct profile for the welded joint and this is generally done by grinding which generates large quantities of metallic dust / grit, some of which will inevitably find its way into the pipe depending on conditions on site at the time.

4.62. Any welding process gives rise to a heat affected zone that typically extends a few inches either side of the weld. The metal temperatures in this region during the welding process (including any preheat necessary to ensure satisfactory weld metallurgy) will result in extensive damage to the internal and external pipe coating. Whilst the external coating will be remediated, it is not practicable to repair the internal coating so there will always be some uncoated sections within the pipeline whilst the welding process will give rise to a certain amount of extraneous material within the pipe.

4.63. Once any pipeline has been fabricated it is subject to a hydraulic strength test which entails filling the section of pipe with water, pressurising it to the required pressure before draining the pipe (often a length of many miles) before drying it prior to commissioning. This process will inevitably give rise to a certain amount of flash rusting of uncoated surfaces albeit as a one-off event.

4.64. 2) There are known corrosion reactions between iron and sulphur and iron and carbon dioxide which give rise to iron oxides and sulphides but the rates of these reactions are extremely slow at the temperatures that the transmission system operates at so any residual corrosion is far more likely to be as a result of any reaction with oxygenated water that finds its way into the network.

4.65. 3) In addition to the metallic debris associated with construction remaining in the pipeline, given the nature of cross country construction sites, it is inevitable that a certain amount of soil will enter the pipeline during construction and this will gradually dehydrate over the years.

4.66. 4) Subsequent maintenance activities can also give rise to new sources of debris in the pipeline. Removal and replacement or piping through of valves will give rise to debris similar to that found during construction whilst any ‘hot tapping’ activities (where a hole is drilled under pressure into the existing pipeline to facilitate a new connection (including connections for stoppling to allow pipelines to be diverted whilst in service to avoid having to isolate the feeder)) will give rise to considerable quantities of metallic swarf which is generally very difficult to remove from the feeder.

4.67. Thus, it can be seen that there are a number of sources of debris within the pipeline network. Most are related to original construction and subsequent maintenance activities plus small quantities arising from radioactive decay of NORM.

4.68. There is very little that can be done practically to remove this debris from the network and it does become mobile as flows change across the network with there being clear evidence that high flows cause material to become mobile.

Have solid materials affected other sites on the NTS?

4.69. Gas at Kings Lynn Compressor Station passes through scrubbers prior to compression and although the scrubbers are primarily designed to remove liquids they will remove some solids. No solid material has been identified within the scrubbers/condensate tank at the Kings Lynn station, however when the scrubber at Chelmsford were inspected recently solids were found in the vessel, highlighting that solid materials are present within the system.

4.70. Located between Kings Lynn and Bacton sit two offtake sites, Brisley Offtake & West Winch Offtake, both Cadent offtakes on Feeder 2. Engagement completed between GSO and Cadent did not identify any experiences or concerns of material/solids within the offtake's filters. Both sites are connected to Feeder 2 via two 90o tees from the feeder, either side of the mainline isolation valves. The connection geometry could mitigate the impact of material within the system.

What is the material make up of the solid material?

4.71. Following each filter maintenance activity as part of the disposal process, waste samples of liquid and solid debris have been sent to [redacted] to undertake laboratory testing of the composition.

4.72. The data we present below is based on samples collected from February 2021 to September 2022 through the various filter maintenance activities completed.

4.73. In summary, significant deposits of Iron (Fe) based materials were present across the sampling conducted from all of the recovered materials, with quantities of Mercury, TPH, Barium, Lead, Benzene, Chromium and Zinc present. Figure 8 below presents a cumulative summary from the sample analysis completed over this period.

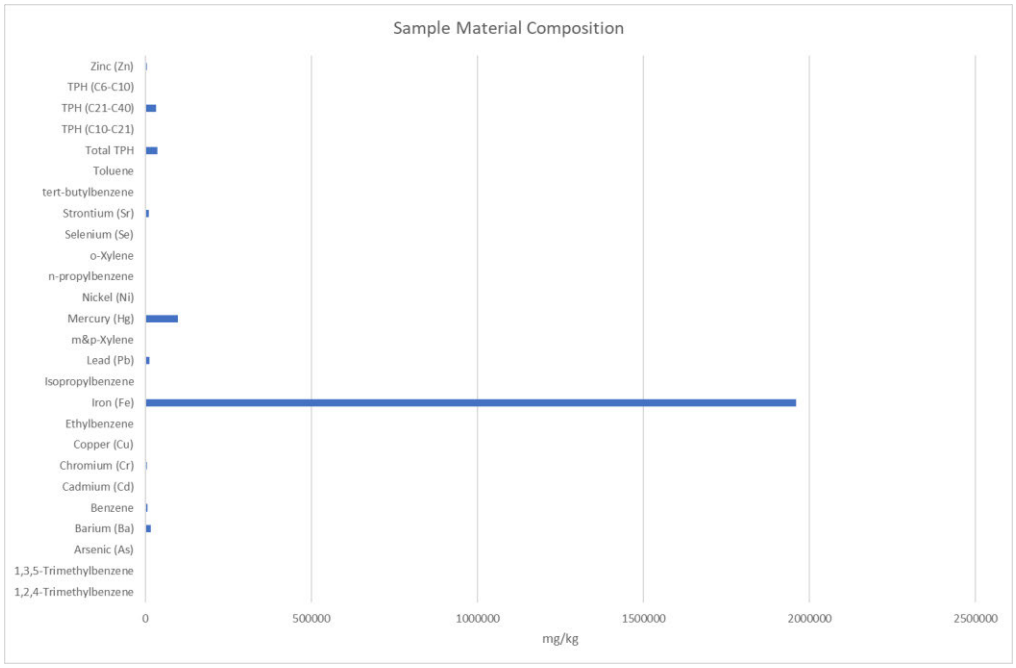


Figure 8 Filter Maintenance Material Sample Chemical Analysis

4.74. Further information on the composition of material collected through the filter maintenance can be found in Appendix 1.

4.75. As explained, the presence of NORM within the collected material requires significant operational burden to mitigate the risk to the health and safety of our site operatives. Figure 9 presents the quantity of naturally occurring radioactive material (NORM) in Kg collected during the filter maintenance activities conducted across 2022 Pre November 2021, we have not seen significant volumes of NORM collected through filter maintenance.

Figure 9 Quantity of Contaminants

Figure 10 Flow vs Cumulative Kg of NORM

4.76. Figure 10 shows the correlation between the cumulative weight of NORM against gas flows (mscm/d) at the Interconnector which is a good indicator of the quantity of solid contaminants (i.e. dust). The quantity of contaminants demonstrably increases in line with the Interconnector flow rate with this having increased across sustained high export flows.

Feeder 2, 4 & 27

4.77. For export flows from Bacton Terminal, Feeders 2, 4 & 27 are utilised to move gas across the NTS to the Terminal. Feeder 2, 4 & 27 each have a Maximum Operating Pressure (MOP) of 75bar.

4.78. Feeder 27 can accommodate flows of [redacted] and Feeder 2 and 4 each up to [redacted].

4.79. IGEM's IGEM/TD/1 specification states recommended maximum velocities for filtered and unfiltered gas. Unfiltered gas is recommended to have a maximum velocity of 20m/s and filtered gas 40m/s.

4.80. Given our network is operated as an unfiltered system until the exit points, Feeder 2, 4 & 27 are operated to a maximum velocity of 20m/s in line with this policy. We have undertaken a range of modelling simulations as part of the needs case development. Our modelling system (SIMONE), used to support the design development shows, based on recent operating conditions, a maximum velocity of 10m/s across feeder 2 & 4 respectively, with Feeder 27 on outage. This is the worst-case scenario due to Feeder 27 used for bulk export transmission for BBL. This analysis shows that these feeders have not been exceeding the Industry Standard velocities.

4.81. NGT isolated Feeder 4 between King's Lynn and Bacton in May 2022 due to concerns around the level of material ingress occurring from operation of this asset. No customers are located along this feeder, so no customers were directly related.

4.82. An Inline Inspection (ILI run) of the feeder was scheduled for November 2022 and conducted between 7th November and 25th November from Wisbech Nene East to Bacton Terminal (Figure 11 below). Throughout these ILI runs gas was double filtered to mitigate any further material ingress into the site.

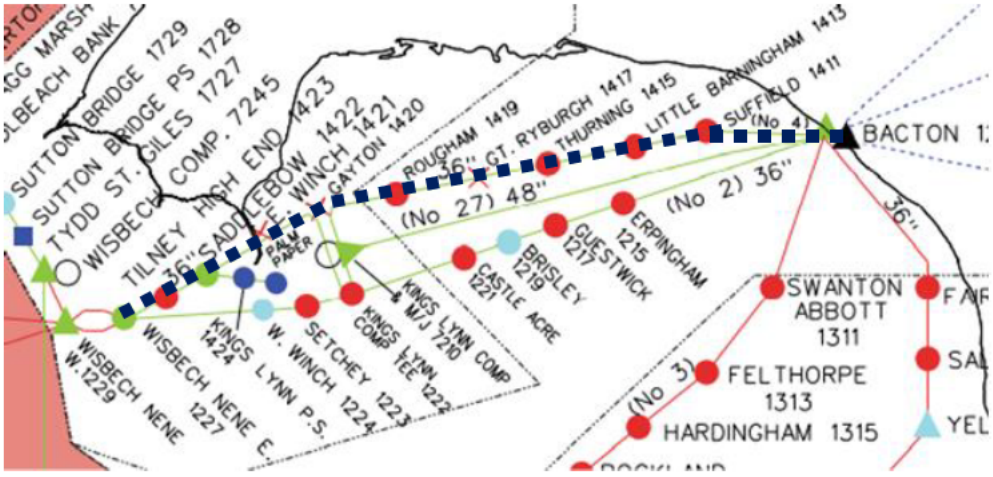


Figure 11 Feeder 4 ILI Run

4.83. A total of four cleaning ILI runs were completed and a fifth run with a Magnetic Flux Leakage (MFL) In Line inspection tool. A total of [redacted] of materials was collected and three litres of liquid. Table 3 summarises the results per run:

	Run 1	Run 2	Run 3	Run 4	Run 5	Totals
Date	15/11/2022	17/11/2022	19/11/2022	21/11/2022	23/11/2022	
Dust KGs	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Liquid (Litres)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 3 Feeder 4 ILI Run material Collection

4.84. Following the In-line inspection Feeder 4 was returned into operational service, however, to mitigate any risk of additional solid debris being located within the feeder we undertook operational mitigations to double filter the Feeder 4 gas.

4.85. The 135kgs of materials collected through these five runs was significantly in excess of the materials collected through the previous Feeder 2 & Feeder 27 In-Line Inspections. Feeder 2 was inspected in May 2021 and Feeder 27 in February 2021.

4.86. Feeder 2 was inspected from Bacton to Wisbech, and Feeder 27 inspected from King's Lynn to Bacton. Figure 12 and 13 summarise these routes. Through both inspections cleaning runs were completed with minimal materials collected ([redacted]).

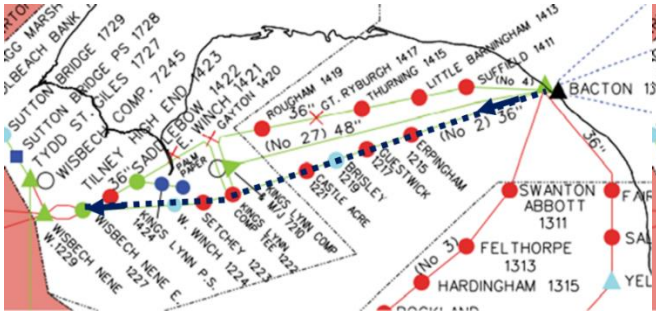


Figure 12 Feeder 2 ILI Run (May 2021)

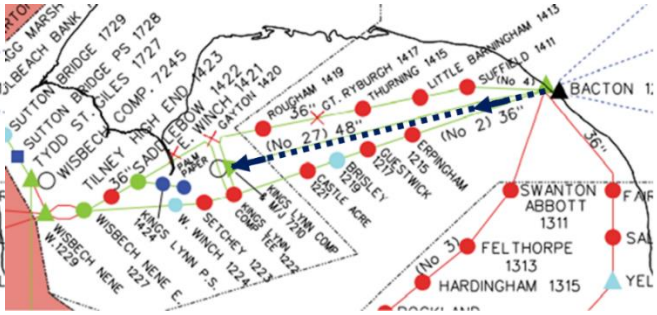


Figure 13 Feeder 27 ILI Run (Feb 2021)

4.87. Whilst the previous ILI run conducted on Feeder 2 collected no significant materials, this has not always been the case. In 2003 Inline inspections were conducted on Feeder 2 & Feeder 4, in line with our inspection frequency. Both feeders were inspected towards Bacton with [redacted] of materials recovered across both Feeders. This suggests that there is an inherent long term need that requires mitigation.

Summary

4.88. Our investment seeks to enhance our filtration to mitigate disruptions to operation of the site in both net export and net import modes of operation and ensure security of supply is maintained.

4.89. Not undertaking any additional investment results in:

- continued operational mitigations occurring (Double Filtration), which has significant health, safety and environmental risks that we find intolerable,
- requires proactive operational management which diverts resources away from operational day to day duties, and has significant operational impacts to Terminal operation both for NGT and upstream customers with the potential to impact on security of supply through one of our two COMAH sites which can supply gas to meet up to one third of the UK gas demand.

Under what circumstances would the need or option change for this project?

4.90. The high velocity, turbulent flows seen entering Bacton as a result of high exports are thought to be a contributory factor for the presence of dust and liquid due to the increased velocity and turbulence increasing the likelihood of contaminants being picked up and transported, however, our feeders have operated within the velocity limits even during the feeder 4 isolation.

4.91. Any reduction in Terminal exit flows could reduce the amount of dust and liquids entering the Terminal, driven from the reduced velocities being seen along our feeders. This is unknown at present as capacity at the site has been sold up to, and in excess of, obligated

capacity based on a need from our customers. We cannot risk disruptions within our Terminal impacting on the security of supply of gas flowing through the Terminal.

4.92. Analysis of the quantity of materials collected shows materials have been collected prior to the point additional (non-obligated) capacity has been issued, therefore whilst this may have exacerbated the position it is not deemed to be a direct driver.

4.93. It is unknown how long the current rate and volume of export may continue at the site. However, given the significant reduction in Russian gas supplies into Europe, and Europe's LNG importation constraints (number and capacity of existing LNG Terminals; and the lead time to commission additional LNG importation capacity), it is believed that there will be continued domestic supply shortfalls.

4.94. The UK gas market has significant LNG regassification capacity, a range of domestic (UKCS) supply sources, and significant system capacity. Forward prices across the curve to Winter 2023/24 show a discount for the UK National Balancing Point (NBP) trading point over the Dutch Title Transfer Facility (TTF) and Zeebrugge Trading Point (ZTP) prices. Ongoing utilisation of the NTS as a transportation route to support European Security of Supply is likely. In this scenario there could be instances of significant exports. Our investment seeks to mitigate the risk to this security of supply through the build-up of solid debris within the Terminal.

What are we going to do with this project?

4.95. In order to mitigate the risks from material ingress into the Terminal, and the impact this has on our customers and European security of supply, NGT reviewed options to ensure 100% of NTS gas entering Bacton is filtered.

4.96. Our options should look to reduce the operational burden, operational management and reduce the health & safety risk to operatives at the site. For process safety systems and risk management a swiss cheese model for safety is considered for risk analysis. Our option shall consider the combined risk mitigation operational mitigations and asset investments provide to benefit security of supply at the site.

4.97. Our options will consider filtration for the Terminal operating in net export mode, however any enhancement to filtration will result in significant benefits to security of supply in ensuring robust bi-directional Terminal operation.

What makes this project difficult?

4.98. The project needs to be completed whilst sustaining gas exports to Europe via Interconnector Ltd and BBL interconnectors. Options selection process has considered the

disruption options have to the Terminal, given the ongoing requirement to support European security of supply.

4.99. Physical space is limited at Bacton Terminal in the locations of the Feeder connections. Although sufficient physical space exists for the new filtration equipment, required separation distances between gas assets to meet NGT Policy are not met. This will require a quantified risk assessment to be undertaken and subject to the outcome a successful deviation to Policy to render the options feasible.

4.100. Limited space will also be considered in a constructability review of the options to ensure safe construction for each option. This will require further development through detailed design phase with additional constructability reviews and Hazard of Construction (HAZCON) assessments. Options requiring additional land take (greenfield site extension) were discounted at long list options review stage due to the significant delays related to land ownership and planning permission and associated additional cost.

4.101. Feeder filter locations are adjacent to and partially within areas of the site occupied by Interconnector Ltd. To manage the project effectively and safely, will require close engagement and collaboration through detailed design, pre-construction and construction phases to ensure minimal disruption to Customer and NGT operations.

4.102. A range of other investments are progressing at the site, funded through baseline RIIO-2 business plan funding. In addition, a range of additional investments, identified through the creation of our investment strategy are in the early stages of development. We need to balance the delivery of these projects with the resources and disruption to site operations.

What are the key milestone dates for project delivery?

4.103. The project aims to have enhanced filtration installed at the Terminal by November 2025, enabling enhanced filtration to operate during a period of potential high export to Europe. Milestone dates have been informed by scheduling of this project against lead times for long lead items required for the project, e.g., valves and filters.

4.104. We are currently at stage 4.2 of the Network Development Process (ND500) - a process aimed at defining and managing the projects lifecycle from inception to closure, ensuring we meet minimum requirement for each project phase.

4.105. Due to the significance and immediacy of the problem, we have progressed this project at pace to ensure security of supply to Europe is not compromised. Figure 14 provides a summary of the programme. We have undertaken spend at risk on this project due to the urgency of implementing a solution to ensure Security of Supply to Europe is maintained.

ND500 Milestone	Milestone Description	Month
T2		Jan-23
F2	Feasibility Sanction	Jan-23
T3	Agreement to proceed to conceptual design	Jul-23
F3	Long Lead Item sanction (critical path valves, 48 weeks)	Jul-23
T4	Scope Freeze	Jun-24
F4	Detailed Design & Build sanction	Jun-24
T5	Detailed Design challenge & review completed	Nov-27
	Valve delivery	Mar-25
	Site works on Feeders 2 and 4	Sep-24 - Nov-25
	Commissioning	Jul-Nov 25
	Operational Acceptance	Dec-25
	Records updates and contingency	May-27
	Asset Acceptance	Jun-27
T6	Hand back for closure	Jul-27
F5	Closure	Nov-27

Figure 14 Project Stage Summary

How will we understand if the project has been successful?

4.106. Overall project success will be confirmed by commissioning and asset acceptance of the preferred option, meeting customer demands throughout the construction period, enhanced filtration of gas within Bacton Terminal, as well as the project completed safely and to time, quality and cost.

4.107. The project shall be successful if it reduces the amount of filter maintenance required to be conducted and reduces the operational burden currently incurred through double filtering operations.

Related Projects

4.108. There are key interactions with other significant investments at Bacton and across the National Transmission System (NTS).

Bacton Future Operating Strategy

4.109. The Bacton Future Operating Strategy (FOS), National Transmission System Gas Transporter Licence Condition 3.10 Bacton Site Redevelopment Re-opener, is a key interaction. As part of this strategy, optioneering is currently in progress to consider future strategic direction for the Terminal, including new Terminal options or asset health options.

4.110. As part of the FOS optioneering, under any option incomer locations & feeder locations within the site are not proposed to be modified. Assets are proposed to be retained up to 2035 for incomers and throughout the full time period range (to 2050) for Feeder 2, 3, 4, 5 & 27. The Future Energy scenarios shows United Kingdom Continent Shelf (UKCS) supplies will continue until at least 2035 and, therefore, the risk of upstream issues remains in the long term.

Bacton Investment Strategy

4.111. The Bacton Investment Strategy is a two-phase strategy to ensure clarity on short- and medium-term asset health investments (Phase 1) and longer-term future Terminal operating strategies (Phase 2). The Strategy was signed off by the Gas Transmission Investment Committee (GTIC) in September 2022 and a summary is provided within this submission.

4.112. This filtration project is aligned to Phase 1 which aims to deliver accelerated and medium-term investments to provide certainty on Terminal operation requirements to 2026. Accelerated investments have been identified to address short term requirements, whilst medium-term investments have been identified as no regrets based on the options under consideration through the Future Operating Strategy (FOS) workstream. Our Phase 1 investment plan is in development thus our list of investments may iterate.

4.113. Phase 2 includes enduring Terminal solutions required beyond 2035 aligned to the development of the Future Operating Strategy to reduce overall Terminal operating risks. Figure 15 provides a summary of the investment areas within the Investment Strategy.

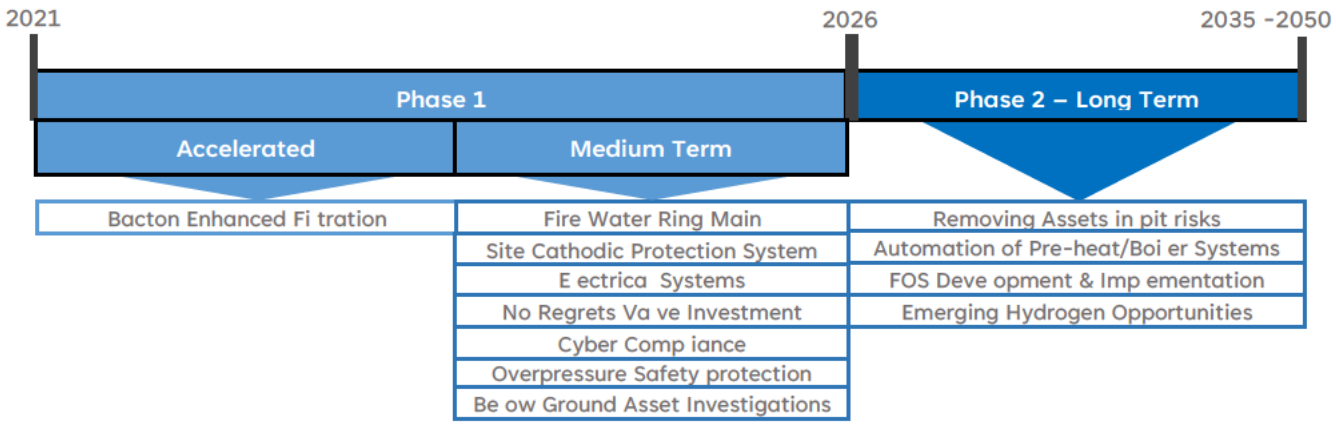


Figure 15 Bacton Investment Strategy

King's Lynn Compressor MCPD

4.114. To address the Medium Combustion Plant Directive (MCPD), we have developed a Compressor Emissions Asset Management Plan (CE-AMP) which details how we will

manage, maintain, and invest in compression assets in line with emissions legislation. The King's Lynn FOSR, included our preferred investment option.

4.115. King's Lynn, which consists of two non-compliant MCPD units (one disconnected, the other installed in 1973), and two compliant MCPD units (installed 2003), is a critical site for supporting Bacton entry and exit flows.

4.116. There is need to consider the intrinsic link between projects to explore opportunities such as the alignment of works and outages, however the outcome of these two UMs are separate and not impacted by each other.

Project Boundaries

4.117. The scope of this project is delivery of investments to enhance the filtration at Bacton Terminal to ensure the gas does not contain solid or liquid material which may interfere with the integrity or operation of pipes or any gas appliance2.

4.118. The project focusses in two areas:

- Enhancing current incomer filtration banks by installing new filter vessels and increasing the quantity of filter basket spares held at the site.
- Proposes the installation of new filtration systems on the feeders connected to the Terminal site.

4.119. The scope of the investments within this paper does not include mitigations for liquid collection within the Terminal. Due to the risks of liquid excursion from upstream parties entering the Terminal and materials being discharged to our downstream customers and out into the NTS, we are considering investment to manage and mitigate the impacts from these events. This is outside the boundary of this paper but will be included within a subsequent funding request proposed to be submitted through the Asset Health Re-opener windows (National Transmission System Gas Transporter Licence Condition 3.14 Asset Health Re-opener (AHt)). Separate technology is required for the filtration of solids and liquids, and the source of liquid is generally found to enter the Terminal at a different location.

The scope of this paper does not include investment on any other asset systems at the Terminal. Further Engineering Justification Papers (EJPs), in line with our Investment Strategy, will be developed where no regrets investments are proposed to be undertaken as these scopes are developed.

[2] Gas Safety (Management) Regulations 1996 GS(M)R

5. Project Definition

5.1. The scope of works proposed in this project is to be carried out at Bacton Terminal, located on the east coast of the UK. One of nine gas Terminals connected to the NTS, Bacton is a site of strategic importance due to supplying up to one third of the UK gas demand on a winter day whilst importing and exporting to and from Europe via two interconnectors.

5.2. Built and commissioned in 1968, the Terminal operates 24 hours a day 365 days a year, regularly supplying 10% to 20% of the UK's natural gas supplies.

5.3. Gas enters and exits Bacton at various points, including via the NTS through five feeders connected to the site shown in Figure 16 (Feeders 2, 3, 4, 5 & 27).

Figure 16 Bacton Terminal Location

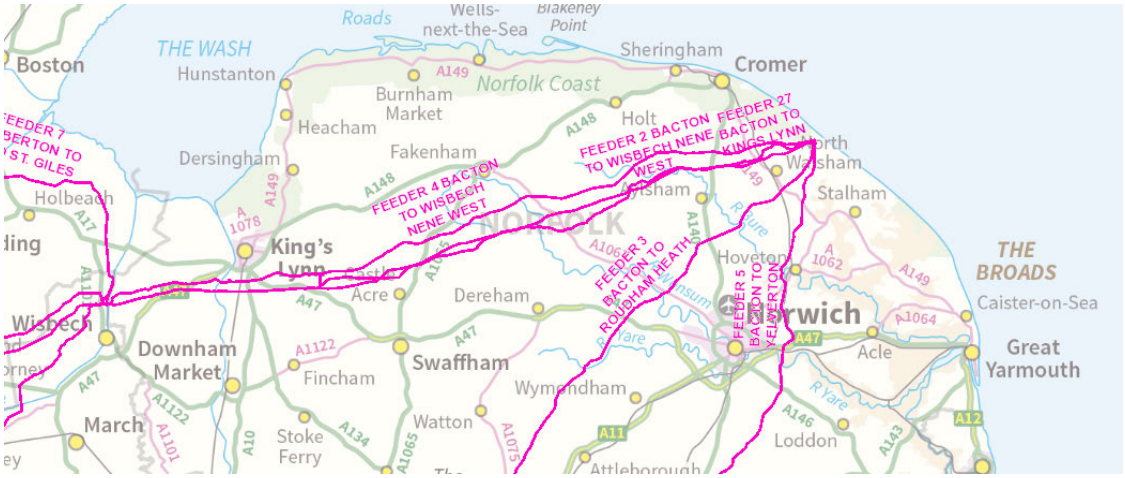


Figure 17 NTS Feeder Connections at Bacton Terminal

5.4. Gas is discharged to local exit customers including Cadent GDN offtake, Great Yarmouth Power Station and to the two interconnectors operated by Interconnector Ltd and BBL for export to Europe.

5.5. The interconnectors also provide the critical ability to import gas from Europe, with Bacton Terminal being pivotal to facilitate flows in both directions.

5.6. In addition to interconnector and NTS connections, gas also enters the Terminal for onward transmission from UK Continental Shelf (UKCS) gas operators i.e., Perenco and Shell Beach Terminals.

5.7. There is no NGT-owned compression on site as upstream and downstream parties provide their own compression. Gas enters the site in line with Network Entry Agreements (NEAs) and exits in accordance with contractual obligations and agreements e.g., Interconnector Agreements.

5.8. Figure 18 provides a high-level overview of the site layout and connections. The manifold and Terminal ring main are utilised to co-mingle gas from the incomers, interconnectors and feeders for discharge to exit customers/NTS, and manage exit flows and pressures.

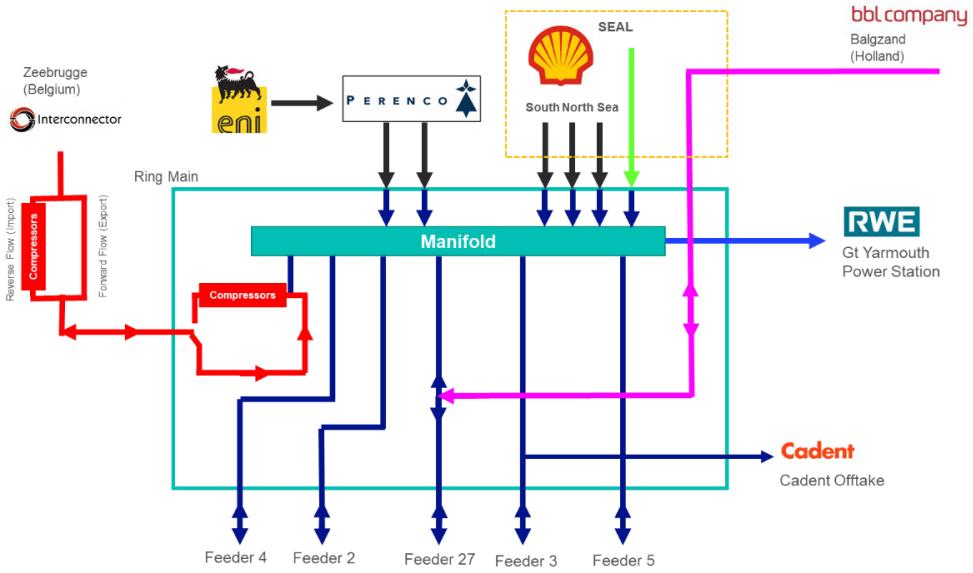


Figure 18 Bacton Terminal Site Layout

5.9. Except for the BBL interconnector connection, the general arrangement shown in Figure 22 is consistent across all incomers and comprises of:

- Primary Protection and Gas Quality Monitoring – Provides downstream pressure protection and temperature and pressure monitoring. Gas Analysers (All in one and Danalysers) and CV and Dewpoint monitoring.

- Filtration and Pre-Heating – Incoming gas is filtered to 2 microns and preheated prior to flow control. Several filter vessels are installed on each filter bank.

- Flow Control and Manifolds – Gas is controlled with Flow Control Valves (FCV) and manifold valves to control blending and pressure.

- Metering – to meter the gas flowing onto the manifold through each incomer.

Figure 19 General Arrangement of Bacton Incomers

5.10. Incoming gas from upstream Shell and Perenco Terminals passes through filter vessels. Each incomer has a filter bank containing multiple filter vessels. This provides flexibility and resilience to Terminal operations and ensures security of supply is maintained through the Terminal. Table 4 shows the current vessels installed at the Terminal as of October 2022.

Perenco A1		Perenco A2		Shell S1		Shell S2 (Spare)		Shell S3 (Shell)		Shell S4 (SEAL)	
A	16" class 600 horizontal vessels	A	16" class 600 horizontal vessels	A	16" class 600 horizontal vessels	A	16" class 600 horizontal vessels	A	16" class 600 horizontal vessels	A	18" class 600 horizontal vessels
B	16" class 600 horizontal vessels	B	16" class 600 horizontal vessels	B	16" class 600 horizontal vessels	B	16" class 600 horizontal vessels	B	16" class 600 horizontal vessels	B	18" class 600 horizontal vessels
C	Vacant	C	16" class 600 horizontal vessels	C	Vacant	C	16" class 600 horizontal vessels	C	16" class 600 horizontal vessels	C	18" class 600 horizontal vessels
D	Vacant	D	16" class 600 horizontal vessels								
E	Vacant	E	16" class 600 horizontal vessels								

Table 4 October 2022 Incomer Filtration

5.11. The upstream Shell Terminal is connected to NGT's Terminal through four incomers, Shell S1, S2, S3 and S4. The S4 SEAL gas supply is particularly important as it is a clean and dry supply of gas which is regularly added to feeder and customer supplies when needed.

5.12. The Class 600 horizontal filter vessels, shown in Figure 22, Figure 23 & Figure 24 overleaf, are installed across all UKCS (Shell & Perenco) incomers. These filters remove solids / fine dust particles up to 2 microns (µ) but are not designed to remove large quantities of liquid or droplets transported as a mist.

Figure 20: Perenco A2 Incomer Class 600 Horizontal Filter Vessels

Figure 21:Shell S2 Incomer Filter Maintenance

Figure 22: Class 600 Horizontal Filter Vessel

5.13. In addition to the filter banks, Line-Vu cameras are installed into Perenco A1 & A2, & Shell S3 incomers to provide live video of gas streams for the identification of liquid carry-over and containments from upstream parties. Figure 23 is a snapshot of Line-Vu footage which shows contaminants within Perenco A2 incomer. These contaminants are collected within our incomer filtration system, however if significant quantities are collected this results in differential pressure readings and a requirement to complete maintenance.

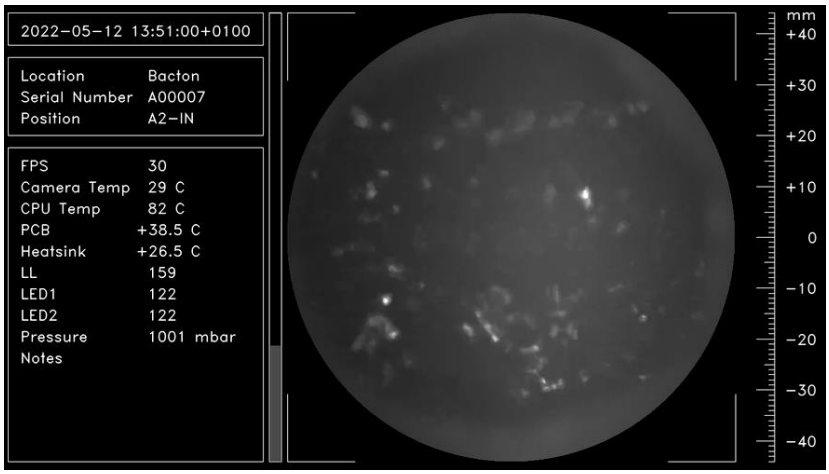


Figure 23 A2 Incomer Line-Vu Footage (May 2022)

5.14. Figure 24 shows the standard general arrangement of feeder connections at the Terminal which includes pig trap and metering assets connected to the ring main and manifold. No filtration is installed on any of the five NTS feeders at Bacton.

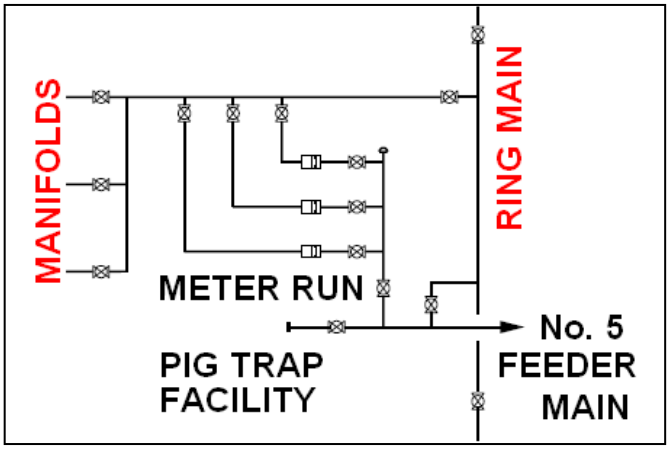


Figure 24 General Arrangement of NTS Feeders

5.15. Further information on the Terminal and its operation can be found within the RIIO-2 Bacton Investment Strategy Summary submitted with this EJP.

Supply Demand Scenario

5.16. Russian gas flows to Northwest Europe have now fallen significantly with the closure of the Nordstream 1 pipeline. Flows are not expected to recover easily given reports of damage to both Nordstream pipelines in the Baltic Sea, however we have no way to know how long this situation will continue for, extending the current supply/demand behaviour.

5.17. Until the cancellation of European buyers' contracts from Q2 2022, Russian gas flows via Nordstream 1 had been fairly steady, operating at close to its 55bcm/yrs capacity level, but a sharp drop in flows occurred in July 2022 ahead of the pipeline's annual maintenance. Flows continued to decline until the pipe was halted at the end of August.

5.18. Gazprom can re-route contracted flows to European buyers via other routes but has opted not to do so. Overall Russian gas supply to Europe is currently around 20% of the 2020 gas year average.

5.19. As published in our Gas Winter Outlook 2022/23 report3, LNG Imports into Europe have significantly increased to help fill the gap, with year-to-date imports amounting to ~90bcm in October, up from ~50bcm during the preceding year.

5.20. Nearly 20bcm of additional LNG importation capacity is expected to be brought online this winter across Northwest Europe to mitigate the impact from Russian supply decline.

[3] https://www.nationalgrid.com/gas-transmission/document/140921/download

However, interconnector exports from UK to Europe have also increased from usual winters through Bacton Terminal utilising Interconnector Ltd and BBL.

5.21. Figure 254 shows a summary of three European supply sources, Russian supplies (Labelled as East), LNG and UK interconnector exports from 1st October 2021 to 1st October 2022. This shows the significant decline in Russian supplies across calendar year 2022, whilst UK exports remain consistent from April apart from when asset interruptions occur.

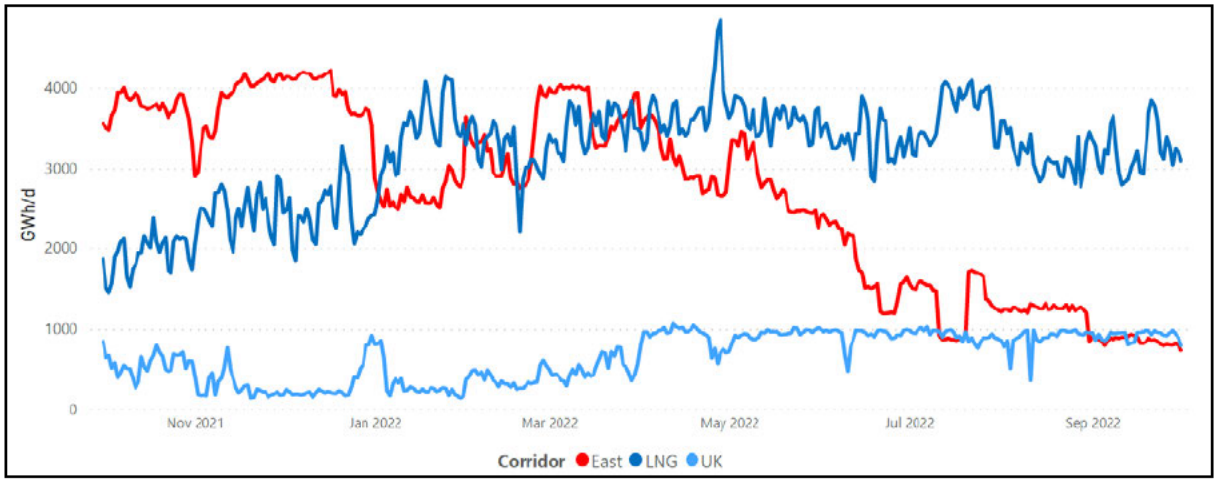


Figure 25 European Supplies October 2021 – October 2022

5.22. The supply constraint and demand levels observed in Europe have caused the market to respond as expected, with the price of gas in Europe higher than the prices seen in the UK resulting in net exports from UK to Europe. Figure 26 below shows a comparison between average daily exports in each month across 2022/23 compared to the previous year (2021/22).

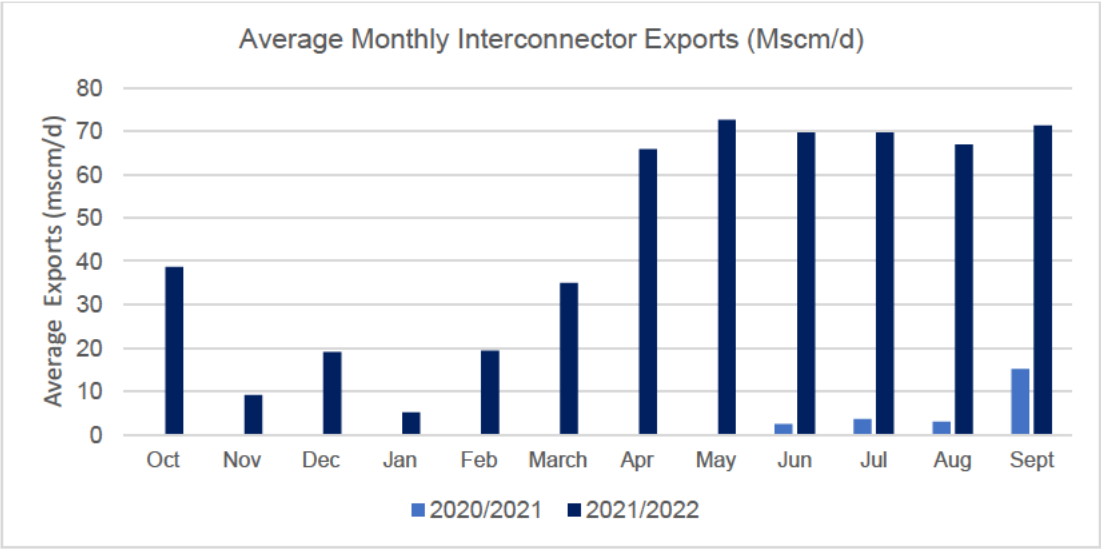


Figure 26 Average Monthly Interconnector Exports 2022/23 vs 2021/22

[4] https://gasdashboard.entsog.eu/#map-storage

5.23. Even in a scenario where UK demand for gas materially decreases, the UK NTS will be a crucial conduit for UKCS gas, Norwegian gas and global LNG to be exported to continental Europe. This is particularly the case while LNG regasification capacity in Europe remains limited.

5.24. Figure 27 shows Zeebrugge Trading Point (ZTP), Title Transfer Facility (TTF) and National Balancing Point (NBP) prices across the contract periods Summer 2023 to Winter 2024-25 seasons based on the price paid on 31st October 2022.

5.25. ZTP is the Zeebrugge trading point reflecting the European market for Interconnector Ltd flows, whilst TTF is the trading point for BBL flows on the European side. Price differentials between these trading points and the NBP trading point, the UK Market, can provide indications of the behaviour of interconnectors between the UK and Europe.

Figure 27 Gas Price Forecast

5.26. The continued differentials between UK and European gas prices, with NBP discounted to ZTP and TTF, suggests ongoing exports from UK to the continent. With this continuing across a range of forward curve contracts out towards Winter 2024-25 this behaviour is likely to continue out into the medium term. This is the best indication we have that our customers and shippers will continue to operate in line with current conditions.

5.27. The price differentials shown in Figure 27 appear to converge which is fundamentally due to shippers being uncertain of long-term demand four seasons ahead.

5.28. The supply and demand pattern over previous seasons in Figure 28 shows the bi-directional interconnectors generally operate in export (i.e., gas exits the UK NTS to Europe) configuration throughout summer seasons to enable European nations to replenish storage facilities. Conversely, the interconnectors facilitate imports (i.e., Entry into the UK NTS) during winter seasons to meet peak demand.

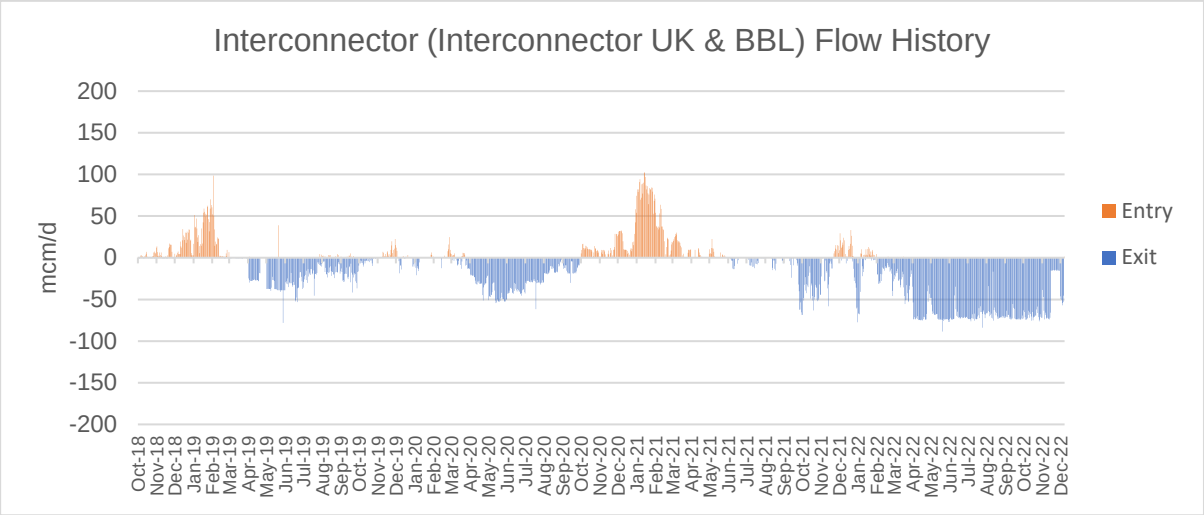


Figure 28 Bacton Import and Export Flows

5.29. The UK is fortunate to have direct access to UKCS, but limited storage capacity necessitates a reliance on gas importation to meet high demand scenarios. For example, Figure 29 shows over 60% of the natural gas supply was imported in 2021 with net continental flows making up a total of 2% of the natural gas supply.

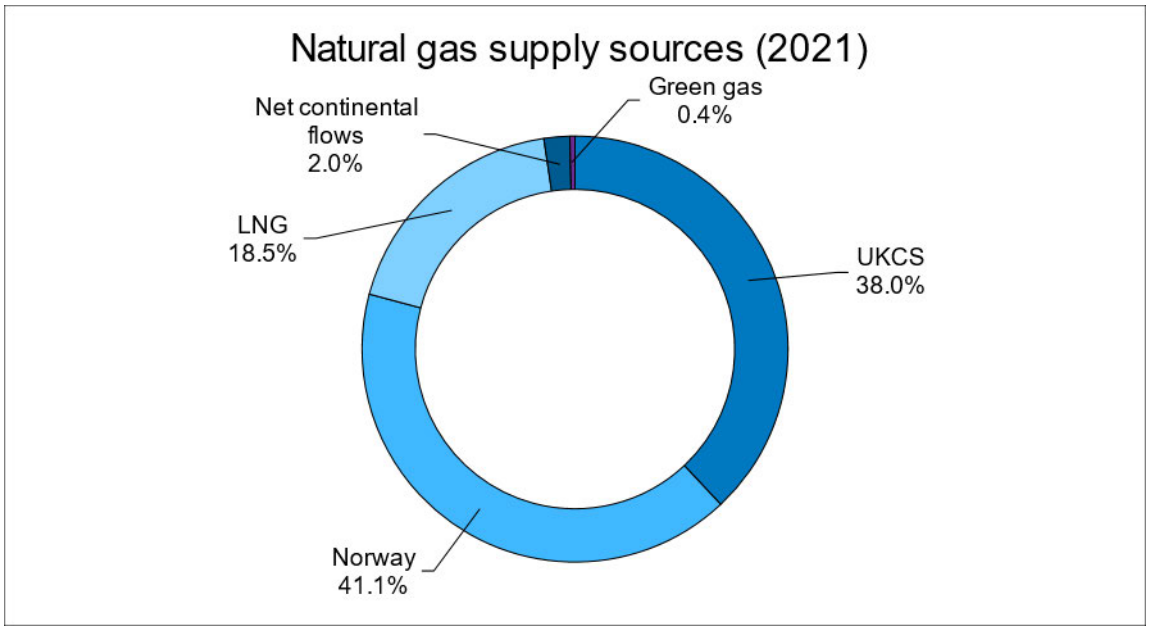


Figure 29 2021 National Gas Supply Sources:[5]

5.30. Although this may represent a proportionally small percentage compared to Norwegian, UKCS and LNG supplies, it is a highly important and strategically significant supply source.

[5] Source: FES 2022: Figure ES.N.01: Natural gas supply and demand sources in 2021 (% of total)

5.31. Figure 30 shows the sources of NTS demand as percentages, with supplies from Europe via the Bacton Interconnectors (IUK and BBL) making up significant proportions of the total gas demand during winter seasons.

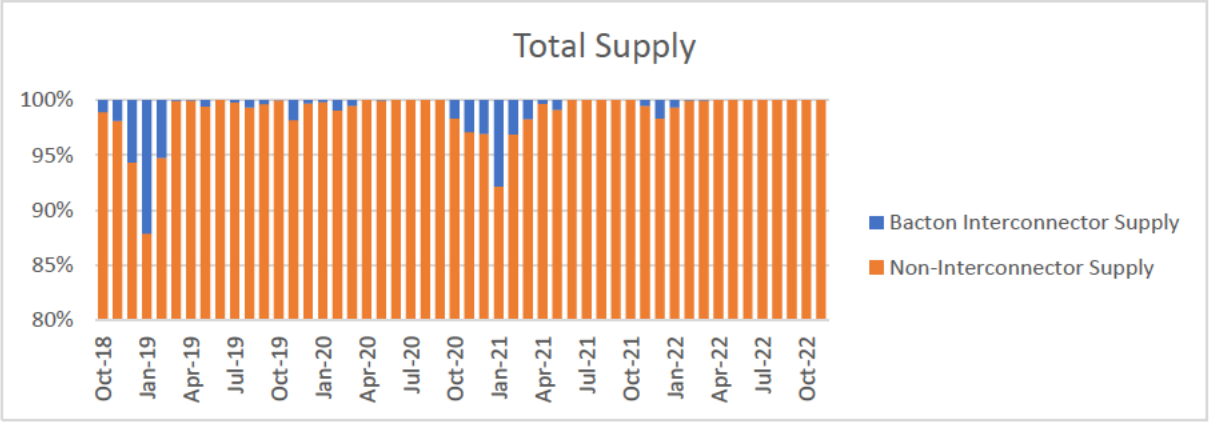


Figure 30 UK Natural Gas Supplies

5.32. Whilst interconnector operators can reconfigure for a change of flow direction in less than 24 hours, interruptions such as the Interconnector Ltd outages shown in Figure 3 prevent gas from flowing in either direction for prolonged periods.

5.33. This demonstrates that without suitable mitigation, there is a risk that continued solid debris (dust) ingress could impact UK supplies, especially considering continued recent exports during Winter 22/23 as shown in Figure 3.

5.34. Close cooperation between all parties at Bacton Terminal including NGT, interconnector operators and beach gas customers enables outages to be carefully planned. In addition to safety, operational and commercial agreements, this ensures outages are kept to a minimum to ensure demand is not interrupted more than necessary.

5.35. As the interconnectors facilitate flows in both directions, filtration would provide mitigation against solid debris entering UK NTS from Europe. Increased supply resilience could also be achieved due to having the ability to filter any non-GSM(R)-compliant gas excursions if interconnectors could not provide filtration on gas entering NTS.

Summary

5.36. Significant quantities of solid debris, comprising of NORM and Pyrophoric dust have been collected through the site's filtration systems through double filtering a proportion of gas utilising a spare incomer and the ring main. However, due to the capacity of the ring main [redacted], full volumes of gas exported via Interconnector Ltd and BBL cannot be filtered, resulting in continued potential risk exposure to our downstream customers.

5.37. Based on the European supply landscape and market data, the requirement for continued exports from the UK to Europe is indicated to continue in the short to medium term,

necessitating high utilisation of Bacton Terminal and high feeder flows, with velocities within expected parameters. Our investment seeks to prevent interruptions to this supply through mitigating the build-up of materials in UK-Europe gas exports through our customers (Interconnector Ltd & BBL).

5.38. Significant operational risks are experienced by GT Operations through filter maintenance due the type of materials (NORM and Pyrophoric Dust). This exposure has been in excess of usual maintenance frequencies due to the amount of material collected, therefore increasing the risk to personnel on site.

5.39. The latest Future Energy Scenarios 2022 did not include the impact of the geopolitical Russia Ukraine conflict repercussions, and therefore we have utilised data from the more recent Gas Winter Outlook Report, which suggests continued exports across this Winter 2023 season.

5.40. The continued NBP discount to ZTP and TTF trading hubs over the medium term (out to Winter 2024-25) suggests ongoing exports from UK to the continent subsequent to this winter, suggesting continued operation of the Terminal in its current mode of operation over this period. Sustained periods of high flows due to price dynamics may result in similar impacts to those seen across calendar year 2022. Operational mitigations are unsustainable, and an alternative approach to manage the risk is required.

5.41. Our project seeks to enhance the level of filtration at the site, to mitigate outages experienced by our downstream customers, whilst providing an efficient approach to double filtration using dedicated filters. It shall ensure 100% of gas entering the Terminal is filtered rather than c50% of it. It also reduces the operational risk in being able to utilise spare incomers to manage upstream process events, upstream maintenance and provides effective whole system operation with our upstream customers. Both UK and European consumers benefit from an efficient interconnected transmission system free from interruptions and constraints.

5.42. Our project shall also seek to reduce the health & safety risks to Terminal operational staff, who are exposed to NORM and Pyrophoric Dust through filter maintenance which has been conducted up to only 8 weeks apart. Dedicated filters will allow better control and management of all the issues listed in this section as the solution provides more flexibility that the temporary operational management procedures being deployed as a mitigation.

Project Scope Summary

5.43. Our preferred option for filter enhancements at Bacton Terminal comprises a wide range of connected investment activities at the site, these include:

- Strengthening existing incomer filtration through installing additional filter vessels into Perenco A1 incomer;

- Procurement of additional filter basket spares to assist with filter maintenance activities;
- Install solid debris filtration onto Feeders 2 and 4 to filter 100% of gas into the site from the NTS through these feeders upon net Bacton exports.

5.44. Table 5below provides a summary of the project scope

Final Preferred Option	1. Installation of additional filtration onto Feeder 2 & Feeder 4, Separate Filtration 2. Strengthen existing incomer filtration through installing additional filter vessels into Perenco A1 incomer bank	
Location	Brownfield within Terminal Boundary	
Unit Investment Details	Incomer Filtration	Feeder Filtration
Investment Action	Install 2x new and 1x reconditioned filter vessels	New Build Filtration, common across Feeder 2 & Feeder 4
Month & Year of Commission	[redacted]	[redacted]
Scope Boundaries	The scope of this project is for costs associated with the enhancement of filtration at Bacton Terminal site to mitigate disruption to our downstream customers and ensure European Security of Supply. These are costs associated with the enhancement to existing incomer filtration and the installation of additional filtration on Feeders connecting the National Transmission System (NTS) to the Terminal.	
Availability Required	Filtration of gas whilst ensuring [redacted] when Feeder 27 is on suction of King's Lynn Comp) without breeching the 20m/s velocity limit for unfiltered gas. Filtration ensures 45barg contractual minimum end of day pressure, 75barg maximum operating pressure are maintained.	

Table 5 Bacton Filters Project Scope Summary

6. Options Selection

Options Considered

Introduction

6.1. This section focuses on the engineering options and commercial rules and tools available to solve the problem identified in Section 4 and uses the project scope information in Section 5 to identify plausible options. This section of the report shall explain the process undertaken to identify options, the assessment of options through to the development of options within our short-listed options.

6.2. Figure 31 below serves to identify the various stages involved in a typical option selection process.

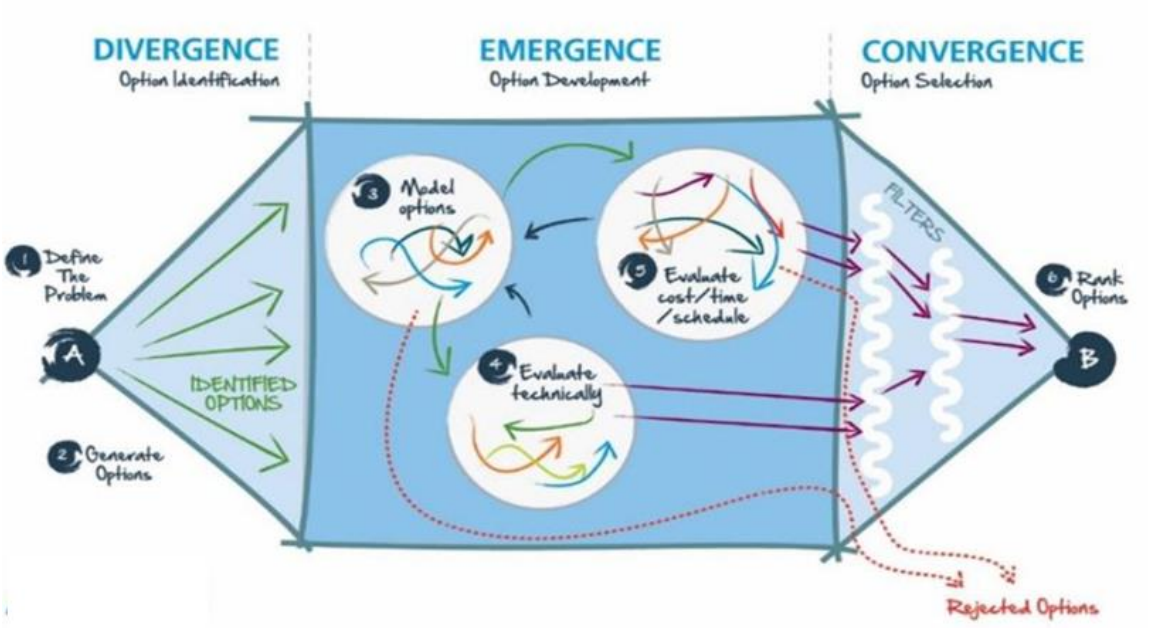


Figure 31 Generic Options Selection Process

6.3. This section of the paper has been split into two parts, Part 1 covers the options that were considered to enhance the incomer filtration systems, where existing solid debris filtration vessels are installed. Part 2 covers options that were considered to install mitigate the risk for material ingress into the Terminal from the NTS and from the Terminal into the NTS (Feeder Filtration).

6.4. Robust and regular engagement is essential to bring internal and external stakeholders along on the investment journey. We have prioritised touchpoints with Ofgem to update them on our investment progress, outlining the next steps and to seek their feedback on any gaps or technical challenges we have discovered.

6.5. We have also engaged with other stakeholders such as our connected customers at the Terminal to inform them of the progression of our mitigations and seek to understand their challenges, and engagement with BEIS around the potential impact on Security of Supply.

6.6. The following is a series of engagements which have influenced the Options Selection process for Bacton filters:

- Interconnector Ltd Workshop and bilateral engagement
- BBL bilateral engagement
- Ofgem bilateral Engagement

Part 1 – Incomer Filtration

6.7. In early 2022, NGT assessed a range of options to enhance the existing incomer filtration capability. As referenced in Project Definition, there are four vacant filtration positions, three on Perenco A1 and one on Shell S1 incomers.

6.8. Having experienced a range of upstream liquids incidents and utilising double filtering operational mitigations there are opportunities to strengthen the existing filters. This could not only provide operational resilience but extend the amount of time between filter maintenance activities.

6.9. Through assessment of the materials already on site a class 600 horizontal vessel was identified from the ENI incomer filtration systems, disconnected in 2018. Rather than procure a new vessel it was identified that reconditioning this existing vessel had several benefits, including, a lower cost to operation and the faster lead time to commission.

6.10. For further spaces on the Perenco A1 incomer, two new 16" class 600 horizontal vessel have been procured using baseline funding. Table 6 shows the locations where these vessels are proposed to be installed.

Perenco A1		Perenco A2		Shell S1		Shell S2 (Spare)		Shell S3 (Shell)		Shell S4 (SEAL)	
A	16" class 600 horizontal vessels	A	16" class 600 horizontal vessels	A	16" class 600 horizontal vessels	A	16" class 600 horizontal vessels	A	16" class 600 horizontal vessels	A	18" class 600 horizontal vessels
B	16" class 600 horizontal vessels	B	16" class 600 horizontal vessels	B	16" class 600 horizontal vessels	B	16" class 600 horizontal vessels	B	16" class 600 horizontal vessels	B	18" class 600 horizontal vessels
C	16" class 600 horizontal vessels	C	16" class 600 horizontal vessels	C	Vacant	C	16" class 600 horizontal vessels	C	16" class 600 horizontal vessels	C	18" class 600 horizontal vessels
D	16" class 600 horizontal vessels	D	16" class 600 horizontal vessels								
E	Reconditioned 16" class 600 horizontal vessels	E	16" class 600 horizontal vessels								

Table 6 Location for installation of new vessels

6.11. Due to the known operating performance and parameters of Class 600 Horizontal vessels and the availability of one within the existing site, it was deemed that fitting further vessels provided the best balance between risk mitigation, cost and timeframe to commission the plant.

6.12. Line Vu cameras have been installed on A2 and S3 incomers to monitor the gas stream to aid with solid and liquid material identification from upstream suppliers. This increases our ability to monitor and manage upstream process gas quality variances.

6.13. The table below, Table 7 presents the costs incurred for the procurement, installation and commissioning of the reconditioned vessel, the procurement of filter basket spares and Line Vu modifications.

6.14. Procurement of additional filter baskets shall enable these spares to be installed when soiled baskets need cleaning, ensuring that we continue to operate with 100% incomer filtration at the site.

Cost Element	2022/23	2023/24	2024/25	2025/26	Total Cost
Insta ation of Line Vu cameras, rep acement of A1/E fi ter vesse and insta ation of a re va idated vesse into A1 incomer fi ters.	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
New Fi ter Baskets	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 7 Incomer Filtration Cost

Part 2 – Feeder Filtration

Initial Option Selection

6.15. In August 2022, NGT assessed a full range of options including operational mitigations, commercial options and a range of asset options around enhancing filtration of gas entering the Terminal from the wider NTS and gas that is discharged from the Terminal into the wider NTS.

6.16. Prior to this, no dedicated filtering was located at the site to filter gas entering the Terminal via this route. Further to this assessment, NGT engaged with [redacted] to undertake an Engineering Feasibility Study to refine the identified options.

6.17. Options identified at this stage looked to mitigate the downstream disruptions whilst maintaining Security of Supply to Europe, though continued European exports. No option was discounted at this time and initially all five feeders (Feeders 2, 3, 4, 5 & 27) were within the scope of this assessment.

Section 6.18 is additional information provided as part of the Jan 23' submission SQ process.

6.18. The ongoing quantity / levels of dust and solid material entering the terminal are difficult to truly quantify. Gas flows and pressures are the fundamental basis of design. To avoid flow restrictions within the Terminal and at exit points, the filter banks, associated pipework and valves within our basis of design had to be sized to accommodate the technical maximum flows across each feeder, which are 35 mcm/d (2x35=70) and to ensure both 45barg contractual minimum end of day pressure and 75barg maximum operating pressure are maintained.

6.19. Table 8 below shows the full list of options that were identified from the initial options identification process, along with a description of the option. Options can be split into Asset Options, Commercial Options and Operational Options.

	Asset	
Investment Solution		*Investment Detail*
1	Magnetic Fi ters	Insta ation of Magnetic Fi tration System with Se f C eaning Capabi ity. Magnetic fi tration wou d co ect ferrous meta ic e ements that have been found to make up significant vo umes of the materia co ected based on aboratory ana ysis.
2	Fi tration on Ring Main	Insta fi tration on the ring main to enab e NGT to fi ter gas from any route (I.e., incomer or feeder connection).
3	Fi ters on Feeder connections	Insta ation of Fi tration onto the Feeders where they enter the Termina from the wider NTS.
4	Fi ters ocated outside the site on Termina Extension	This option is simi ar to the option above in that fi tration is insta ed onto the Feeders, however fi tration is insta ed outside of the Termina boundary due to proximity distances with other assets at the Termina .
5	Fi ters insta ed at B ock Va ves on Feeder 2, 4, e.g., Suffie d B ock Va ve or Erpingham B ock Va ve	Insta ation of Fi tration to each feeder through insta ation of fi tration systems to sites ocated on those feeders, e.g., b ock va ve sites. Assets wou d be insta ed to fi ter the gas f owing through these b ock va ve sites without impacting on the abi ity for the site to iso ate the feeder (their primary purpose). Sites such as Suffie d B ock Va ve on Feeder 4 and Erpingham B ock Va ve on Feeder 2 cou d be uti ised.
6	Fi ters insta ed at King's Lynn	Insta ation of additiona Fi tration systems within King's Lynn Compressor & Mu tijunction Site to fi ter the f ow of gas through the station before discharging it to Feeder 2, 4 & 27.
7	Fi tration Types	Fi tration for So ids insta ed to manage the risk of so ids from entering and eaving the Termina site through the feeders.
8		Fi tration for Liquids insta ed to manage the risk of iquids from entering and eaving the Termina site through the feeders.
	Commercia	
	Investment Solution	*Investment Detail*
9	Limit Interconnector export f ows to Ob igated Leve s	Stop re easing the additiona non-Ob igated capacity at the Bacton IP Exit point, and manage any Termina ingress through operationa mitigations.
10	PARCA	PARCA is raised to forma y increase the base ine capacity offered at Bacton IP Exit Point. Associated network and asset imp ications sha be considered based on the request. The PARCA wou d be inked to

		a modification of the existing NTS connections if additiona capacity was required. This wou d need to be driven by the customer
	Operationa	
	Investment Solution	*Investment Detail*
11	Doub e Fi ter using Ring Main & Incomer Fi ter Banks	Continue to undertake doub e fi tering of Feeder 2 & Feeder 4 gas through the Termina . Fi tration of up to [redacted] of export vo ume from the NTS.
12	Doub e Fi ter using King's Lynn	Route gas back to Kings Lynn to go through the compressor scrubbers, or insta additiona fi tration.
13	Conduct more frequent C eaning ILI runs	Feeder 4 ast c eaned November 2022. Recent c eaning run removed [redacted]. More frequent c eaning may reduce dust and iquid entering Bacton Termina .

Table 8 Long List Options

6.20. We considered a range of asset driven options as part of NGT's full suite of measures to manage the dust from entering the Terminal from the NTS [Options 1-8]. Options were identified to install filtration on various asset systems around the site, e.g., Feeders & Ring Main.

6.21. Commercially driven options were also considered [Options 9-10] considering both the reduction of offered capacity down to baseline levels at the exit point and increasing the baseline capacity via the PARCA.

6.22. A reduction of offered capacity down to baseline levels would result in a reduction in the capacity available at Bacton IP exit point, which would reduce the flows from the UK to Europe. This would go against the discussions with BEIS for NGT to support the needs of the United Kingdom and European Gas Markets by maximising the availability of exports to Europe from Bacton Terminal. There is also no evidence that undertaking this action would resolve the issue.

6.23. Option 10 above is the formal route to increase obligated capacity levels. A PARCA (Planning & Advanced Reservation of Capacity Agreement) would need to be submitted by the party/parties requesting the additional capacity at the Bacton IP exit point, which would enable NGT to determine how and when the capacity requested can be delivered and what asset impacts this has. This would be a long, complex process (up to 24 months) given that two parties (BBL & Interconnector Ltd) can utilise capacity at the Bacton IP exit point capacity location and this option would only solve the problem in the short to medium term.

Sections 6.24 and 6.25 below are additional information provided as part of the Jan 23' submission SQ process.

6.24. BBL and Interconnector have not requested a PARCA for firm capacity to be increased on a permanent basis and PARCA funding is only designed to make additional capacity available, not to fund other non-capacity related works on the system. A PARCA doesn't seem to be a suitable mechanism to fund filtration unless it could be clearly demonstrated that this were

the cause of a physical capability constraint. We would not ordinarily expect to see filtration proposed (or approved by Ofgem) as part of a PARCA solution.

6.25. For the average daily non-obligated capacity released across 2022 [redacted] ([redacted] this would give an estimated project cost of [redacted]. Of this [redacted], Interconnector and BBL would be required to make long term incremental capacity bookings to the value [redacted] ([redacted] of the estimated cost), in line with the Exit Capacity Release methodology. The remaining investment cost (which may be higher if the real project cost/allowed revenue is greater than [redacted]) would be recovered from industry/consumers through our NTS Transportation charges.

Asset Options

6.26. Asset Options were assessed against a range of metrics across four categories: Performance, Cost, Construction and Operations. as detailed in Table 9.

Option Selection Categories	Option Selection Criteria	Option Selection Criteria RAYG Description
Performance	Filtration Duty	Assesses the option's abi ity to fi ter 100% of export f ows from Feeders 2 & 4. • 100% of gas from feeders is fi tered is assessed as Green • Up to 100% is assessed as Ye ow • Between 25% and 50% of export f ows fi tered is assessed as Amber • 0-25% fi tered is assessed as Red
	GSM(R) Compliance	Assesses whether the option he ps maintain GS(M)R comp iance at the site, based on the abi ity to fi ter as much of the f ow a ong Feeders 2 & 4 as possib e. Insta ation of Fi ters on the Ring Main and Metering are ranked as Amber due to the abi ity to on y fi ter a proportion of the f ow a ong Feeders 2 & 4 with fi ters insta ed at these ocations.
	Entry Flow Capability Feeder – 2 & 4 - [redacted] Basis of Design (RAG)	Assesses the abi ity for the option to accommodate [redacted] per feeder which is the capacity basis of design specified to be achieved through our needs case assessment (Theoretica maximum). Through options se ection process we have considered options that can on y accommodate [redacted] based on this being the maximum vo ume experienced by the site based on site operating configurations.
Cost	Capex Cost £m	Capex Cost RAG status. Highest Cost options given a red RAG status.
Construction	Brownfield / Greenfield	Options that can be undertaken without a site extension can be undertaken as a brownfie d option, undertaken under permitted deve opment and not require p anning permission, therefore can be comp eted quicker. Green Brownfie d Amber Brownfie d with technica deviation Red - Greenfie d Brownfie d options within the Bacton Termina require a technica deviation to G/37 due to separation distances stipu ated within this po icy
	Planning Permission	Assesses whether p anning permission is required for the option, or whether it can be comp eted through permitted deve opment, this impacts on the duration of the construction programme. • Amber P anning Permission required • Green: Permitted Deve opment
	Development & Build Duration (Timeframe)	Assesses the timeframe for the so ution to be de ivered up unto the assumed commissioning dates. Longest timeframes are given a red ranking.
	Constructability	Assesses the cha enges in constructing the proposed option, such as outage avai abi ity/comp exity, space restrictions and construction methodo ogy imitation. Any option that wou d impact on Termina operations has been given a Red ranking.
	Disruption to Site & Feeder Operation (Outages)	Assesses the disruption to site and feeder operation that is experienced de ivering the option. This is not the maintenance impact but the initia impact de ivering the so ution. • Red: impacts Termina Ring Main operation • Amber: Impacts operation of mu tip e feeders during construction • Green: Impacts operation of a sing e feeder during construction

Option Selection Categories	Option Selection Criteria	Option Selection Criteria RAYG Description
Operations	Expected Frequency of Filter Maintenance	Assesses the frequency of expected fi ter maintenance activities based on the technica option.
	Personnel Health & Safety Risk	Assesses the risk to Gas Transmission Operations staff to faci itate fi ter maintenance. A Options have a simi ar impact apart from magnetic fi tration options, due to the materia co ection vesse in this option reducing the maintenance burden for operationa staff. This a so reduced exposure to pressurised systems.

Table 9 Asset Options Selection Criteria

6.27. Through a qualitative assessment workshop, with a range of internal and external stakeholders, an assessment of the asset options was completed utilising a Red, Amber, Green (RAG) criteria. This was completed utilising quantitative data where the metric enabled this, otherwise a qualitative assessment was completed using engineering judgement. A workshop was undertaken with Interconnector Ltd in June 2022 to discuss the interruptions experienced across 2022 and options available to address this.

6.28. The range of metrics were selected to assess both the construction of the solution, the impact this had to ongoing Terminal operations and the performance of the options identified. This performance was assessed based on the amount of gas that could be filtered by the options based on feeder capabilities and historic levels of operation operating in export mode.

6.29. The table below, Table 10 summarises the assessment of the Asset options against the selection criteria.

			Performance			Cost	Construction					Operations		
	Option	Detail	Filtration Duty	GSM(R) Compliance	Entry Flow Capability Feeder 2 & 4	Capex Cost £m	Brownfield / Greenfield	Planning Permission	Development & Build Duration (Timeframe)	Constructability	Disruption to Site & Feeder Operation (Outages)	Expected Frequency of Filter Maintenance	Personnel Health & Safety Risk	Shortlist
1	Magnetic Filters	nstall innovative Magnetic Filters with self-cleaning.	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
2	Filtration on Ring Main	To filter gas from any route (i.e. ncomer or Feeder connection).	~25-50% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
3	Filters on Feeder connections (Above)	Filters on Feeders 2, 3, 4, 5 & 27.	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
4		Filtration on Feeders 2, 4 & 27	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						Y
5		Separate Filtration on Feeders 2 & 4 (2x 3 6 Filters)	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						Y
6		Common Filtration on Feeders 2 & 4 (5 Filters)	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						Y
7		Separate Filtration on Feeders 2 & 4 (2 Filters)	>100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						Y
8		Common Filtration on Feeders 2 & 4 (3 filters)	>100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						Y
9	Filters on Feeder connections (Below)	Filters on Feeders 2, 3, 4, 5 & 27.	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
10		Filtration on Feeders 2, 4 & 27	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
11		Separate Filtration on Feeders 2 & 4 (2x 3 6 Filters)	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
12		Common Filtration on Feeders 2 & 4 (5 Filters)	100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
14		Separate Filtration on Feeders 2 & 4 (3 Filters)	>100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
15		Common Filtration on Feeders 2 & 4 (3 filters)	>100% NTS Export Gas Filtered				Brownfield - Requires G/37 Technical Deviation	Permitted Development						N
16	Filters located outside the site on Terminal Extension		100% NTS Export Gas Filtered				Greenfield - Planning permission needed (2 years)	Planning Permission						N
17	Filters installed at Block Valves on Feeder 2, 4, e.g. Suffield BV or Erpingham BV		~25-50% NTS Export Gas Filtered				Greenfield - Planning permission needed (2 years							N
18	Filters installed at Kings ynn		100% NTS Export Gas Filtered				Brownfield							N

Table 10 Asset Option Selection results

6.30. The complete list of all solutions is shown in Table 11. This table includes the output of the qualitative and quantitative assessments completed on the asset options as well as qualitative assessments completed on the commercial and operational options.

6.31. The table provides detail on the solutions which have been discounted from further investigations and the solutions that have been shortlisted. Further detail on each investment option is provided including the rationale for progression, or not, of the options to the short list.

Asset			
Investment Solution	*Investment Detail*	*Progression to Shortlist*	*Rationale*
Magnetic Fi ters	Insta ation of Magnetic Fi tration System with Se f C eaning Capabi ity. Magnetic fi tration wou d co ect ferrous meta ic e ements that have been found to make up significant vo umes of the materia co ected based on aboratory ana ysis.	û	Techno ogy unproven (i.e. not designed to fi ter hazardous materia s). Need design deve opment phase to deve op catch pot for NORM and hazardous materia s extending programme of the project, and to test the options range of operation. Not comp iant with G/37 separation distances. Option is [redacted] of norma Ce eros vesse techno ogy, proposed to be uti ised in other options.
Fi tration on Ring Main	Insta vesse fi tration system on the ring main to enab e NGT to fi ter gas from any route (I.e., incomer or feeder connection)	û	This option wou d on y enab e up to [redacted] to be fi tered, which is the technica capacity of the ring main. With exports seen across 2022 reaching ~60mcm/d on y 1/3 of gas vo umes wou d be fi tered which does not mitigate the risk to downstream exports.
Fi ters on Feeder connections	Insta vesse fi tration system onto the Feeders where they enter the Termina from the wider NTS. Various options have been considered inc uding fi tration insta ed on: Feeders 2, 3, 4, 5 & 27	û	Insta ation of fi tration on the feeders within the site boundaries wou d enab e fi tration of gas into the Termina or eaving the Termina via the feeders. 100% of gas f owing through the feeders can be fi tered uti ising this option. Options discounted as genera y feeders 3 & 5 are uti ised to manage South East pressures uti ising UKCS gas rather than uti ised to support Interconnector Import/Export
	Insta vesse fi tration system onto the Feeders where they enter the Termina from the wider NTS. Feeders 2, 4 & 27	ü	Insta ation of fi tration on the feeders within the site boundaries wou d enab e fi tration of gas into the Termina or eaving the Termina via the feeders. 100% of gas f owing through the feeders can be fi tered uti ising this option. Feeders 2, 4 & 27 are uti ised to Bu k transmission for interconnector Import/Export.
Fi ters ocated outside the site on Termina Extension	Insta vesse fi tration system onto the Feeders but outside of the existing Termina boundary.	û	Option wou d require P anning Permission, which cou d have a ead time of ~2 years. P anning permission not guaranteed if sufficient space is avai ab e within the Termina boundary. Given we be ieve this is the case, option discounted.
Fi ters insta ed at B ock Va ves on Feeder 2, 4, e.g., Suffie d B ock Va ve or Erpingham B ock Va ve	Insta ation on Fi tration to each feeder through insta ation of fi tration systems to sites ocated on those feeders. E.g., Suffie d B ock Va ve on Feeder 4 and Erpingham B ock Va ve on Feeder 2	û	Majority of pipework are ocated be ow ground on b ock va ve sites; therefore option wou d resu t in significant modifications being required to be made to the site. This cou d require site extensions resu ting in engthy negotiations with p anners and andowners. Any source of materia ocated downstream of these sites wou d resu t in materia entry into the Termina .
Fi ters insta ed at King's Lynn	Insta ation of Additiona Fi tration systems within King's Lynn Compressor & Mu tijunction Site.	û	Insta ation of Fi ters at King's Lynn wou d mitigate any materia pick up upstream of King's Lynn but not downstream of it. Comp ex fi tration arrangement wou d be required due to the mu tip e positions of

			Feeder 2, 4 & 27 on the site and the ocation of p ant within the King's Lynn Compressor site.
Fi tration Types	Fi tration for So ids	ü	So ids & Dust particu ates have been identified entering the Termina and therefore fi tration to manage has been taken forward to the short ist.
	Fi tration for Liquids	û	No iquids have been identified to be entering the Termina from the NTS, therefore Fi tration for iquids has been discounted.
Commercial			
Investment Solution	***Investment Detail***	***Progression to Shortlist***	***Rationale***
Limit Interconnector export f ows to Ob igated Leve s	Stop re easing the additiona Non-Ob igated capacity at the Bacton IP Exit point and manage any Termina ingress through operationa mitigations.	û	Whi st we cou d reduce the amount of non-ob igated capacity re eased back down to zero, there is no guarantee that doing this wou d reduce the amount of materia co ected at the Termina . If materia continues to be co ected there is no significant change in risk mitigation to manage this position.
Increase base ine capacity via PARCA process	PARCA is raised to forma y increase the base ine capacity offered at Bacton IP Exit Point. Associated network and asset imp ications sha be considered based on the request.	û	Combined IP Exit point wou d require both BBL and Interconnector Ltd to agree to this.
Operational			
Investment Solution	***Investment Detail***	***Progression to Shortlist***	***Rationale***
Doub e Fi ter using Ring Main & Incomer Fi ter Banks	Continue to undertake doub e fi tering of Feeder 2 & Feeder 4 gas through the Termina . Fi tration of up to [redacted] of export vo ume from the NTS	ü	Current y operating in this configuration 24/7 since May 2022. Has reduced outages but is unsustainab e ong term and increases overa risk at the Termina due to the fact it negates the abi ity of the Termina to manage upstream process upsets, continues to cause operationa burden and heightened H,S & E issues.
Doub e Fi ter using King's Lynn	Route Gas uti ising Feeder 2, 4 or 27 back to King's Lynn to go through the compressor scrubbers or insta additiona fi tration to then route this back to Bacton Termina .	û	Wou d increase operationa burden on this part of the network, at Bacton and at King's Lynn. Routing the gas through this arrangement wou d have an impact on exit pressures at Bacton Termina .
Conduct more frequent C eaning ILI runs	Feeder 4 ast c eaned November 2022. Recent c eaning run removed [redacted]. More frequent c eaning may reduce dust and iquid entering Bacton Termina .	û	A though it wou d he p reduce the presence of dust, there is significant operationa burden to comp ete the ILI runs. ILI runs require significant p anning to manage pressures for our exit customer, manage resource and manage third party contractors who undertake ILI runs.

Table 11 Options Summary

Option Shortlist

6.32. Following on from the options selection analysis for the full list of investment solutions, a shortened options list was defined. Options centred around the filtration of gas from Feeders 2, 4 & 27.

6.33. These options were further developed, costed and benefits and limitations of each option identified. The shortlisted options are shown below:

- Option 1 - Separate Filtration on Feeders 2 & 4 (2 x 3 = 6 Filters)
- Option 2 - Common Filtration on Feeders 2 & 4 (5 Filters)
- Option 3 - Separate Filtration on Feeders 2 & 4 (2 x 2=4 Filters)

- Option 4 - Common Filtration on Feeders 2 & 4 (3 filters)
- Option 5 – Separate Filtration on Feeders 2, 4 & 27 (3 x 3 = 9 Filters)
- Option 6 (Counterfactual) – Double Filtration Operation

6.34. In order to evaluate the impact for no further capital investment at Bacton, NGT have included the "counterfactual" or "do minimum" investment option, this being Option 6, continuation of Double Filtration Operations.

Option Descriptions

6.35. Option 1 installs separate Filtration on each of Feeders 2 & 4 (2x 3 = 6 Filters). Separate filtration can be separately managed and isolated. Filtration is sized for the technical Feeder 2 & 4 maximum flow of [redacted].

6.36. Option 2 considers combining the two filtration banks in Option 1 into a common filtration bank with five filters. Filters and associated pipework are sized to accommodate [redacted] per feeder, which is the technical maximum for Feeder 2 & 4.

6.37. Option 3 considers the installation of separate filtration systems on Feeders 2 & 4 but with two filters per feeder rather than three, (2 x 2 = 4 filters in total), based on accommodating [redacted] which is the maximum flow we have seen historically on each of these feeders.

6.38. Option 4 considers combining the two filtration banks in Option 3 into a common filtration bank with three filters. Filters and associated pipework are sized to accommodate [redacted] per feeder, the maximum flow we have seen historically.

6.39. Option 5 considers the installation of Separate Filtration onto all Feeders (Feeder 2, 4 & 27) utilised for exports from the Terminal. Separate filtration can be separately managed and isolated. Filtration is sized for the technical Feeder 2 & 4 maximum flow of [redacted], and Feeder 27 of [redacted].

6.40. Option 6 is our counterfactual option and considers continuing double filtering regimes at the Terminal to filter a proportion of the export gas volume utilising spare incomers alternated in line with operational requirements.

Option Summary Tables

6.41. Summary tables of the main options considered, as well as their costs and benefits & limitations can be found within Options Considered.

Main Options Breakdown

6.42. This section of the report provides further details of each of the options that have progressed to the shortlist. Each option has a short description, summary cost breakdown, with narrative on the delivery timescale, operational impacts and descriptions of the benefits and limitations.

6.43.

Option 1 – Separate Filtration on Feeders 2 & 4 (2x 3 = 6 Filters)

Option Description

6.44. This option installs three filters onto each of Feeder 2 and Feeder 4. To fit the new filtration equipment in the required location and available space, each Feeder would be excavated and cut below ground. New pipework would be connected at this cut location bringing the Feeders above ground. Each new section of Feeder pipework would then be connected to a bank of three new filters, together with the minimum number of new valves necessary for safe isolations to facilitate filter cleaning and maintenance. The outlet of each filter bank would then be connected back into the respective downstream Feeder.

6.45. Each individual filter has been sized for [redacted] gas flow. Two filters would be in service in each bank, providing [redacted] gas filtration against the technical maximum gas flow through each feeder of [redacted]. The third filter provides redundancy. As the filters in service blind with solid debris, one filter on each bank would be isolated for cleaning and the third stand-by filter brought into service to maintain full filtration capacity. The [redacted] filter sizing is a product of design calculations for the filters and associated piping to meet the technical maximum gas flows and not exceed maximum permissible gas velocities (the filters have not been oversized).

6.46. Figure 32 presents a 3D image of the proposed arrangement for Feeder 4, which is also typical for Feeder 2.

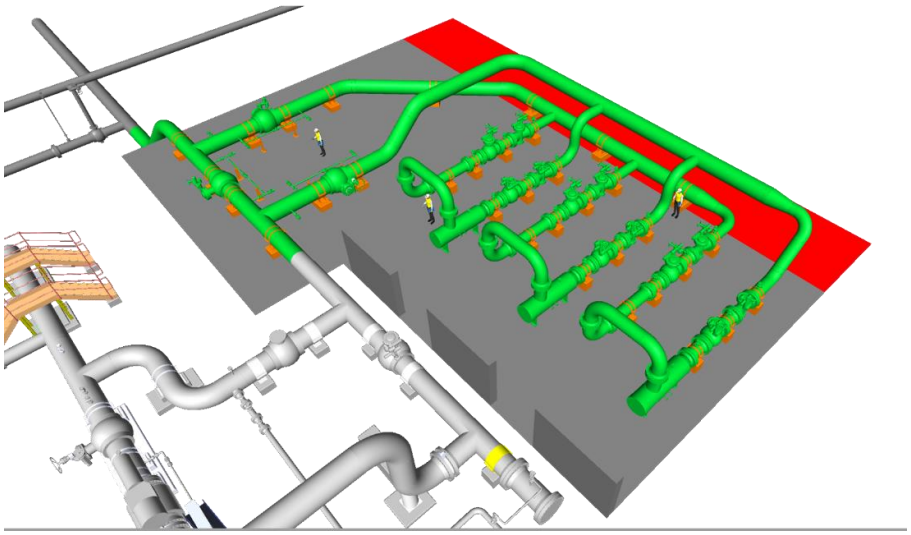


Figure 32 Bacton Feeder No 4 Option 2 3D Image

Cost Breakdown (2018/19 Pricing)

6.47. The cost breakdown of the option, Option 1, is given in Table 12, below.

Separate Filtration on Feeders 2 and 4 (2 x 3 = 6 Filters)		
Work Element / Deliverable	**Cost £m**	**Source of Cost Presented**
EPC Estimate	[redacted]	Supplier Quotation – Direct Allocation
EPC PM	[redacted]	Supplier Quotation - Direct Allocation
NGT Direct Company Costs	[redacted]	Internal Estimate of Staff Costs
NGT Indirect Company Costs	[redacted]	Internal Estimate of Staff Costs
NG Project Risk (Direct)	[redacted]	Quantified Risk Register based on supplier quotations and known risks
Total Installed Cost	[redacted]	
Cost Estimate Accuracy	**-5+30%%**	

Table 12 Option 1 Cost Breakdown

Cost Basis

6.48. Given the significant risk to security of supply, our approach was largely shaped to achieve the shortest delivery timescale, whilst cognisant of providing value to the Consumer.

6.49. In collaboration with our FEED Consultant [redacted] General Arrangement and 3D models were produced and assessed through Design Reviews, Formal Process Safety Assessments and against technical performance, cost, programme, and other criteria. Following this, detailed Material Take-offs (MTOs) were produced and Data Sheets for main components of the option including Filters, Valves / Actuators, Pipe and Fittings.

6.50. Regardless of Asset Option the same type of materials require procurement. We anticipated these 'Long Lead items' would likely drive the overall delivery programme. On this basis Suppliers on our Qualified Vendor Database (QVD) were engaged through Competitive tender to obtain confirmed cost and deliveries based on our MTO's and Data Sheets. The technical detail in these documents is considered well advanced for Conceptual stage, providing high confidence in cost and programme estimates.

6.51. To meet 'best achievable timescale' we must be ready to proceed with detailed design immediately upon Regulator support and sanction. [redacted] are uniquely positioned given they have undertaken the FEED stage Conceptual Design Study (CDS), hold all design information and are fully up to speed.

6.52. [redacted] were engaged through CDS to impart valuable expert opinion on Engineering and Constructability of the options. Further input is required from a Main Works Contractor (MWC) at the front end of Detailed Design in the form of Ground Investigations (bore holes and sample excavations) to inform detailed design. [redacted] has confirmed capacity

for these front end works and construction of the main works in line with our programme and free-issued Long Lead Material deliveries. Other potential MWC's were discounted on either capacity or capability to deliver the requirements.

6.53. The Ground Investigations work is well defined; therefore, it is proposed to contract this work with [redacted] on a direct allocation, fixed priced basis. The elements of detailed design are consistent across options, only scale varies. On this basis, [redacted] has provided a Cost, Time, and Resource (CTR) quotation against our scope. It is proposed to let this Contract on a cost reimbursable basis to limit contractor risk allowance and allow the creative design process to proceed unhindered by Contract administration delays.

6.54. Cost estimation for the construction element of the options is based on the normalisation of two methods. Firstly, [redacted] were engaged to provide a budgetary quotation against the Conceptual Design level information and programme. This was combined with quotations from the market for long lead items and NGT costs, to produce the estimates. Independently of this, and to provide assurance, our NGT Cost Estimation Team were provided the same Conceptual Design information from which to estimate the options based on internal unit cost data. These two estimates were comparable and following 'normalising' were used as the basis of cost estimate ranges.

Delivery Timescale

6.55. Based on Regulator support in July 2023, filters on Feeders 2 and 4 would be operational by July and November 2025 respectively. The sequence of Feeder outages may change subject to Operational conditions of the network. Project timescales are dependent on the timeframe for the procurement of long lead items, hence specifying the date of confirmation of Regulator Support.

Operational Actions/Activities

6.56. As this option provides full filtration capacity with 50% redundancy (two filters in service, with one on stand-by), all Feeder 2 and 4 gas could be filtered without interruption to required operations. This would negate the requirement for continued 'Double Filtration' through UKCS related Incomers.

6.57. Maintenance Activities would be required to be undertaken on the filters in line with biennial schedule maintenance and PSSR, with filters being removed for inspection on an approximate 12 yearly interval. The 50% filter redundancy would allow filter removal for inspection without loss of full filtration capability and avoid the necessity to lift filters over live pipework which is always avoided due to risks to integrity should lifting operations fail.

Benefits and Limitations

Benefits

6.58. All Feeders 2 and 4 NTS gas filtered avoiding disruption to downstream Customer flows.

6.59. Above ground build avoids technically challenging and costly below ground works given this area of the Terminal has a high-water table and would require significant temporary works and de-watering to assure safe construction activities. Above ground build also allows some off-site pre-fabrication and build, reducing cost and overall build timescale compared with a largely below ground solution.

6.60. This option is sited within the existing Terminal boundary fence under 'Permitted Development' avoiding the requirement for a greenfield site extension and associated land acquisition, planning permissions, additional cost and timescale. The option is however non-compliant with NGT Standards namely T/SP/G/37 for separation distances between gas assets. This would require a successful deviation subject to the outcome of a quantified risk assessment to be completed early in detailed design. This T/SP/G/37 non-compliance is common for all Options.

6.61. Construction of each Feeder filtration would be completed in series with single outages required on each Feeder. This would allow the required Terminal operations avoiding unmanageable interruption to customer flows.

Limitations

6.62. Maintenance Activities would be required to be undertaken on the filters in line with PSSR, with filters being removed for inspection on an approximate 12 yearly interval. Additionally, yearly scheduled maintenance is also required by Policy. This results in an increase in planned maintenance requirements. However due to this being planned maintenance rather than unplanned maintenance it can be efficiently scheduled with other terminal operations activities.

Option 2 - Common Filtration on Feeders 2 & 4 (5 Filters)

Option Description

6.63. This option installs a common bank of five filters for gas from both Feeders 2 and 4. Feeder 2 would be cut below ground and new pipework connected bringing the Feeder above ground to a set of five new filters. Feeder 4 existing pipework would be cut above ground and connected into the same bank of five filters, together with the minimum number of new valves necessary for safe isolations to facilitate filter cleaning and maintenance. The outlet of the common filter bank would then be connected back into each Feeder downstream.

6.64. Each individual filter has been sized for 20mcm/d gas flow. Four filters would be in service, providing [redacted] gas filtration against the technical maximum gas flow through each feeder of [redacted]. The fifth filter provides redundancy. As the filters in service blind with solid debris, one would be isolated for cleaning and the fifth stand-by filter brought into service to maintain full filtration capacity. The [redacted] filter sizing is a product of design calculations for the filters and associated piping to meet the technical maximum gas flows and not exceed maximum permissible gas velocities (the filters have not been oversized).

6.65. Figure 33 presents a 3D image of the proposed arrangement for Feeder 2 and 4 common filtration.

Figure 33 Bacton Feeder No 2 & 4 Option 3 3D Image

Cost Breakdown (2018/19 Pricing)

6.66. The cost breakdown of option 2 is given in Table 13 below.

Common Filtration on Feeders 2 and 4 (5 Filters)		
Work Element / Deliverable	**Cost £m**	**Source of Cost Presented**
Total Installed Cost	[redacted]	
Cost Estimate Accuracy	**+-30%**	

Table 13 Option 2 Cost Breakdown

Cost Basis

6.67. Cost, Sourcing and Contracting methodology of this option is the same as Option 1 above.

Delivery Timescale

6.68. Based on Regulator support April 2023, filters on Feeders 2 and 4 would be operational by November 2025. Project timescales are dependent on the timeframe for the procurement of long lead items, hence specifying the date of confirmation of Regulator Support.

Operational Actions/Activities

6.69. This option also provides full filtration capacity (four filters in service), but with reduced redundancy (1 back-up filter), compared with Option 1. All Feeder 2 and 4 gas would be filtered, however this would require increased frequency of filter cleaning compared with Option 1. In scenarios of high solids where more than one filter blinds, this may result in the requirement to also 'double filter' gas through UKCS related Incomers to avoid disruption to Customer flows.

Benefits and Limitations

Benefits

6.70. All Feeders 2 and 4 NTS gas filtered avoiding disruption to downstream Customer flows.

6.71. Benefits with above ground installation within the Terminal boundary are the same as for Option 1, however this Option has an additional benefit in that it requires only a single outage on Feeder 2.

Limitations

6.72. Maintenance Activities would be required to be undertaken on the filters in line with PSSR, with filters being removed for inspection on an approximate 12 yearly interval. Additionally, biennial scheduled maintenance is also required by Policy. This results in an increase in planned maintenance requirements. However due to this being planned maintenance rather

than unplanned maintenance it can be efficiently scheduled with other terminal operations activities.

6.73. The reduced filter redundancy compared with Option 1 would mean that when a 'centrally positioned' filter is removed for PSSR inspection it would need to be lifted over live gas pipework. It is NGG procedure for this to always be avoided, therefore a de-gassing / pressure reduction of the adjacent filters (or possibly entire filter bank) would be required, potentially removing all filtration capacity for Feeders 2 and 4. In this scenario, 'double filtration' through UKCS related incomers would be required to mitigate the risk of downstream customer interruptions

6.74. This Option would also reduce current operational resilience by removing an existing back-up gas supply into Interconnector Ltd, due to the pipework arrangement required for this design. This secondary route can be utilised in scenarios to manage the exit pressures to our customer providing redundancy and resilience to security of supply. This option would introduce a single point of failure for Feeder 4 gas supply to Interconnector Ltd and not allow manageable valve / asset maintenance on the single supply into Interconnector Ltd. This presents an intolerable risk in security of supply which we are not willing to accept. These risks in consideration of the negligible cost reduction compared with Option 1, render this option unsupported.

Option 3 - Separate Filtration on Feeders 2 & 4 (2 x 2=4 Filters)

Option Description

6.75. This option installs two filters onto each of Feeder 2 and Feeder 4. Filtration would be tied into each Feeder in the same manner as Option 1 above, however each filter bank has a reduced number of two filters each.

6.76. This option provides full filtration capacity for NTS gas from Feeders 2 & 4 but provides no resilience to facilitate maintenance on any of the filters installed (2 filters in service, with no stand-by). Based on our filtration maintenance policy this is scheduled to occur biennially.

Cost Breakdown (2018/19 Pricing)

6.77. The cost of option 3 is given in Table 14 below.

Separate Filtration on Feeders 2 and 4 (2 x 2 = 4 Filters)	
Total Installed Cost	[redacted]
Cost Estimate Accuracy	+-30%

Table 14 Option 3 Cost Estimate

Cost Basis

6.78. Cost, Sourcing and Contracting methodology of this option has the same basis as Option 1 above, however costings were derived by scaling of Option 1, not detailed estimation.

Delivery Timescale

6.79. Based on Regulator support April 2023, filters on Feeders 2 and 4 would be operational by July and November 2025 respectively. The sequence of Feeder outages may change subject to operational conditions of the network. Project timescales are dependent on the timeframe for the procurement of long lead items, hence specifying the date of confirmation of Regulator Support.

Operational Actions/Activities

6.80. This option provides full filtration capacity with no redundancy. All Feeder 2 and 4 gas could be filtered until any filter blinds. At this point, any blinded filters would be isolated for cleaning, requiring gas to be 'double filtered' through UKCS related Incomers with resulting reduction in filtered gas and possible interruptions to Customer flows. This option would require increased frequency of filter maintenance and cleaning compared with Options 1 and 2.

6.81. Filter maintenance and PSSR inspections are the same as for other options. Given the lack of redundancy, during biennial scheduled maintenance and removal for PSSR inspections, each filter bank would be at 50% capacity or completely out of service. This would necessitate 'Double Filtering' through UKCS related Incomers to avoid disruption to Customer flows.

Benefits and Limitations

Benefits

6.82. Benefits with above ground installation within the Terminal boundary and manageable outages are the same as for Option 1.

6.83. The option is the lowest cost separate filtration option.

Limitations

6.84. 100% NTS gas would be filtered until any of the filters blind. While blinded filters are isolated and cleaned, and dependent upon the level of solids encountered, Feeders 2 and 4 gas would be potentially unfiltered (or at least a 50% reduction in filtering capacity). During this operation gas would be 'double filtered' through UKCS related Incomers, reducing the amount of filtered gas. This would occur in line with PSSR, with filters being removed for inspection biennially and on an approximate 12 yearly interval. The lack of filter redundancy compared with Option 1 would mean that when a filter is removed, filtration capacity for Feeders 2 and 4 would be reduced to 50%. In this scenario, and during cleaning, 'double filtration' through UKCS related incomers would be required to limit / avoid any disruption to Customer flows. This reduction in unfiltered gas does not meet the intent of the scheme,

and given the risk associated with disruption to Customer flows and negligible cost reduction compared with Option 1, this option unsupported by NGT.

Option 4 - Common Filtration on Feeders 2 & 4 (3 filters)

Option Description

6.85. This option installs a common bank of three filters for both Feeders 2 and 4 (reduced from five filters in Option 2 above). Feeder 2 would be connected into the Filter bank in the same manner as for Option 2 above.

6.86. Each filter on the common filter arrangement has been sized to flow [redacted]. All three filters would be in service providing [redacted] filtration capacity compared with the technical maximum NTS flows through Feeders 2 and 4 of [redacted]. The option therefore does not provide full filtration capacity and has no redundancy. As filters blind with solid debris, they would be isolated for cleaning, further reducing filtration capacity requiring 'Double Filtration' through UKCS related Incomers. Even with additional 'double Filtration' not all NTS gas could be filtered with no redundant filters available to replace capacity.

Cost Breakdown (2018/19 Pricing)

6.87. The cost of option 4 is given in Table 15 below.

Common Filtration on Feeders 2 and 4 (3 Filters)	
Total Installed Cost	[redacted]
Cost Estimate Accuracy	**+-30%**

Table 15 Option 4 Cost Estimate

Cost Basis

6.88. The cost, sourcing and contracting methodology of this option has the same basis as Option 2 above, however costings were derived by scaling of Option 2, not detailed estimation.

Delivery Timescale

6.89. Based on Regulator support April 2023, filters on Feeders 2 and 4 would be operational by November 2025. Project timescales are dependent on the timeframe for the procurement of long lead items, hence specifying the date of confirmation of Regulator Support.

Operational Actions/Activities

6.90. This option only provides maximum [redacted] filtration capacity, versus a technical maximum requirement to filter [redacted] with no redundancy. As not all Feeders 2 and 4

gas could be filtered, this would result in the requirement to also 'double filter' gas through UKCS related Incomers.

Benefits and Limitations

Benefits

6.91. Benefits with above ground installation within the Terminal boundary are the same as for Option 1, however this option has an additional benefit in that it requires only a single outage on Feeder 2 during construction and commissioning.

6.92. This option is the lowest cost asset option within the shortlist option, excluding the counterfactual.

Limitations

6.93. For this option, interruptions to Customer flows are highly likely compromised and only possible with additional 'Double Filtering' through UKCS related Incomers. The risks of requiring filters to be removed for PSSR inspection and lifting over live gas pipework are the same for Option 2, as are the reduction in resilience and introduction of a single point of failure for Feeder 4 gas supply into Interconnector (UK). In consideration of these risks and given the negligible cost delta with its parent Option 2, this option is not supported by NGT.

6.94. Maintenance Activities would be required to be undertaken on the filters in line with PSSR, with filters being removed for inspection on an approximate 12 yearly interval. Additionally, biennial scheduled maintenance is also required by Policy. This results in an increase in planned maintenance requirements. However due to this being planned maintenance rather than unplanned maintenance it can be efficiently scheduled with other terminal operations activities.

Option 5 – Separate Filtration on Feeders 2, 4 & 27 (3 x 3 = 9 Filters)

Option Description

6.95. This option installs three filters onto each of Feeder 2, Feeder 4 and Feeder 27. To fit the new filtration equipment in the required location and available space, each Feeder would be excavated and cut below ground. New pipework would then be connected at this cut location bringing the Feeders above ground. Each new section of Feeder pipework is then connected to a bank of three new filters together with the minimum necessary new valves required for safe isolations to facilitate filter cleaning and maintenance. The outlet of each filter bank is then connected back into the respective downstream Feeder.

6.96. Each Filter arrangement has been sized per Option 1, with two filters in service on each bank providing full NTS filtered gas for each Feeder. One filter on each bank on stand-by providing

50% redundancy on each Feeder. As filters blind with solid debris, one filter on each bank would be isolated for cleaning and the third redundant filter brought into service to maintain full filtration capacity.

Cost Breakdown (2018/19 Pricing)

Separate Filtration on Feeders 2, 4 and 27 (3 x 3 = 9 Filters)	
Total Installed Cost	[redacted]
Cost Estimate Accuracy	+-30%

Table 16 Option 5 Cost Estimate

Cost Basis

6.97. Cost, Sourcing and Contracting methodology of this option has the same basis as Option 1 above, however costings were derived by scaling of Option 1, not detailed estimation.

Delivery Timescale

6.98. Based on Regulator support April 2023, filters on Feeders 2, 4 and 27 would be operational by July, November 2025 and February 2026 respectively. The sequence of Feeder outages may change subject to Operational conditions of the network. Project timescales are dependent on the timeframe for the procurement of long lead items, hence specifying the date of confirmation of Regulator Support.

Operational Actions/Activities

6.99. Operational activities are the same as for Option 1, but with the additional maintenance on Feeder 27 related filters / assets.

Benefits and Limitations

Benefits

6.100. 100% NTS gas filtered avoiding disruption to downstream Customer flows and assuring compliance with GS(M)R (Gas Safety (Management) Regulations) requirement for clean gas.

6.101. Benefits with above ground installation within the Terminal boundary and manageable outages are the same as for Option 1.

6.102. Construction of each Feeder filtration would be completed in series with single outages required on each Feeder. This would allow required Terminal Operations avoiding unmanageable interruption to Customer flows.

Limitations

6.103. Maintenance Activities would be required to be undertaken on the filters in line with PSSR, with filters being removed for inspection on an approximate 12 yearly interval. Additionally, biennial scheduled maintenance is also required by Policy. This results in an increase in planned maintenance requirements. However due to this being planned maintenance rather than unplanned maintenance it can be efficiently scheduled with other terminal operations activities.

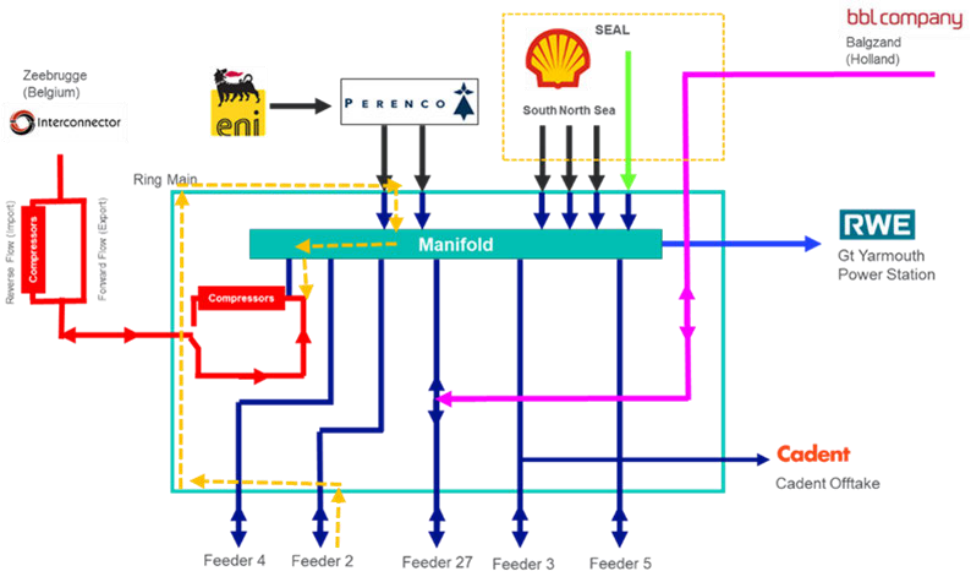
6.104. Whilst this option provides filtration to Feeder 2, 4 & 27 this results in this option having the highest capex cost of our shortlisted options.

6.105. Due to the installation of filtration on three feeders (Feeder 2, 4 & 27) rather than two as on our other options (Feeders 2 & 4) the project timescales to deliver the solution are longer that these options. It is estimated an additional 3 months is required for installation and commissioning.

Option 6 (Counterfactual) – Continued Double Filtration Operational Mitigations

Option Description

6.106. This option proposes the continuation of the current mitigations adopted at the Terminal to manage the material ingress from the NTS. Through continued utilisation of a spare incomer at the Terminal we would 'Double Filter' a proportion of the gas discharged to Interconnector Ltd from Feeder 4 & Feeder 27, utilising the existing approach as explained in Section 4.



6.107. Assuming the rate of filter maintenance continues at the same rate as seen across calendar year 2022 we would undertake eleven occurrences of filter maintenance.

Benefits and Limitations

Benefits

6.108. The capex cost of operating in this arrangement is much lower than undertaking any of the other options, however more frequent operational mitigations increase filter maintenance capex and opex costs.

Limitations

6.109. Continuing this option does not materially change the risk position at the Terminal. There is still an inherent risk of material ingress from the NTS that would only be partially mitigated through double filtering operations, given that double filtering can only filter c50% of NTS gas used for exports.

6.110. This spare incomer is rotated in line with operational requirements from our upstream customers, however there are circumstances, including during upstream process incidents, where the spare incomer is required to be used to mitigate the risk of an incident before the impact is seen on the wider NTS or to our downstream customers. This would result in the lack of availability of this incomer for double filtration purposes, resulting in unfiltered gas being discharged to our downstream customers.

6.111. Operating outside of the design for these incomers leads to inefficiencies and increased operations management requirements at the Terminal. Accelerated wear on metering and flow control valve assets, increasing the frequency of necessary asset health interventions on these assets to keep these operational.

6.112. Gas supplied to IUK and BBL via Feeder 27 cannot be double filtered due to pressure differentials resulting in unfiltered gas being discharged to our customers. Given the presence of solid debris within the network this could result in disruptions leading to security of supply impacts both in the Terminal operating in next export mode or net import mode.

6.113. Maintenance of the filters requires a reduction in pressure necessitating the filter bank gas inventory to be reduced. This is currently vented to atmosphere resulting in [redacted] of carbon being released upon each filter maintenance. Double filtration substantially increases the required filter maintenance (11:2 in 2022), therefore resulting in significantly more carbon being released to atmosphere [redacted] per annum. Ongoing operation at this frequency is not in line with the Global Methane Pledge agreed at COP26 or the Government's target to reach net zero by 2050.

Option Table Summary

6.114. Option summary tables are provided for the following aspects to allow for cross comparison across the main options considered:

- Options Shortlist
- Options Cost Breakdown

Option Shortlist

Option Cost Comparison Table (18/19 Prices)	Project Start Date	Project Finish Date	Total Cost (18/19 £m)	Cost Accuracy
1 – Separate Filtration Feeders 2 & 4	July 2023	[redacted]	[redacted]	-5+15%
2 – Common Filtration Feeders 2 & 4	July 2023	[redacted]	[redacted]	+-30%
3 – Separate Filtration Feeders 2 & 4	July 2023	[redacted]	[redacted]	+-30%
4 – Common Filtration Feeders 2 & 4	July 2023	[redacted]	[redacted]	+-30%
5 – Separate Filtration Feeders 2, 4 and 27	July 2023	[redacted]	[redacted]	+-30%
6 – Continued Double Filtration Operational Mitigations	N/A	N/A		

Table 17 Options Shortlist Summary

Project Spend Profile

6.115. Indicative spend profile for preferred Option 1 in 2018/19 pricing.

Element / Deliverable	FY22	FY23	FY24	FY25	FY26	Total Cost
EPC Estimate	[redacted]					
EPC PM						
EPC Site Establishment						
NGT Direct Company Costs						
NGT Indirect Company Costs						
Contractor Risk						
NG Project Risk (Direct)						
NG Project Risk (Indirect)						
EPC Estimate						
EPC PM						
Total						
Cumulative						

Table 18 Option 1 Indicative Spend Profile

7. Business Case Outline and Discussion

7.1. This section shall provide a summary of the key business case drivers for each of the shortlisted options.

Key Business Case Drivers

Security of Supply

7.2. Managing the security of supply both from UK to Europe and Europe to the UK is a key driver for investment for this project. The build-up of solid and liquid materials within Bacton Terminal has the consequence of protracted disruption to our exit customers at the Terminal (Including BBL & Interconnector Ltd).

7.3. Our shortlisted options provide flexibility in filtering gas from the NTS exported to continental Europe, and filtering gas transported from Continental Europe to the UK before it enters our NTS.

7.4. Even in a scenario where UK demand for gas materially decreases, the UK NTS will be a crucial conduit for UKCS gas, Norwegian gas and global LNG to be exported to continental Europe. This is particularly the case while LNG regasification capacity in Europe remains limited.

7.5. Our shortlisted option ensures gas flow along Feeders 2 & 4 is filtered prior to entering into the Terminal's systems, before exiting the Terminal to the Interconnectors and our other directly connected customers (Cadent Offtake and Great Yarmouth Power Station).

7.6. Whilst across 2021/22 and 2022/23 gas years UK to European exports have been the predominant mode of operation, UK net imports are required on days of high UK demand driven by market dynamics. The UK is fortunate to have direct access to UKCS, but limited storage capacity necessitates a reliance on gas importation to meet demand in periods of high demand. This balance is sought from either LNG or Interconnector supply, depending on wider market factors impacting availability.

7.7. Our shortlisted Asset Options (Option 1 – Option 5) provide various levels of feeder 2 & Feeder 4 filtration capability. The tables overleaf, Table 19 &Table 20 present a summary of the filtration capacity in the short-listed options both in capacity in mcm and in percentage capability against feeder flows specified in the basis of design. Filtration system sizing must be in accordance with IGEM/TD/1, however with standard filtration sizes being utilised some options exceeds the technical maximum flow through both Feeders (70mcm/d) and therefore have greater than 100% filtration capability. The redundancy percentage is based on the availability of standby filters within each option.

	Filtration	Redundancy	Total Filtration Capacity
Option 1			
Option 2			
Option 3			
Option 4			
Option 5			
Option 6			

Table 19 Filtration Capacity

	Filtration	Redundancy
Option 1	114%	57%
Option 2	114%	28%
Option 3	114%	0%
Option 4	85%	0%
Option 5	114%	57%
Option 6	c28%	0%

Table 20 Filtration Capacity Percentage against Basis of Design

7.8. Options 4 & 6 do not enable 100% of gas to be filtered through Feeder 2 & 4 due to the capacity of the filtration assets proposed to be installed or the capacity of the ring main to facilitate double filtration. The residual risk to disruptions to Terminal operations from these options is not a tolerable position for NGT.

7.9. Whilst Option 3 provides 100% gas filtration in normal operation. At the point of filter binding, filter maintenance would need to be conducted resulting in this filter being removed from operational service to facilitate cleaning.

7.10. This would result in filter capacity that is less than the flow capability, providing c85% flow filtration. Providing less than 100% filtration would necessitate double filtration activities are undertaken to manage the residual risk however this would still likely result in unfiltered gas being discharge to our downstream customers. We do believe this option provides the level of risk mitigation or provide value to consumers, and therefore is discounted.

7.11. Option 5, installing separate filtration onto feeders 2, 4 & 27 was discounted after the shortlist due

7.12. Option 6 “Double Filtration Operational Mitigation” does not materiality reduce the risk of interruptions to downstream operations. Due to only c28% of NTS gas can be filtered through a spare incomer, c28% of NTS gas transported to Bacton IP is unfiltered, which has the potential to result in disruption to both customers connected at this point.

Health & Safety

7.13. The Health and Safety of our site operatives is paramount in everything that we do. At present enhanced filter maintenance is required to be conducted on the spare incomer

utilised for double filtration. This results in this incomer not being able to be utilised to manage upstream risks associated with operational incidents.

7.14. All options apart from option 6 result in the installation of additional filters. The additional assets should mitigate the need to undertake double filtration at the site and extend the duration of filter maintenance activities from the current 8-week frequency.

Sections 7.15 7.31 contain additional information provided as part of the Jan 23' submission SQ process.

7.15. In reviewing the operational impact of the shortlisted options, a range of criteria were utilised to undertake a qualitative assessment of the respective benefits of options to enable for comparison to be made. The criteria are shown below with our assessment against these on the next page:

Level of Incomer Resilience reduced	Assessment based on the forecast level of double filtration required to support the operation of each of the shortlisted options within the Engineering Justification Paper. Option 1 & 2 would require no double filtration operation to support the solution, whereas this might be needed upon filter maintenance for Options 3 & 4.
Level of Filtration Maintenance (Planned)	Whilst the amount of planned filter maintenance would increase with the asset options considered, by its nature it can be scheduled around other operational activities at the site. Unplanned maintenance such as through continued double filtration option can be estimated but cannot be scheduled thus could result in changes to existing scheduled maintenance. If the terminal experiences an incomer issue or bypass issue, or there is a sudden upstream stream failure, then there is a high likelihood that we won't be able to provide any double-filtering capacity for a short or medium term. Option 1 & 2 should result in no double filtration and therefore not contribute to the unplanned maintenance frequency.
Level of Filtration Maintenance (Unplanned)	
Isolation envelope	Each of the options installs double block & bleed isolation valves either side across each individual filters. This enables isolation of single filters, reducing gas inventory having to be vented compared to the incomer filtration banks where we can only isolate the whole filter bank. We estimate the carbon emitted for each incomer filter bank maintenance is [redacted] Isolation of individual filters should reduce this to by 4/5th due to the individual filter isolation capability.
Nitrogen Purge Usage'	Nitrogen is not currently used for leak testing of filter vessels as per NGT policy, however we understand this approach is carried out by other operators. Nitrogen is utilised for purging the filter vessels in advance of filter maintenance being conducted. This will be across each filter for Options 1 - 4 and across the filter bank for Option 5. Option 1-4 requires approximately[redacted] of nitrogen to purge and make safe. By having bespoke Double Block & Bled isolations, in Option 5, [redacted] of nitrogen will be required, circa 1/3 of the average required from utilising the filter bank..
Time taken to remove filters **Time taken to return to service**	Each of the options shortlisted installs double block & bleed either side across each individual filter. This enables isolation of single filters, reducing the time to undertake maintenance. Estimated that we could undertake filter maintenance for a vessel across 1-2 days (including isolation and recommissioning) This is less than utilising incomer filtration banks where we can only isolate the whole filter bank resulting in maintenance taking 5 days, therefore this reduced maintenance durations by at least 3 days. The reduced duration has implications on the level of operations risk as during this period the terminal is operating with reduced filtration capability and flexibility which needs careful management against the prevailing conditions to ensure the continued security of supply.
Environmental Impacts	Being able to isolate across each filter vessel reduces the amount of gas inventory vented to atmosphere compared with our counterfactual option

Safety Impact	Installation of additional filters shall extend the frequency between filter maintenance activities due to the increase in filtration duty. This provides maximum reduction in the health & safety risk to operatives due to extended frequencies between filter maintenance
Manual handling	Up to a 40% reduction in the level of manual handling could be seen compared to the double filtration option, due to the impact the additional filtration assets have on level of filter binding
Valve life considerations	Installation of additional vessels and the extension of filter maintenance frequencies reduces the cycling of vessel door opening and closing and valve opening and closing. This shall extend the period between interventions to replace seals, resulting in lower capital expenditure

EJP Option Reference / Criteria	Option 1	Option 2	Option 3	Option 4	Option 6
Basis of Design	[redacted]	[redacted]	[redacted]	[redacted]	Double Filtration
Additional Filters	6 filters	5 filters	4 filters	3 filters	
Level of ncomer Resilience reduced	No Doub e F ra on requ red due o add ona ers prov d ng u capac y or Feeder 2 & 4 ow. No orecas eve o ncomer res ence reduc on	No Doub e F ra on requ red due o add ona ers prov d ng u capac y or Feeder 2 & 4 ow. No orecas eve o ncomer res ence reduc on	F ers opera ed as 1 Opera ona F er and 1 s andby per eeder([redacted] or run hem oge her (4 ers n opera on). Once b nded we wou d doub e er, u s ng 1 o he s es ncomer er banks. Es [redacted]. he erm na exper ences a ncomer ssue or bypass ssue, or here s a sudden ups ream s ream a ure, hen here s a h gh ke hood ha we won' be ab e o prov de any doub e er ng capac y	Doub e ra on requ red dur ng norma opera on, hus [redacted], assum ng 1 ncomer s used o doub e er. However he erm na exper ences a ncomer ssue or bypass ssue, or here s a sudden ups ream s ream a ure, hen here s a h gh ke hood ha we won' be ab e o prov de any doub e er ng capac y or a shor or med um erm.	[redacted]
Level of Filtration Maintenance (Planned)	B enn a as per po cy (T/PR/MA NT/2 Par 3)	B enn a as per po cy (T/PR/MA NT/2 Par 3)	B enn a as per po cy (T/PR/MA NT/2 Par 3)	B enn a as per po cy (T/PR/MA NT/2 Par 3)	B enn a as per po cy (T/PR/MA NT/2 Par 3)
Level of Filtration Maintenance (Unplanned) - ncomer filter maintenance	Based on ow and capac y unp anned ma n enance requenc es cou d be reduced by up o 75% [redacted] c rca 32 weeks or more	Based on ow and capac y unp anned ma n enance requenc es cou d be reduced by up o 75% ([redacted], c rca 32 weeks or more	Based on ow and capac y unp anned ma n enance requenc es cou d be reduced	Based on ow and capac y unp anned ma n enance requenc es cou d be reduced	Based on recen h s ory er ma n enance conduc ed every 8 weeks
solation envelope	Each o he op ons proposes doub e b ock & b eed so a on va ves e her s de across each nd v dua ers. Th s enab es so a on o s ng e ers, reduc ng gas nven ory hav ng o be ven ed compared o he ncomer ra on banks where we can on y so a e he who e er bank.				so a on across er bank
Nitrogen usage for leak testing	N rogen s no curren y used or eak es ng o er vesse s as per NGT po cy, however we unders and h s approach s carr ed ou by o her opera ors. N rogen s u sed or purg ng he er vesse s n advance o er ma n enance be ng conduc ed. Th s w be across each er or Op ons 1 4 and across he er bank or Op on 6. Op on 1 4 requ res approx ma e y [redacted] o n rogen o purge and make sa e. By hav ng bespoke Doub e B ock & B ed so a ons, n Op on [redacted] o n rogen w be requ red, c rca 1/3 o he average requ red rom he curren doub e ra on approach.				
Time taken to remove filters Time taken to return to service	Each o hese op on has doub e b ock & b eed e her s de across each nd v dua er. Th s enab es so a on o s ng e ers, reduc ng he me o under ake ma n enance. Es ma ed ha we cou d under ake er ma n enance or a vesse across 1 2 days (nc ud ng so a on and recomm ss on ng) Th s s ess han u s ng ncomer ra on banks where we can on y so a e he who e er bank				2 days o so a e, 2 days o recomm ss on and hen 1 day per er or ma n enance
Environmental mpacts	Be ng ab e o so a e across each er vesse reduces he amoun o gas nven ory ven ed o a mosphere compared w h he op on 6				so a on o who e er bank, resu ng n ven ng o gas nven ory across h s bank, wh ch s s gn can y more han or each er
Safety mpact	ns a a on o add ona ers sha ex end he requency be ween er ma n enance ac v es due o he ncrease n ra on du y. Th s prov des max mum reduc on he hea h & sa e y r sk o opera ves due o ex ended requenc es				F er ma n enance up o every 8 weeks con a ns s gn can hea h and sa e y r sk o s e opera ves
Manual handling	A 40% reduc on n he eve o manua hand ng cou d be seen compared o he doub e ra on op on, due o he mpac he add ona ra on asse s have on eve o er b nd ng	A reduc on n manua hand ng cou d be seen compared o Op on 6 due o he add ona ers ns a ed			Manua hand ng o er baske s up o every 8 weeks o remove and ns a er baske s
Valve life considerations	ns a a on o add ona vesse s and he ex ens on o er ma n enance requenc es reduces he cyc ng o vesse door open ng and c os ng and va ve open ng and c os ng. Th s sha ex end he per od be ween n erven ons o rep ace sea s, resu ng n ower cap a expend ure				Doub e b ock and b eed va ves opera ed every 8 weeks, acce era ed wear on va ve sea s used or so a on. n add on here s acce era ed Vesse door sea s wear, ead ng o po en a gas nven ory escape, one o our arges r sk areas on he s e.

7.16. All options apart from our counterfactual option, Option 6, have similar isolation envelopes, and time taken to remove filters and return the filters to service, due to the location of the isolation valves. This then results in similar environmental impacts as we shall have the ability to isolate individual filters within the filter bank.

7.17. Options 1 & 2 provide the greatest levels of resilience and therefore should extend the frequency between filter maintenance activities due to the increase in filtration duty. This provides maximum reduction the health & safety risk to operatives due to extended frequencies. These options are also estimated to have a 40% reduction in the level of manual handling could be seen compared to the double filtration option

7.18. Installation of additional vessels and the extension of filter maintenance frequencies reduces the cycling of vessel door opening and closing and valve opening and closing. This shall extend the period between interventions to replace seals, resulting in lower capital expenditure

7.19. Options 1 & 2 are assessed to result in no requirement for double filtration and therefore it is forecast that there shall be limited future impact on the resilience of our incomer assets, since double filtration operation shall no longer be required to manage solid material ingress into the terminal from the feeders.

7.20. Options 1-4 will reduce the frequency of filter maintenance required at the site, due to the increase in capacity of filtration at the site, and therefore reduce the exposure of our site operatives to this risk, whilst also managing the environmental risks associated with this activity. Option 6 does not change the current risk position and therefore due to this is discounted for these reasons.

7.21. The qualitative assessment for each of the shortlisted options identified options 1 and 2 being preferable based on the considerations identified above.

Financial

7.22. NGT Transportation charges (General Non Transmission Services Charges (Commodity) and Transmission Services Exit Charges (Capacity)) are derived through agreed price control formulae within NGT License. These determine the maximum revenue NGT can earn from the transportation of gas and are utilised to set the baseline charges and auction reserve prices. In October 2022 NGT published an updated Gas Transmission Transportation Charges statement6. This document set out the auction reserve prices for the aforementioned capacity products that are released by NGT for utilisation of the National Transmission

[6] https://www.nationalgas.com/document/140851/download

System and the auction reserve price for the procurement of capacity at entry and exit network locations.

7.23. For Bacton IP exit point this auction reserve price is set at [redacted]. This is the starting price for exit capacity auctions, but is not necessarily the price for which the exit capacity is ultimately procured at due to the level of demand for capacity and the prices bid by the users at this license network location.

7.24. The volume of non-obligated capacity offered and procured at Bacton IP exit point across 2022/23 financial year to date was significantly higher than in previous years at [redacted].

7.25. The revenue generated for this offered capacity upto the end of Jan 2023 has been [redacted]. This is [redacted] higher than the value of this exit capacity at the auction reserve price defined within the Gas Transmission Transportation Charges statement. This increase has been driven by the demand for this capacity by shippers.

7.26. The increase in flows at Bacton Interconnector Exit Point also has implications on the NGT charge rates set for both General Non Transmission Service Charges (Commodity) and Transmission Service Exit Charges (Capacity). The additional flows through Bacton IP have result in higher commodity volumes and an increase in capacity bookings for the allowed revenues to be collected against thus reducing forward looking auction reserve prices.The information presented below provides an indication of what the impact on October 2022 prices would have been, had the additional flows seen at the Bacton Interconnector Exit Point been wholly accounted for. Note: This analysis only revises the forecast of the Bacton exit IP flows, and does not adjust any other value. All other variables remain consistent with those used to set the charges for October 2022.

7.27. The forecast impact on the auction reserve price for commodity charges is shown below

Non–Transmission Service Charges (Commodity)		
Scenario 1 – Pre 2022	Not accounting for any revision to Bacton Flows from those seen historically	[redacted]
Scenario 2 – 2022 Charging Statement	Final Published price for October 22 (where we made a revision to increase the flows at Bacton)	[redacted]
Scenario 3 – Potential 2023 Charging Statement	Using Actual Flow data for Bacton exit IP since April 22	[redacted]

7.28. The impact on capacity prices at exit offtakes is lower than for commodity due to the fact that this is based on the forecast of capacity bookings rather than flows (which is driven by the flow forecast and capacity booking profiles of users). The forecast of capacity booking is heavily influenced by the forecast of capacity bookings value is GDN bookings, who book their 1 in 20 peak value for each day which accounts for c80% of the capacity forecast.

Transmission Services Exit Charges (Capacity)		
Scenario 1 – Pre 2022	Not accounting for any revision to Bacton Flows from those calculated by the FCC Methodology	[redacted]
Scenario 2 – 2022 Charging Statement	Final Published price for October 22 (where we made a revision to increase the flows at Bacton)	[redacted]
Scenario 3 – Potential 2023 Charging Statement	Using Actual Flow data for Bacton exit IP since April 22	[redacted]

7.29. There are many variables within the charging model but, as demonstrated above, the higher the Bacton throughput (forecast and actual) this will reduce the relative charges i.e. other variables may lead to an increase in charges overall. The reduced relative charges to shippers at Bacton IP has the potential to lead to overall lower shipper costs which would flow through to consumers. The net position cannot be determined due to changes in transmission charges at other system entry and exit points impacting on individual shipper's portfolios

7.30. NGT through operating an efficient network to meet the needs of the market, particularly at Bacton Interconnector exit point, with high levels of asset availability can effectively support high utilisation ultimately providing value for money to consumers through lower charges.

7.31. 6.20.6.31. Our filtration investments at Bacton shall ensure we achieve this efficient network.

Business Case Summary

7.32. In its present form the Cost Benefit Analysis (CBA) methodology is not suited to this type of project, as the benefits of the investment are not only to UK consumers but also to European Consumers. Therefore, we have not completed a traditional CBA on the options, however through considering a range of business case drivers the application of these to the options presented within the shortlist we have been able to conduct quantitative and qualitative assessment of the options shortlisted.

8. Preferred Option Scope and Project Plan Phasing

Preferred Option for the request

What is the Driver for this Investment?

8.1. The Primary driver for investment in filtration at Bacton Terminal is to ensure gas flowing through Bacton Terminal is free from solid particles. These can result in disruption to downstream customers and be transported out to the National Transmission System (NTS) and our wider customers. The benefits of this are that security of supply into and out of the UK can be more effectively accommodated and managed without lengthy interruptions to undertake maintenance because of the build-up of materials within Terminal assets.

8.2. In addition to ensuring security of supply, NGT must also ensure that our site operatives are subject to safe operating conditions and operational burden currently experienced at the Terminal is reduced.

Our Investment Recommendation

8.3. Our Preferred Option decision has been based on qualitive and quantitative engineering and cost assessments of the available options. Our Preferred option is Option 1 as presented in Options Selection (Separate Filtration on Feeders 2 & 4 (2x 3 = 6 Filters)) and the installation of two new and one reconditioned class 600 vessel on our incomer filter banks.

Feeder Filtration

8.4. Two new dry gas filtration systems are proposed to be installed on the existing Feeder 2 and Feeder 4 within the existing Bacton Gas Terminal, allowing gas from the NTS to be filtered prior to entering the Terminal and mitigating the risk of dust being supplied further downstream including to Interconnector Ltd.

8.5. The red box in Figure 34, highlights the area on site for the installation of the Feeder 4 filters. The blue box highlights the area of the proposed works on site for the installation of the Feeder 2 filters.

Figure 34 Preferred Option Location

8.6. For Feeder 4, the arrangement involves replacing a buried section of the Feeder 4 pipeline and installing an above ground 900mm NB block valve arrangement to form 900mm NB inlet and outlet connections to the filter stream headers.

8.7. Unfiltered gas will be brought into site via Feeder 4 and fed into the filter pipework arrangements via the new 900mm NB ball valves and low level 900mm NB inlet filter stream header pipework. The gas will then be filtered through the 600mm NB horizontal dry gas filters and the filtered gas exits via the high level 900mm NB outlet header. Following this it will pass through new 900mm NB ball valve and existing 900mm NB ball valves.

8.8. Due to space constraints and close proximity to the inner electrified security fence, the 900mm NB outlet header will be installed circa 4m high from finished ground level, directly above the 900mm NB inlet header. As a result, bespoke high level pipework steel supports will be required to support the high-level pipework sections.

8.9. Three new concrete blast walls will be required to protect the existing NGT pipework assets from fire impingement and missile projection in the unlikely event the filter enclosures were to fail. The design and requirements of the concrete blast walls will be determined in detailed design. This arrangement makes use of the existing site road and does not require for a new road to be constructed.

8.10. The figure below, Figure 35, presents an isometric 3D model of the Feeder 4 pipework arrangement. The assets in white and grey are existing assets within the Terminal, with green and orange assets being new assets installed through this project.

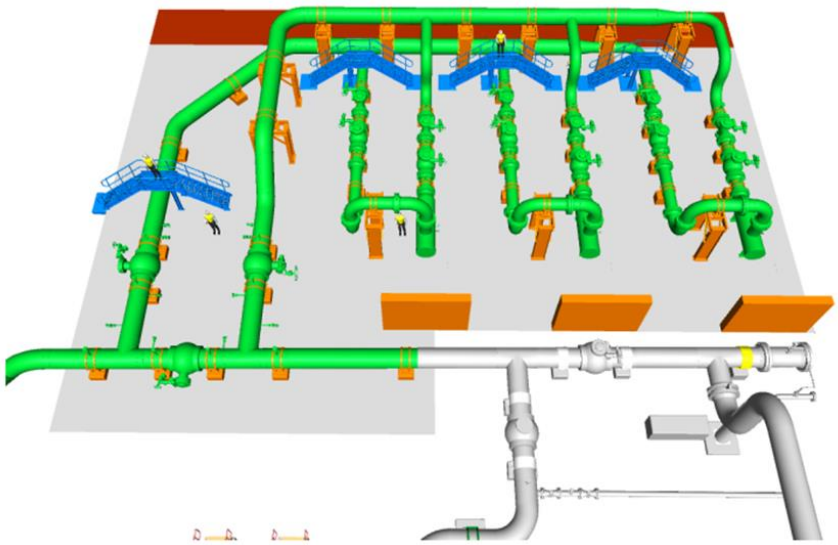


Figure 35 3D Model of Feeder 4 Filter Pipework Arrangement

8.11. Similar to Feeder 4, for Feeder 2, the arrangement involves raising a section of the Feeder 2 pipeline and installing the inlet and outlet headers, and 900mm NB block valve arrangement above ground.

8.12. Unfiltered gas is brought into site via Feeder 2 and fed into the filter pipework arrangements via the new 900mm NB ball valve and low level 900mm NB inlet header. The gas will then be filtered through the 600mm NB dry gas horizontal filters. The filtered gas exits via the

high level 900mm NB outlet header and passes through new 900mm NB ball valve and existing 900mm NB ball valves to feed into Interconnector Ltd.

8.13. Due to space constraints and close proximity to the existing metering pipework, the 900mm NB inlet and outlet headers will be required to be installed vertically, with the outlet header installed circa 4m high from finished ground level directly above the inlet header. As a result, bespoke high level steel supports are required to support the high-level pipework sections. Three new concrete blast walls will be required to protect the existing NGT assets from fire impingement and missile projection in the unlikely event the filter doors were to fail.

8.14. The figure overleaf, Figure 37, presents an isometric 3D model of the Feeder 4 pipework arrangement. The assets in white and grey are existing assets within the Terminal, with green and orange assets being new assets installed through this project.

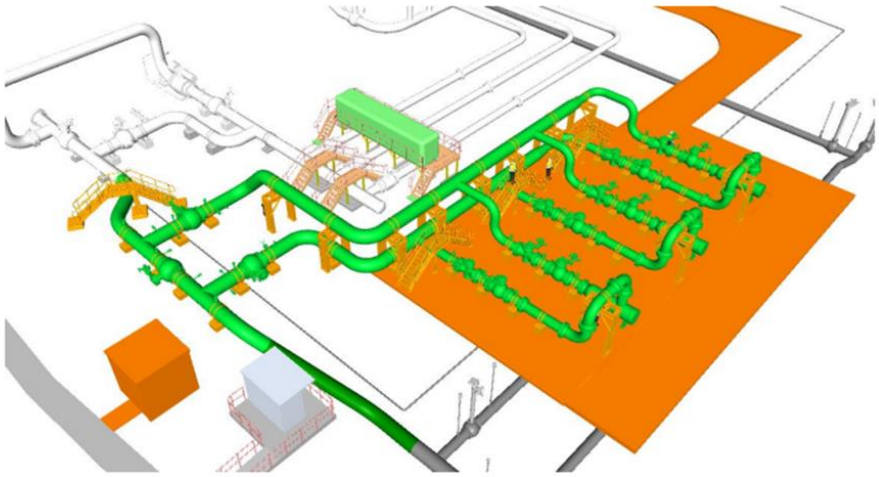


Figure 36 3D Model of Feeder 4 Filter Pipework Arrangement

8.15. Common to both Feeders 2 and 4 filter arrangements, filters will be horizontal dry gas filters. Each filter has been sized for 50% technical maximum flow (two in service, one stand-by) per Feeder.

8.16. The filters are to operate in single direction with gas flow from the NTS into the Terminal. Controls / interlocks valves are required to prevent damage to the new filters when the Feeders are flowing gas back into the NTS.

8.17. To provide adequate isolation of filters, each individual filter stream includes inlet and outlet isolating valve arrangements. This comprises 600mm NB ball valves both upstream and downstream of the filters.

Incomer Filtration

8.18. Through assessment of the materials already on site, a class 600 horizontal vessel was identified from the ENI incomer filtration systems, disconnected in 2018. Rather than procure

a new vessel it was identified that reconditioning this existing vessel had several benefits including a lower cost to operation and the faster lead time to commission.

8.19. For a further space on the Perenco A1 incomer two new 16" class 600 horizontal vessel has been procured using baseline funding.

8.20. Due to the known operating performance and parameters of Class 600 Horizontal vessels and the availability of one within the existing site it was deemed that fitting further vessels provided the best balance between risk mitigation, cost and timeframe to commission the plant.

8.21. The table below provides a summary of the costs.

Cost Element	2022/23	2023/24	2024/25	2025/26	Total Cost
Insta ation of Line Vu cameras, rep acement of A1/E fi ter vesse and insta ation of a re va idated vesse into A1 incomer fi ters.	[redacted]				
New Fi ter Baskets					
Total					
Cumulative					

Table 21 Incomer Filters Cost Estimate

Project Plan Phasing

8.22. Our planning assumption is to receive Regulatory Final Determination such that the project is sanctioned and proceeds into Long Lead Procurement / Detailed Design phase by Aug-23. Our delivery plan has been developed in conjunction with our Detailed Design and Main Works (Construction) Contractors.

8.23. The first phase of delivery is to commence with Long Lead procurement as Valves and Filters are on the primary and secondary critical paths, respectively. Suitable data sheets for these items were produced as part of Conceptual phase study allowing procurement to proceed without delay.

8.24. In parallel, ground investigation works will be undertaken which are critical to inform detailed design. Detailed design will commence shortly after completion of the ground investigation works.

8.25. Once valves and fittings are received from Suppliers, each filter system will be largely prefabricated off-site, providing efficiency in time and cost compared with on-site fabrication. This also allows the systems to be hydrostatically tested ahead of installation. Hydrostatic testing of these systems on site would not be feasible / safe given their height and proximity to other live gas assets.

8.26. An outage will be required on each of Feeder 2 and 4 to tie in the new filter systems. Ahead of outage, site preparation works will be conducted including necessary civil works to minimise outage durations and associated risks with changing Network conditions. The outages on Feeders 2 and 4 will be done in series to manage Network constraints.

8.27. Our current planning assumption is to undertake Feeder 2 outage first. The first stage of outage would be to re-compress Feeder 2 from the Bacton Terminal, back to the first available block valve site. Once re-compression is completed and the Feeder made safe, the Feeder would be cut inside the Terminal and the new filter system tied in and brought into service. Once Feeder 2 is in back in operation and filtering gas from the NTS, works on Feeder 2 outage would commence. Feeder 4 sequence of events for outage and tie in are as per Feeder 2.

8.28. High level dates for key milestones in the project plan are shown below

- Regulatory approval to proceed – July 2023
- Long Lead Procurement commences – Aug 2023
- Ground investigations to inform detailed design Jan-Mar 2024
- Detailed Design Jan-July 2024
- Construction on site Sept-24 – November 2025
- Commissioning (gas on and filtering) July and November 2025 respectively for each Feeder.

Project Spend Profile

8.29. For our preferred option, the project spend profile is largely driven by the Long Lead materials which are on the critical path for delivery. Payment terms with suppliers are yet to be agreed, but profiles are based on the payment terms suggested by suppliers.

8.30. Contractor and NG costs have been profiled against S curves typical for the nature of this project and are subject to detailed forecasting prior to any Contract award with our Detailed Design and Main Works Contractors.

8.31. The table below summaries the preferred feeder filtration option costs.

Element / Deliverable	FY22	FY23	FY24	FY25	FY26	Total Cost
EPC Estimate						
EPC PM						
EPC Site Establishment						
NGT Direct Company Costs						
NGT Indirect Company Costs						
Contractor Risk						
NG Project Risk (Direct)						
NG Project Risk (Indirect)						
EPC Estimate						
EPC PM						
Total						
Cumulative						

Table 22 Feeder Filtration Cost Breakdown

8.32. For our incomer filtration investments, the project spend profile is shown in the table below

Cost Element	2022/23	2023/24	2024/25	2025/26	Total
Insta ation of Line Vu cameras, rep acement of A1/E fi ter vesse and insta ation of a re va idated vesse into A1 incomer fi ters.					
New Fi ter Baskets					
Total					
Cumulative					

Table 23 Incomer Filtration Cost Profile

Efficient Cost

8.33. Due to the Security of Supply risk, we are balancing the timescale for delivery with the cost efficiency of our option. Long lead items have been sourced through a competitive tender exercise, ensuring value from our supply chain.

8.34. Detailed Design and Construction Main Works Contractors have been selected on a 'best for task' basis. Both elements were costed using Conceptual Design level engineering information by both the supply chain and our internal cost estimation team. Both estimates were within a reasonable tolerance giving assurance that although not competitively tendered, provide value.

Key Business Risks & Opportunities

8.35. Our preferred Option, Separate Filtration on Feeders 2 & 4, requires a single outage on each of Feeder 2 and 4. Although this is considered manageable, Network conditions may present challenges in undertaking the outages as planned leading to changes in planning assumptions.

8.36. None of the shortlisted options meet NGT standards for Separation Distances between gas assets. The feasibility of options depends on the outcome of a Quantified Risk Assessment (QRA) to either support or discount options. The QRA will be conducted Feb-Mar 23 and the output used to either discount options or support a deviation request in support of options.

8.37. Long Lead items are critical to the programmes and cost of options. Valve and Filter deliveries are on the primary and secondary critical paths, respectively. Market forces mean that costs and lead times are uncertain which is a risk to deliverability on time and cost.

Outputs and Allowances in RIIO-T2

8.38. In RIIO-T1 NGT did not have any outputs relating to enhancements to the filtration at Bacton Terminal. We did not incur any costs from this project during the RIIO-T1 regulatory period as the project only commenced once NGT has entered RIIO-2.

8.39. In RIIO-2 NGT has a Bacton Terminal Redevelopment PCD detailed in Special Condition 3.10 Bacton Site Redevelopment Re-opener. The provision for the installation of additional filtration at the Terminal was included within the optioneering conducted as part of the FEED Feasibility. However due to changes in the geo-political European climate and the associated change in Supply and Demand patterns and the focus on Security of Supply we have chosen to accelerate this element of the scope.

8.40. As part of our RIIO-T2 regulatory funding we requested and received Asset Health allowances for baseline funding to undertake filtration PSSR inspections at the Terminal. These involved completing filter PSSR inspections and replacing filter baskets on two of the incomer filter banks.

8.41. Funding was awarded against the RIIO-2 Unique Identifier (UID) below to complete these inspections and replacements.

UID	Intervention	Unit of Measure	Volume	Baseline Funding
[redacted]	Filters PSSR Inspections & Major Overhauls	Per Asset	[redacted]	[redacted]

Table 24 Business Plan UIDs

8.42. The bottom-up plan for this UID is shown in the table below. The 6 volumes identified in the plan were based on inspections and filter replacements on Perenco A1 and Shell S1.

Incomer	PSSR Inspection	Filter Replacement Planned RIIO-2	Filter Replacement Volume
Perenco A1	Y	Y	[redacted]
Perenco A2	N	N	
Shell S1	Y	Y	[redacted]
Shell S2	N	N	
Shell S3	N	N	
Shell S4	Y	N	

Table 25 UID RIIO-2 Bottom-up plan

8.43. Where filter replacements are proposed, the quantity measure is per filter rather than per filter bank. Therefore, showing three filters baskets within Perenco A1 were planned to be replaced, and similarly in Shell S1.

8.44. As highlighted in earlier chapters of the report for some of the incomers we have completed three filter replacements of all filter baskets installed on the incomer (Perenco A1 in February 22, July 22 & November 22 on two filters). For Perenco A1 we have therefore undertaken 6 filter replacements across RIIO-2 so far, utilising all requested volumes against the baseline funding awarded.

8.45. The projects included within the Engineering Justification paper, to enhance the filtration through the installation of additional filters on the feeders and the installation of additional vessels on the incomer was not part of the scope of this RIIO-2 awarded funding.

Additional RIIO2 Outputs

UID	Baseline volume of Intervention (By PP) (by un t of measure)	Baseline total funding available (18/19)	Baseline total funding available (18/19)	ECC unit cost (18/19)	Current volume of intervention (by un t of measure)	ECC total funding required (18/19) £0.00	Output Year	UID funding requ through UM
[redacted] Insta ation of Fi ters on Feeders at Bacton	0	*0.00*	£0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted] Insta ation of Fi ters on the Incomers at Bacton	0	*0.00*	£0	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 26 Additional RIIO-2 Outputs

NARMs Benefit

8.46. Following discussions with Ofgem in the NARM Development Monthly Meetings, it is proposed that for simplicity all the investments that arise from the UMs are collated and one NARMs update is provided in February 2024 post Plant and Equipment submission. Note there are no other New Addition UIDs within the current mechanism. For further details and a summary of UIDs please see Section 7 and Appendix 2 of the Asset Health UM Overarching Document.

9. Conclusion and Next Steps

9.1. Based on the outcome of the options assessment and considering the criticality of Bacton Terminal to the Security of Supply to both the UK and Europe and the impact of interruptions to this supply, the installation of additional filter vessels on our incomers and the installation of new filtration assets on Feeders 2 & 4 is our Preferred Option. Our Engineering Justification Paper is providing Ofgem with the details relating to the project need and options analysis to support our preferred option.

9.2. Ofgem are invited to assess and approve the two preferred options and associated funding request for the Feeder Filtration and Incomer Filtration RIIO-T2 investment costs through the Asset Health Re-opener. This shall be submitted in line with Special Condition 3.14, which will request an adjustment to the value of the NARMAHOt term.

9.3. Our project is at stage 4.2 of the Network Development Process and following approval will progress to stage 4.3 Long Lead Procurement.

9.4. Whilst this investment mitigates the risk of solid debris ingress from disrupting our downstream customers and from entering the National Transmission System (NTS) which has the potential to result in disruptions to Network Offtakes and the build-up of material within our pipeline system, the paper has also presented some of the challenges experienced at the site in relation to liquid filtration.

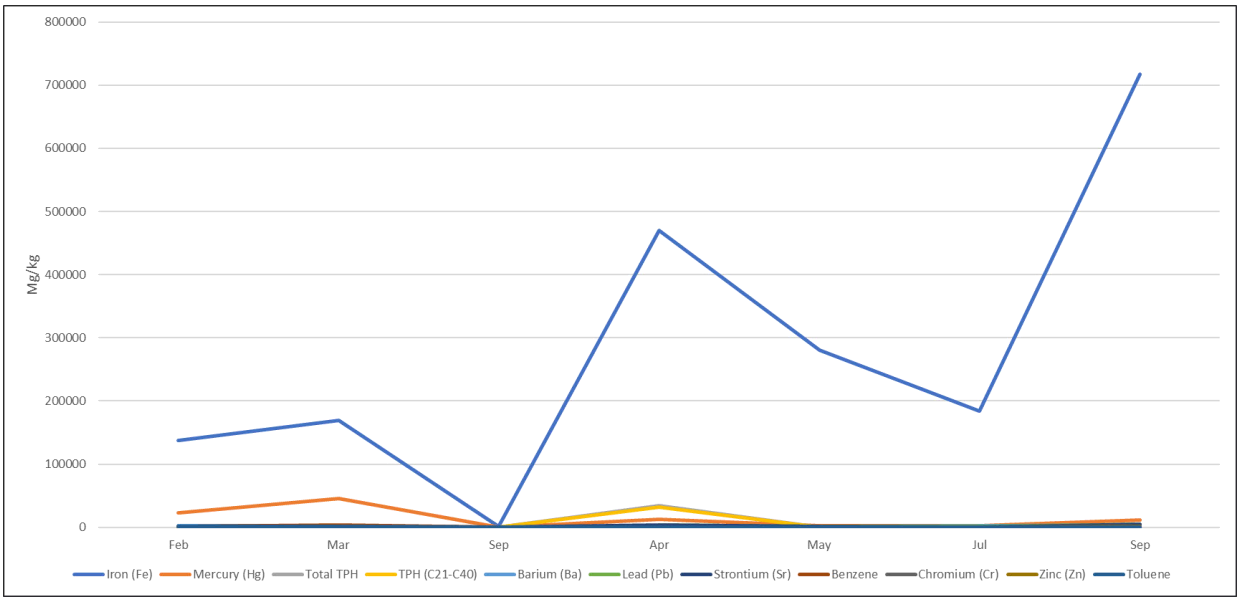
9.5. A number of liquid excursion events have occurred at the Terminal over the last couple of years. The largest of which resulted in [redacted] of Glycol being discharged into Bacton Terminal from one of our upstream customers. Whilst we have operational mitigations (Line-Vu camera detection and Terminal Flow Advice (TFA) actions) once the liquid has entered our Terminal we have limited options to filter and collect this liquid.

9.6. We have started to review the level of risk mitigation our current liquid ingress mitigations provide at the Terminal and may revert back through the June Asset Health Uncertainty Mechanism window with a further proposal for investments to mitigate this risk.

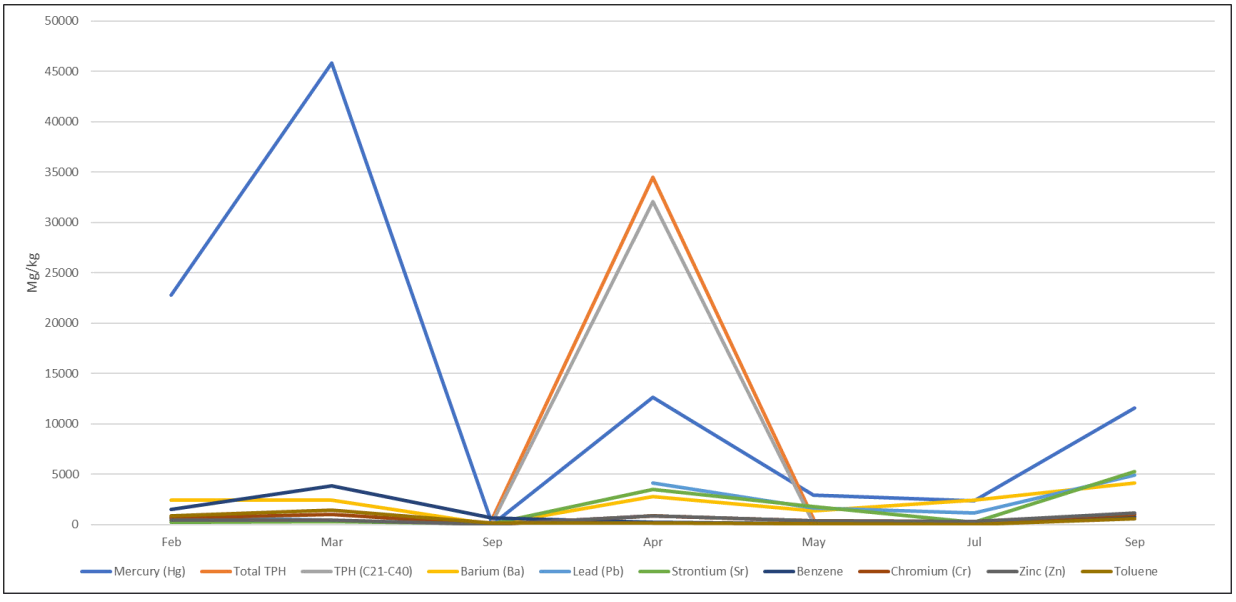
10. Appendices

Appendix 1 – Material Composition Analysis

As part of Filter Maintenance routine sampling of the materials collected is undertaken. Samples from each of the materials collected were sent for chemical composition testing. The data we present below is based on samples collected from February 2021 to September 2022 through the various filter maintenance completed. The various data lines correspond to different particulates within the sample. Iron was the largest element from the composition of material collected.



Removing iron from the graphs provides better granularity of the other elements identified. A range of other elements were generally identified within the samples, including Mercury, TPH (Total Petroleum Hydrocarbons), Barium, Strontium. These elements are generally found with gas composition and are a by-product of the extraction.



The table below provides a tabular view of the data presented in the graphs above. Data points are presented in mg/kg.

(mg/kg)	2021			2022				Tota (mg/kg)
	Feb	Mar	Sep	Apr	May	Ju	Sep	
Iron (Fe)	138,000.0	169,264.2	957.0	470,000.0	280,529.8	184,000.0	717,000.0	1,959,751.0
Mercury (Hg)	22,800.0	45,806.1	3.8	12,610.0	2,943.7	2,340.0	11,600.0	98,103.6
Tota TPH			582.0	34,500.0	600.0			35,682.0
TPH (C21-C40)			238.0	32,100.0	152.9			32,490.9
Barium (Ba)	2,420.0	2,426.0	2.0	2,760.0	1,388.0	2,420.0	4,140.0	15,556.0
Lead (Pb)	725.0	412.0		4,150.0	1,630.0	1,150.0	4,880.0	12,947.0
Strontium (Sr)	261.0	322.1	61.7	3,500.0	1,761.2	261.0	5,250.0	11,417.0
Benzene	1,530.0	3,822.0	632.0	238.6	69.2	70.4	780.0	7,142.2
Chromium (Cr)	667.0	997.0	5.7	840.0	358.0	283.0	1,032.0	4,182.7
Zinc (Zn)	470.0	464.6	7.6	863.0	343.8	312.0	1,188.0	3,649.0
To uene	888.0	1,434.0	134.0	145.5	56.8	53.5	599.0	3,310.8

11. Glossary

Glossary	
BBL	Balgzand Bacton Line, One of two interconnectors that connect the UK, from Bacton Terminal, to continental Europe Gas Transmission Systems.
Brownfield	Construction within the existing site perimeter fence
CBA	**Cost Benefit Analysis:** A mathematical decision support tool to quantify the relative benefits of each site option.
CDS	Conceptual Design Study
COMAH	Control of Major Accident Hazards (COMAH). Bacton Terminal is one of two designated NGT COMAH sites. The other being St Fergus Terminal
Entry Capacity	Holdings give NTS users the right to bring gas onto the NTS on any day of the gas year. Capacity rights can be procured in the long term or through shorter term processes, up to the gas day itself. Each NTS Entry point has an allocated Baseline which represents a level of Capacity that NGT is obligated to make available for delivery against on every day of the year
Exit Capacity	Holdings give NTS users the right to take gas off the NTS on any day of the gas year. Capacity rights can be procured in the long term or through shorter term processes, up to the gas day itself. Each NTS Exit point has an allocated Baseline which represents a level of Capacity that NGT is obligated to make available for offtake on every day of the year.
FCV	Flow Control valve
FEED	**Front End Engineering Design:** The FEED is basic engineering which comes before the detailed design stage. The FEED design process focusses on the technical requirements as well as an approximate budget investment cost for the project.
FES	**Future Energy Scenarios:** An annual industry-wide consultation process encompassing questionnaires, workshops, meetings and seminars to seek feedback on latest scenarios and shape future scenario work. The Future Energy Scenarios document is produced annually by National Grid ESO and contains their latest scenarios.
FOS	Future Operating Strategy
FOSR	Final Option Selection Report
Greenfield	Construction on land that is outside of the existing perimeter site boundary
GS(M)R	**Gas Safety (Management) Regulations:** The Gas Safety (Management) Regulations 1996 (GS(M)R) apply to the conveyance of natural gas (methane) through pipes to domestic and other consumers
ILI	In-Line Inspection
IUK	Interconnector Ltd, One of two interconnectors that connect the UK, from Bacton Terminal, to continental Europe Gas Transmission Systems.
LNG	Liquified Natural Gas
MCPD	Medium Combustion Plant Directive
MTO	Material Take Off

Glossary	
MWC	Main Works Contractor
NBP	'National Balancing Point' is a market place for the procurement of gas within the United Kingdom
NEA	Network Entry Agreement
NGT	National Gas Transmission
NORM	Naturally Occurring Radioactive Material
NTS	**National Transmission System:** The high-pressure system consisting of Terminals, compressor stations, pipeline systems and offtakes. Designed to operate at pressures up to 85 barg. NTS pipelines transport gas from Terminals to NTS offtakes.
Ofgem	**Office of Gas and Electricity Markets:** The regulatory agency responsible for regulating Great Britain's gas and electricity markets.
PARCA	Planning and Advanced Reservation of Capacity Agreement
QVD	Qualified Vendor Database
Re-opener	Re-openers are a type of RIIO uncertainty mechanism. Depending on their design, they allow Ofgem to adjust a licensee's allowances (in some cases up and in some cases down), outputs and delivery dates in response to changing circumstances during the price control period.
RIIO	**Revenue = Incentives + Innovation + Outputs**: RIIO-T2 is the second transmission price control review to reflect the framework; it sets out what the transmission network companies are expected to deliver and details of the regulatory framework that supports both effective and efficient delivery for energy consumers.
TFA	Terminal Flow Advice, an action utilised to immediately reduce gas flows.
TTF	Dutch "Title Transfer Facility" is a market place for the procurement of gas on the continent.
Uncertainty Mechanism	Uncertainty mechanisms exist to allow price control arrangements to respond to change. They protect both end consumers and licencees from unforecastable risk or changes in circumstances.
UKCS	**United Kingdom Continental Shelf:** The UK Continental Shelf (UKCS) is the region of waters surrounding the United Kingdom, in which the country has mineral rights. The UK continental shelf includes parts of the North Sea, the North Atlantic, the Irish Sea and the English Channel; the area includes large resources of oil and gas.
UID	Unique Identifier
ZTP	'Zeebrugge Trading Point' is a market place for the procurement of gas on the continent.