national gas transmission

Bacton Terminal Site Redevelopment

Final Option Selection Report

February 2024

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1 Executive Summary

Project Snapshot

National Gas Transmission is committed to ensuring the continued safe, efficient, and reliable operation of the National Transmission System (NTS). Bacton Gas Terminal is a critical strategic asset and has formed an integral part of the NTS for over 50 years, acting as both a Southern North Sea input hub for UK domestic supply and in recent decades a key interface between UK / EU gas supplies. It is a complex site managing gas entry and exit, across NTS Feeders, EU Interconnection points, UKCS sub terminals and NTS offtakes.

This Final Option Selection Report (FOSR) is submitted under Special Condition 3.10 Bacton terminal site redevelopment Re-opener and Price Control Deliverable Part C of the Licence. It provides a summary of all the work performed to date to evaluate, cost, analyse and justify the full suite of feasible options available to maintain current levels of network capability and availability for our customers. It sets out the plans that will take the terminal operations up to 2050 and details what specific interventions are required and when, to ensure an efficient and delivery focused programme of upgrades that can be executed driving consumer value, whilst minimising disruption to all connected third parties.

Following a detailed and in-depth option selection process supported by additional survey works, engineering studies and investigations to verify asset condition, this report recommends the investment in a site wide Asset Health solution as the most economic and efficient solution for UK consumers with an indicative overall total project value of [redacted] (±30%), of which [redacted] will be the basis of our re-opener submission. This excludes baseline allowances which will be subject to true-up as part of the re-opener process.

The preferred option presented is the culmination of a gradual refinement process that started with NGT's RIIO-T2 submission, where it was initially proposed that a brownfield terminal re-development solution was preferred. Further optioneering and assessment led to NGT undertaking detailed studies of plant condition and review of option selection criteria (including environmental impact) resulting in the creation of a shortlist of three viable options. Following this assessment and extensive stakeholder consultation, our preferred solution is Option 1, Base Case Asset Health which will retain the Bacton Terminal in its current configuration and undertake essential asset replacements for continued safe operations to 2050.

NGT have also reviewed the case for rationalisation in our assessments and conclude that, the cost of decommissioning, operational disturbance and existing inherent flexibility to manage a range of scenarios with the current physical design, that there is minimal benefit to removing elements of the terminal at this stage in its operational life.

The proposed Asset Health solution provides the benefit of being able to deliver the lowest cost solution to consumers, whilst balancing the need to be flexible in an ever-changing energy landscape including aspects such as hydrogen and carbon capture utilisation and storage (CCUS) within the energy mix.

Subject to Ofgem approval, we aim to accelerate the Bacton terminal site redevelopment Re-opener submission from August 2025 to July 2024. This allows NGT to direct effort in a phased approach, tackling short to medium term 'no regrets' work in the remaining years of RIIO-T2, providing a steady ramp up in workload at the site which continues until the early 2030's. This allows for efficient mobilisation and delivery via our contract partners.

This project aligns with our RIIO-T2 stakeholder priority *"I want to take gas on and off the transmission system where and when I want".* Our Bacton Investment strategy has previously been shared with Ofgem as part of the Asset Health Uncertainty Mechanism windows. It sets out how we propose to manage the assets in the short,

1.1 Introduction

The purpose of this Final Option Selection Report (FOSR) is to seek Ofgem approval of National Gas Transmission's (NGT's) Preferred Option for the Bacton Gas Terminal (referred to as Bacton in generality) to maintain its operations in the short, medium and long-term. The FOSR sets out how we have assessed the current condition of the terminal, the needs and requirements of the site and its customers through consultation, as well as ensuring that a wide range of carefully considered scenarios and options have fed into providing a robust assessment.

As part of our RIIO-T2 submission in December 2019, we proposed to redevelop Bacton through the construction of a new brownfield site within the existing site fence line. Noting the early stage of project development, Ofgem provided funding to complete the options selection, including engineering assessments, within this FOSR and to complete a re-opener submission.

This FOSR is submitted under Special Condition 3.10 Bacton terminal site redevelopment Re-opener and Price Control Deliverable Part C of the Licence, as per Price Control Deliverable Reporting Requirements and Methodology Document and RIIO-T2 Re-opener Guidance and Application Requirements Document. It details the optimum investment strategy at Bacton, to meet our obligations and ensure the best value for consumers.

The energy industry is currently in a watershed moment where more so than ever, due to the availability of information and access to real time news, the UK public understand more about how the energy industry functions and what is required of it. The significance of methane gas has become increasingly apparent, especially in the context of delivering UK industrial and domestic energy needs when energy from intermittent sources is unavailable. NGT plays a crucial role in this energy mix.

1.2 Investment Driver

The purpose of this investment is to identify the best solution at Bacton, to ensure safe, reliable and compliant operation meeting current and future stakeholder needs. Bacton brings gas into the UK from the Southern North Sea and Europe via interconnectors. It provides gas to the Southeast of the UK, a key demand area including London. It is the only terminal on the network that regularly switches from being net supply, to net demand, due to reversal of interconnectors.

Bacton is one of NGT's two Upper Tier, Control of Major Accident and Hazard (COMAH) sites. As such, NGT must effectively manage process safety and demonstrate compliance with COMAH regulations. This includes submission of a safety case to the Health and Safety Executive demonstrating diligent management of the Major accident hazard plant and equipment, for the continued safe operation of the terminal.

NGT must also ensure that the right level of network capability and resilience is maintained to fulfil customers' needs as well as our operational requirements. Ensuring that the optimum mix of assets and the condition of these assets remains fit for purpose is intrinsic in the work we have undertaken

in this FOSR to provide the best value and outcome for consumers. The ultimate goal being to secure a stable energy future, that can facilitate a transition to Net Zero.

1.3 Optioneering

A Front-End Engineering Design (FEED) Feasibility Study was undertaken between May and Nov 2021, considering all options for continued operations at the terminal until 2050, using asset condition information obtained through data collection and site surveys. NGT and the FEED Study Consultant [redacted] completed high level conceptual independent, then collaborative workshops to generate a long list of options for assessment against a set of agreed criteria and weightings as set out below:

Table 1 Feed Feasibility Option Assessment Criteria

Criteria	Weighting (%)
Allows for hydrogen compatible design	2.13
CAPEX	19.16
Constructability Risk (less SIMOPS)	17.02
Greenfield development – planning conditions	14.89
Opex should be reduced	8.51
Permits reuse of existing assets	8.51
Reduces current gas inventory (COMAH)	1.06
Terminal operations simplified	5.32
Minimal environmental impacts	14.89
Above ground piping is minimal	8.51
	100

A joint [redacted] review of the long list was undertaken to determine a short list based on both the criteria above and the re-opener guidance issued by Ofgem. At this early stage, our original preferred option 'T2 Business Plan – Brownfield Terminal Redevelopment' was discounted on technical feasibility and process safety (insufficient space inside Terminal to build / proximity to other assets including Interconnector LTD). The review process utilised to take the long List of options down to a valid short list was conducted in 2 stages:

Stage 1 – Pre-screening by NGT to remove items that would be unsuitable for NGT as they sit outside the remit of our licence for example electricity generation and hydrogen processing on site.

Stage 2 – Focused session on the remaining long list items and review against the following criteria:

- The role of Bacton remaining as a methane terminal
- Defining a least cost option
- Ideas that remain within the existing site boundary
- Ideas that addressed current and foreseeable energy system challenges

- Ideas arising from the creative process that promised functional and efficiency improvements.

Table 2 Feed Feasibility Option Short list

Option Number	Option	Option Variant	Applicable time period reflecting site maximum gas flows
1	Base Case Asset Health		1.1 2021-2035 (site capacity up to 160 mcm/d) 1.2 2035-2050 (site capacity up to 120 mcm/d)
2	Major Rationalisation and Reduce Inventory		2035-2050 (site capacity up to 120 mcm/d)
3	New build (above ground, modular build, minimal reuse of assets)	3.1 Fits within existing site	2035-2050 (site capacity up to 120 mcm/d)
		3.2 Requires site extension/offsite development	

As our RIIO-T2 Business Plan option was no longer viable, and all short-listed options had the same base case asset health investment requirement until at least 2035, it was critical to confirm the condition of the underground assets at the terminal that could not have been investigated during the initial optioneering stage. As some of the oldest assets on the network, certainty was required on the short list option feasibility, and with approval from Ofgem we postponed the submission of this FOSR to complete the necessary work.

The completion of additional surveys along with a Reliability Availability Maintainability (RAM) study and a Remnant Life study have provided the necessary data to give confidence on the condition of the below ground assets and what investment is required, plus fed into the second stage FEED process where the short-listed options were then developed to a greater level of engineering definition, allowing further assessment against the agreed criteria and weightings.

1.4 Final Preferred Option

The studies concluded that most existing primary assets (above and below ground pipework) have more than sufficient remaining life to operate safely into the 2050's. The assessment of ongoing commercial and operational requirements and resilience concluded that the terminal offers most value to consumers by remaining in its current configuration. The main reasons for not rationalising being outlined below with further detail provided in chapter 6:

- The existing infrastructure has in-built flexibility to allow multiple gas paths to be configured. This ensures operational resilience with gas flows maintained 24/7/365 with no disruption.

- Incomer filtration can be used to carry out 'double filtering' which is a transient issue. This low frequency high impact risk can have significant impact to security of supply.
- Maintaining the existing level of incomer streams allows maintenance to take place whilst managing network constraints against a backdrop of double filtration of NTS gas.
- Removal of functionality via decommissioning comes at cost, bringing disruption and removal of current required operational flexibility.
- The site is an Upper-Tier COMAH site requiring a formally agreed level of staffing with the HSE, therefore Operational cost differences in the short-listed options are marginal, with rationalisation driving minimal gains in savings for big increases in risk levels and potential constraint costs.

On this basis, Option 1 Baseline Asset Health was selected as our preferred option as it represents the lowest cost to consumers. Other short list options provide the same deliverability (ability to flow gas as required) and resilience (arguably slightly enhanced with greater levels of new assets), but at considerably higher cost which cannot be justified.

The FOSR identifies that there are three major components to the preferred solution, these being:

- Replacement of the Cathodic Protection System
- Replacement of the LV distribution system
- Replacement of key critical valves and associated valve actuation

These systems have been demonstrated to be subject to a combination of obsolescence and aged assets as well as condition data showing that components are either, not functioning as originally intended; or have become non-compliant with current HSE and technical standards rendering them ineffective and requiring immediate upgrade. They are essential investments to ensure the immediate safe operation and long-term future of the terminal.

On this basis, we are proposing to accelerate the associated re-opener for this Bacton Terminal Site Redevelopment FOSR from August 2025 to July 2024. This would enable the work packages above to start as soon as possible and allow the associated risks to be mitigated and delivery executed in the most efficient manner.

This FOSR provides estimated profiled costs for delivering these work packages. At this stage costs are estimated with the +/-30% cost accuracy and will be refined further for our re-opener submission. The proposed preferred option cost is [redacted] (18/19), which excludes the £10.5m baseline allowances received to develop the FOSR and Re-opener submissions. Of this total, [redacted] will form the basis of our re-opener submission, spanning multiple regulatory periods. [redacted] is forecast within the RIIO-T2 period, excluding baseline allowances which will be subject to true-up as part of the re-opener submission. Our current delivery plan is included in the FOSR, based on our intention to submit an accelerated re-opener submission, with works due to start in 2025, and ensuring alignment with our RIIO-T3 business plan submission.

1.5 Conclusion and Next Steps

Ofgem are invited to assess and approve the proposed Final Preferred Option for the Bacton terminal site redevelopment in line with Special Condition 3.10, Part C, 3.10.9. Following Ofgem's decision on the Final Preferred Option, NGT will use the received Baseline allowances to develop our preferred option further and submit a Re-opener application in line with Special Condition 3.10, part D for Ofgem's consideration in July 2024. This is in advance of the date currently stated in SpC 3.10 Appendix 2, and subject to Ofgem approval.

Due to the nature of the investment and our strategy at Bacton, we are also proposing to true up existing asset health UID's that fall under the Plant and Equipment category, where existing baseline allowances are subject to an uncertainty mechanism. These were omitted from our January 2024 Plant and Equipment Submission to ensure a consistent position is achieved for funding requests at Bacton.

We welcome the engagement with Ofgem throughout the process to date and intend to keep engaging with the regulator at all relevant project development stages, so they remain informed throughout and ensure we successfully deliver our proposed solution at Bacton.

2 Summary Table

Table 3 Final Option Selection Report (FOSR) Summary Table

Name of Project	Bacton Terminal Redevelopment Price Control Deliverable Final Option Selection Report		
Scheme reference/ mechanism or category	PAC3721		
Primary Investment Driver	Resilience		
Project Initiation Year	2021		
Project Close Out Year	2032		
Total Installed Cost Estimate (£m)	[redacted]		
Cost Estimated Accuracy (%)	+/-30%		
Project Spend to date (£m)	3.94		
Price Basis	2018/2019		
Current Project Stage Gate	ND500 4.2 – Option Selection		
Reporting Table	RRP Table 6.2 (Projects), table 6.1 (Capex_Summary) and table 6.3 (Asset Health)		
Outputs included in RIIO-T1	No		
Outputs included in RIIO-T2	<u>Bacton Terminal Redevelopment Price Control Deliverable (PCD):</u> PCD to ensure NGGT delivers a Final Options Selection Report, long lead items and Re-opener submission[1]. • Final Option Selection Report: 28 February 2024 • Re-opener application window: 1 May to 31 August 2025 • Baseline allowances: £10.50m (excl. RPEs)		
Spend Apportionment	**RIIO-T2**	**RIIO-T3**	**RIIO-T4**
	[redacted] (excludes baseline allowances)	[redacted]	[redacted]
Applicable Future Energy Scenario (FES)	FES 2021, FES 2022 and FES 2023		

[1] Detailed in Special Condition 3.10 Bacton terminal site redevelopment Re-opener and Price Control Deliverable

3 Project Status and Request Summary

3.1 Overview

3.1.1 National Gas Transmission (NGT) own and operate a range of high criticality assets across its network. A site of strategic importance, Bacton Gas Terminal (commonly referred to as Bacton or the terminal in this document) 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).

3.1.2 As part of our RIIO-T2 submission in December 2019, we proposed to redevelop Bacton through the construction of a new brownfield site within the existing site fence line. The investment justification at that point was driven primarily by condition information, asset age and health data, underpinned by stakeholder engagement and feedback highlighting how important Bacton Gas Terminal was to them.

3.1.3 As part of the final determinations[2], Ofgem concluded that there was still uncertainty on the final option due to the early stage of project development and questioned the efficiency of the presented option. Baseline funding was provided to complete the option selection process (including engineering assessments) within this Final Option Selection Report (FOSR) and to complete a Re-opener submission as defined within the licence and the Gas Transmission Project Assessment Process (GTPAP[3]), once the project has gone through a full Front-End Engineering and Design (FEED) process for the final preferred option.

3.1.4 This FOSR has been developed using our option selection process (Stage 4.2 of the Gas Network Development Process (GNDP)) to assess credible options to ensure Bacton Terminal site operates in a safe, reliable, and compliant manner continuing to meet the needs of our customers and stakeholders up to 2050 and beyond.

3.2 Project Status

3.2.1 In May 2021, NGT selected [redacted] as Feasibility Consultants to support in further evaluating the available options to ensure the safe and reliable ongoing operation of the terminal until 2050. The Option proposed as part of the RIIO-T2 submission has been further analysed, along with additional alternative options to evaluate if it meets the need case in the most cost-effective manner.

3.2.2 All of the options assessed within the RIIO-T2 period require use of existing assets and comprise a significant volume of asset health work. This led to NGT undertaking additional studies to support the FEED Feasibility development. NGT have undertaken a range of additional studies at the site. These included:

3.2.3 **Remnant Life Study**, with the objective to estimate the fatigue usage of existing assets at the terminal and assess the significancy of integrity threats.

[2] https://www.ofgem.gov.uk/publications/riio-2-final-determinations-transmission-and-gas-distribution-network-companies-and-electricity-system-operator
[3] https://www.ofgem.gov.uk/publications/gas-transmission-project-assessment-process-gtpap-pcd-guidance-and-application-requirements-decision

3.2.4 **Reliability, Availability & Maintainability (RAM) Study** to predict the performance of the site's assets from now until 2050, considering factors such as future flow scenarios and equipment deterioration.

3.2.5 **Cathodic Protection (CP) performance study**, with the objective to understand the performance of the Cathodic Protection system across the entire Terminal site, including installation of Electrical Resistance (ER) Probes for ongoing monitoring of CP performance (deterioration).

3.2.6 As the CP system has been confirmed to not providing adequate protection and has some (limited) RIIO-T2 baseline funding, this has been progressed to stage 4.3 of GNDP, to undertake Conceptual Design and commence Detailed Design.

3.2.7 Based on stage 4.2 planning, and dependant on the outcome and duration of Ofgem determinations, below are our anticipated high-level plans for progressing each main element through the GNDP process of project delivery:

Table 4 Project Delivery Milestones for Asset Health Components

	GNDP Stage		
	4.3 – Conceptual / 4.4 Detailed Design	4.4 – Construction	4.5 – Project Closeout
Cathodic Protection System Replacement	Jan 2024 – Dec 2024	Jan 2025 – Feb 2027	Feb 2027 – Aug 2027
LV Electrical System Replacement	Jan 2025 – Nov 2025	Jan 2026 – Mar 2028	Mar 2028 – Nov 2028
Critical valve and valve equipment replacements	Jan 2025 – Oct 2027	Jan 2026 – Mar 2032	Mar 3032 – Mar 3033

3.2.8 Each main asset health element of the preferred option is proposed to run concurrently, at least for the first few years of on-site construction. This has efficiencies in both NGT and Main Works Contractor Management costs. Actual programme and cost will be driven by timing and outcome of each related cost submission, which in turn will influence our delivery strategies with the Main Works Contractor(s).

3.2.9 Each of these specific technical project elements is described in further detail in Section 8.

3.3 Request Summary

3.3.1 Following completion of the additional studies and collecting information on the condition of our above and below ground terminal assets, NGTs final preferred option is to progress an asset health solution at the terminal, with an associated cost estimate of [redacted] (+30/-10% 18/19 prices), which excludes the £10.5m baseline allowances received to develop the FOSR and Re-opener submissions that will be subject to true-up in the re-opener submission. Our reopener request will cover [redacted] of this project cost associated with the programme of works detailed in this submission.

3.3.2 In this FOSR we outline that asset health forms part of all short-listed options and as such based on the condition data, these investments become 'no regrets' and require action to be taken on an accelerated time frame. NGT are proposing in their submission that the associated cost reopener is brought forward from August 2025 to July 2024, allowing works to be started in RIIO-T2. The report outlines that systems like CP, which is currently non-effective, need to be remedied as soon as reasonably practicable to prevent accelerated deterioration. Our target is to award delivery contracts by January / February 2025.

3.3.3 We have reviewed the Opex costs associated with the current terminal operations and because there is no capability change being proposed to the site, also noting that replacement equipment will require the same level of staffing input owing to the site being an Upper Tier COMAH site with specific Legislative requirements. Consequently, there is virtually no change in Opex.

3.3.4 Our final preferred option is supported by a wider quantitative and qualitative assessment of the specific needs of the site and the detailed studies on asset condition, fatigue life and resilience. A simplified cost benefit analysis has been completed, which considered Capex investment costs against constraint costs and operating costs. Refer to section 7 for more detail on this process.

3.3.5 Our final preferred option is the most cost effective for consumers and manages the ageing asset risks, whilst continuing with the level of flexibility and resilience of the current Terminal design. This is because it utilises the existing main mechanical and civil infrastructure as opposed to a terminal rebuild approach, with these assets defining key physical fixed connection points. The use of the existing infrastructure facilitates a more practical delivery whereby the in-built resilience in interconnecting pipework gives rise to an enhanced ability to take outages and re-configure the site accordingly to accommodate works. In turn this allows the terminal to maintain its availability and reliability levels to consumers and direct connected NGT customers.

3.3.6 The preferred solution also gives rise to better capability to manage an uncertain energy future for example changes in reliance on methane and a transition to Hydrogen and Carbon Capture. Keeping the assets functional will ensure that there is flexibility to slowly merge into a new system when the details are fully developed / known.

3.3.7 We also outline in the FOSR, that as well as undertaking the asset health works proposed here, there are a series of investments referred to as common investments from herein which also need to be undertaken during the remaining operational life of the terminal through RIIO-T3, T4 and beyond into the 2050's. Whilst these investments are discussed at high level in this report, they do not form part of the funding request as part of the Bacton FOSR and its associated cost re-opener.

3.3.8 Ofgem are invited to assess and approve our proposed final preferred option at Bacton in line with Special Condition 3.10 Bacton terminal site redevelopment Re-opener and Price Control Deliverable Part C. We are also proposing to Ofgem to approve our request to accelerate the re-opener application from August 2025 to July 2024.

3.3.9 Following Ofgem's decision on the final preferred option, we will continue to utilise the received FOSR baseline allowances to develop our preferred option further, develop detail to support later stage ordering of long lead items where applicable and submit a re-opener application, including associated Engineering Justification Papers (EJP) in line with special condition 3.10, part D. At which point the PCD will be revised to true up costs incurred through the development phase in addition to those requested through the re-opener application.

3.3.10 Our intended contracting strategy is to award design and build contacts in early 2025 for the works to ensure liabilities are in place for both the design, long lead procurement and final execution. This approach puts emphasis on the delivery partner and strives to prevent any additional cost risk materialising between different contracting and delivery partners at project stages. This also had added advantages of being able to formulate bundles of work that can be delivered more efficiently.

3.3.11 As described in our Asset Health Re-opener submission[4], due to the nature of the final preferred option, the Bacton terminal site redevelopment re-opener will also be used to seek true up or additional funding for five UIDs related to Plant and Equipment assets.

3.3.12 NGT has been reporting on its PCD progress and spend as part of the annual Regulatory Reporting Pack (RRP) table 6.2.

[4] https://www.nationalgas.com/document/143501/download

4 Problem/Opportunity Statement

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

4.1.1 National Gas Transmission has duties under the Gas Act 1986 to develop and maintain an efficient and economic pipe-line system (the NTS) for the conveyance of gas and to comply, so far as it is economical to do so, with any reasonable request to connect to that system.

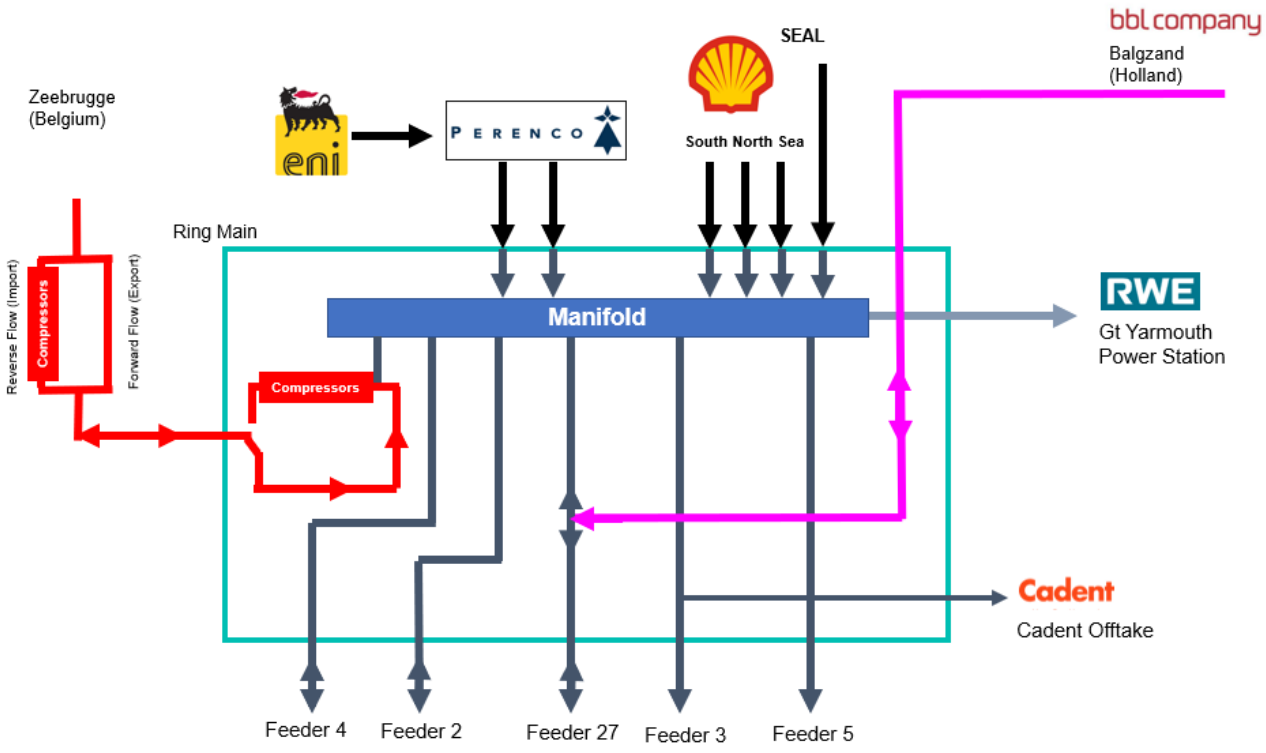
4.1.2 The NGT Bacton Gas Terminal is unique in its setup with multiple entry and exit points and has been in continuous operation since 1968, regularly supplying 10% to 20% of the UKs natural gas supply. Gas enters and exits Bacton at various points. As the Terminal has evolved, so has its cross-site interlinking meaning that when operational challenges arise, the uniqueness allows the site to be configured to provide what is required and still maintain other activities such as planned maintenance, outages and upgrade / project works. The terminal routes gas as listed below:

- Via the NTS through five feeders connected to the site (Feeders 2, 3, 4, 5 and 27).
- via the two interconnectors operated by Interconnector Ltd and BBL which provide the critical ability to both import gas from Europe as well as exporting gas from the UK to Europe from UK Continental Shelf (UKCS) gas operators i.e., Perenco and Shell Beach Terminals
- Gas is discharged to local industrial customers on site including Cadent GDN offtake and Great Yarmouth Power Station

4.1.3 Figures 1 & 2 provide an overview of the site both in aerial form and a simplified terminal schematic.

Figure 1 – Bacton Terminal Layout

Figure 2 – Simplified Terminal Arrangement



4.1.4 The Bacton terminal is integral to the delivery of gas to domestic consumers in the Southeast of the UK, a key demand area including London. Even with the transition to net zero, gas (methane with the potential for an increasing Hydrogen component through blending) will continue to form part of the critical UK energy infrastructure and energy security for several decades.

4.1.5 Bacton is critical in supporting UK and EU Energy Security, especially in the current geopolitical environment. It ensures customers will be able to take gas on and off the system where and when they want providing the necessary energy needs for domestic, commercial, and industrial use at lowest available cost as well as supplementing the key EU storage requirement that has proved so critical in the last couple of years. It also ensures continued flexibility to accommodate changes. Our project seeks to ensure that Bacton's role in this climate is not impacted by asset reliability and availability challenges.

4.1.6 Even with proactive maintenance regimes, the design life of a large number of the core assets systems on site are between 15-40 years, therefore significant investment is required to ensure the assets provide the continuity of service to terminal operations.

4.1.7 There is no practical option to "do nothing". Many of the assets at Bacton are of first generation and nearing or over their original design life; the design life of most asset systems is between 15-40 years. The condition of the assets and their expected continued deterioration over time presents a gradually increasing risk that needs managing. A Reliability, Availability & Maintainability (RAM) study and Remnant Life Study have been undertaken to assess the impact of this ageing on the terminal availability and reliability and how these may change over the next 20 – 30 years.

4.1.8 Several assets are life expired despite significant asset health expenditure on them, which has implications and restrictions on the mode of operation of the terminal, reducing site flexibility and reliability. These issues coupled with the consequence of failure have the potential to significantly impact UK and European Energy Security. Therefore, the option of doing nothing provides a too severe consequence. The average value of constrained gas based on the latest DESNZ[5] reference prices is 73p/therm (or ~£274k/mcm). If the whole UKCS or Interconnector terminal where constrained, we would likely need to buyback the capacity up to the obligated release level.

[5] https://assets.publishing.service.gov.uk/media/6567a7c15936bb001331671d/Annex_M_assumptions_growth_price.ods

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

4.2.1 Our final preferred option is an asset health solution, based on the condition of above and below ground asset systems and the forecast supply and demand scenarios. There are no credible circumstance changes in the methane world that impact the selection process of the FOSR, meaning an asset health approach is the optimum direction. Some examples of changes that could affect the detail of our preferred option, but not the principle of the asset health solution, that offers flexibility to manage within potential changes:

- Significant changes in European markets and thus flows from and to UK through interconnectors (as witnessed in recent years).
- Consolidation of operators could mean that a reduced number of UKCS incomers are required. Additional decommissioning cost would need to be considered along with operator plans to operate any newly acquired assets.
- Changes in global gas (inc LNG) markets.
- Changes in world markets could either reduce or increase the amount of gas coming to the UK.
- Unforeseen Technical challenges to deliver the proposed scheme of a scale beyond that currently anticipated. For example, more rapid or greater increase in the proportion of hydrogen within the pipelines may not be compatible with the older infrastructure at Bacton necessitating a larger scale replacement of facilities.

4.2.2 Overall, out to 2050 and beyond, there is uncertainty arising from the actual pathway to be followed by the UK in pursuit of the net zero transition. Therefore, there remains a need to invest to meet the short-term requirement to ensure continued safe and reliable site operation whist allowing for long term uncertainty.

4.2.3 Our Hydrogen Future statement in Appendix F provides further detail on our view of this future energy landscape and Bacton's role in it. Bacton lies on the Hydrogen Backbone route Project Union, the European Hydrogen Backbone and within the area of Capital Hydrogen and Hydrogen Valley projects.

4.2.4 The exact requirement for hydrogen opportunities is currently unclear, however NGTs preferred option has the advantage of focusing on no regrets work which is required now. This has the benefit of providing time for these potential emerging net zero opportunities to develop. As the asset health solution is progressive, it can allow a divergence and integration at a later date in a controlled manner as opposed to being locked into a fixed long term major project programme that is harder to move away from if the industry shifts to adopt hydrogen at scale.

4.3 What are we going to do with this project?

4.3.1 Our Final Preferred Option is to develop and deploy an asset health solution within the existing terminal footprint, rather than look to rebuild or extend the existing site. The existing terminal design has a high degree of flexibility to manage the full range of operating conditions that is required by our customers. The majority of the terminal was identified to be within IGEM/TD/12 limits in as far as below ground pipework, sustained stress, shakedown stress & fatigue usage were concerned. However, a number of systems are age expired, have a number of defects impacting on their operation and condition data indicating that replacement is required. Our preferred option will address these issues. More detail on our Final Preferred Option can be found within Sections 6, 7 and 8.

4.4 What makes this project difficult?

4.4.1 Bacton Gas Terminal is one of two Upper Tier COMAH sites, critical to ensuring Energy Security to both the UK and to Europe.

4.4.2 During any project works, there is a requirement to minimise disruption to shippers and other customers. Any outage on a range of key systems has the potential to impact on upstream [redacted] and Downstream Customers [redacted]. Our asset health programme has been developed understanding the outage implications and the impact this could have to terminal operations.

4.4.3 Bacton is in a geographically isolated and exposed part of the United Kingdom, which increases the costs of supplying material and personnel to site, as well as being subjected to more coastal winds, sea fogs and other metrological challenges that can disrupt project works. This creates greater demands for additional mitigations e.g. enhanced habitats for surface prep, coating and welding. In addition, the human resources and skill sets required to carry out gas transmission construction projects are in high demand by the rest of the Southern North Sea Oil and Gas Industry, onshore and offshore renewables as well as general large scale construction projects. This can create highly competitive market conditions for these resources affecting cost and programme.

4.4.4 The current national and international geopolitical situation is creating significant uncertainty in prices and availability of materials and labour, which makes estimating project delivery costs more challenging. This will need to be a consideration when finalising the delivery strategy after Ofgem's confirmation/approval of the preferred option.

4.4.5 In addition to this, Bacton is located in a rural area of the United Kingdom. It can be harder to reach these types of communities with updates, therefore early stakeholder engagement has been conducted on our investment plans and the impacts this programme of works has on the local region.

4.4.6 The most potentially disruptive aspects of the preferred solution will be centred around the replacement of main line critical process / isolation valves as this work reduces the potential flow paths within the site impacting site resilience. This work is very similar in scope and nature to the asset health valve replacement works undertaken at Bacton in RIIO-T1 and will be managed in a similar way to minimise disruptions to shippers, customers, and wider markets through a phased valve replacement programme.

4.5 What are the key milestone dates for project delivery?

4.5.1 The project aims to conduct a programme of asset health investments across RIIO-T2, T3 and beyond. The table below sets out the project milestone dates based on our current Bacton Future Operating Strategy sanction.

4.5.2 The stage gates within our GNDP process ensure minimum requirements are met for each phase of investment development.

Table 5 Phase and Milestones

GNDP Phase	Summary of Activities / GNDP Gate Titles	Gate Indicative Milestones		
		CP System	Valves	LV Electrical
Phase 4.0 Establish Needs Case	Identification of the needs case			
	T1 Acceptance of Need Case	N/A	Sep-18	Sep-18
	F1 Optioneering sanction	N/A	Sep-18	Sep-18
Phase 4.1 Establish Scope and Options	• Validation of needs case • Define strategic approach, success criteria and benefits • Establish potential scope and options to be considered in the next phase			
	T2 Sign off preferred strategic option Hand over to delivery team	Sep-20	Jul-20	Jul-20
	F2 Feasibility sanction	Oct-20	Jul-20	Jul-20
Phase 4.2 Select Option	• FEED Feasibility • Assess valid options to establish best value solution which meets the needs case and delivers the identified benefits and success criteria. • Submit Final Option Selection Report			
	T3 Agreement to proceed to conceptual design	Oct-23	N/A	N/A
	F3 Conceptual Design / Long Lead Item sanction	Oct-23	N/A	N/A
Phase 4.3 Conceptual Design	• FEED Conceptual • Develop preferred option to provide certainty over cost, programme, and risks • Submit Cost Reopener • Procurement of Long Lead items • Tender event (if Design and Build)			
	T4 Scope Freeze	Jul-24	Nov-24	Nov-24
	F4 Detailed Design & Build sanction (if Main Works Contract is Design and Build)	N/A	Nov-24	Nov-24

Phase 4.4 Execute Project	• Contract award for Detailed Design or for Detailed Design and Build • Detailed design activities • Tender event (if Build only)			
	T5 Detailed Design challenge & review completed	Nov-24	Nov-25	Nov-25
	F4 Build sanction (if Main Works Contract is Build only)	Dec-24	N/A	N/A
	• Contract award for Build (if not Design and Build) • Delivery, commissioning, and technical completion • Operational Acceptance • Records updates • Asset Acceptance			
	T6 Hand back for closure	May-27	Mar-34	Feb-29
Phase 4.5 Reconcile and Close	• Completion of Financial activities			
	F5 Closure	Aug-27	Jun-34	May-29

4.6 How will we understand if the project has been successful?

4.6.1 Project success will be confirmed by operational acceptance of the replaced or refurbished assets, meeting customer and network demands throughout construction and commissioning period as well as the project completed to time, quality and cost. Additionally, the following specific measures held define the success criteria:

- FOSR execution and completion – A final Options Selection Report issued by February 2024
- FOSR execution and completion – Submit the UM cost re-opener by July 2024
- Determination from Ofgem by November 2024 to allow successful execution of the programme.
- Bacton Terminal end state – By the mid 2030's a reliable terminal that meets customer needs, has an appropriate asset life and is efficient to operate and maintain.

4.6.2 In addition, for this Option Selection Stage the project will have been considered a success if the PCD set out in Special Condition 3.10 is deemed fully delivered. The PCD entails the FOSR being submitted to Ofgem by February 2024 and subsequent Re-opener submission later in the regulatory period, following Ofgem's review of the preferred option that provides the right solution at the best value for consumers.

4.7 Related Projects

4.7.1 There are key interactions with other significant investments, both at Bacton and across the NTS. These are summarised below:

4.7.2 RIIO-T2 Baseline Funding

Funding has been granted through the RIIO-T2 final determination for a programme of Asset Health Works at Bacton on a range of asset systems including, Civil Assets, Cathodic Protection, Filters inspection and refurb as well as the Fire Water Ring Main. Additionally, funding was awarded for Asset Refresh of the sites Security Solution and to decommission redundant assets at the site ([redacted] incomer, Boilers, Dewscopes & Odorant area). These investments are no regrets against the full range of options considered in this FOSR. As part of the final Bacton terminal site redevelopment re-opener submission, NGT plan to present and true up all existing baseline UID's that are associated with the Plant and Equipment theme. These are UID's that were omitted form the January 2024 Plant and Equipment submission and align better with the works proposed at the terminal as a grouping.

4.7.3 [redacted]

[redacted]

4.7.4 Bacton Investment Strategy

Following on from the RIIO-T2 Final Determinations, the strategic direction for our investments proposals at Bacton needed to change for several reasons. The original RIIO-T2 proposals for brownfield development were shown not to be viable due to plant separation and proximity issues associated with NGT's T/PM/G/37 Safety Procedure for site layout studies. Additionally, significant risks relating to dust entering the facility have materialised with this also being exacerbated by the Russia/Ukraine crisis. These topics have raised the focus and profile of the site and its importance to energy security in UK and EU. Noting these facts and as the asset base continues to age, meant careful thought has been put in to how we deal with aged assets subject to condition issues.

Our updated Bacton Investment Strategy sets out our revised investment approach, seeking to adopt a two-phase strategy, Phase 1 No regrets asset health investments that require immediate intervention to ensure continued operation and where NGT have a higher cost confidence and Phase 2 long-term site operating strategies which will form part of NGT's rolling AMP and via RIIO-T3/T4 and beyond. Phase 1 investments were assessed as no regrets against the emerging options developed through this FOSR. The Investment Strategy was submitted in June 2023.

4.8 Project Boundaries

4.8.1 This project seeks investment to secure the continued efficient and reliable functioning of the Bacton terminal. It includes the FEED study completed during RIIO-T2, which has informed the final details of the solution and costs. Ongoing costs for interventions associated with this option are included in this request and have been included within our bulk cost comparison in section 6.

4.8.2 The scope of the project includes all the assets that are situated at Bacton within the fence line. It does not include the road crossing between the NGT terminal and the upstream terminals, given these have been designated as feeders under the Pipeline Safety Regulations (PSR) and are common assets across all options considered in the FOS. The road crossings were exposed via excavation in 2023 which identified these to be in good condition, works to establish a regular inspection regime will for part of the funding request for the RIIO-T3 business plan.

4.8.3 Where relevant, due to the nature of the final preferred option, the project will include a limited number of Plant and Equipment asset health investments for which funding was received in our RIIO-T2 baseline final determination but are subject to an uncertainty mechanism to either true-up or request additional allowances. An example of this is the CP Investigations and Rectification UID, which received limited baseline funding. Our final preferred option for the Bacton terminal site redevelopment Re-opener includes the balance of scope and cost for the full scope of CP system replacement.

4.8.4 Projects that have progressed at risk including intervention on our Over Pressure Protection Systems on our A1, A2 and S4 incomers, safety instrumented system (SIL 2) and are therefore not included within this project and are subject to separate funding requests. These have progressed due to the immediacy of the investment driver and have been subject to separate regulatory discussions and determinations.

4.8.5 The assets owned by Interconnector UK, situated within the boundary of the Bacton Terminal, are outside the scope of this investment as are owned and managed by Interconnector UK.

5 Project Definition

5.1 Expected Flows and Site Operation

5.1.1 The details in the following section are drawn from the Needs Case which is based on the analysis undertaken in support of our 2019 RIIO-T2 business plan submission to Ofgem, and associated Annex A14.02 Bacton Terminal Redevelopment Justification Report December 2019. This has been included in appendix K for information.

5.1.2 The information within the needs case has been updated and refined to support the FOSR. In the RIIO-T2 Final Determination Ofgem accepted the Needs Case, but did not agree with our preferred option. A range of other considerations have been included to improve the operation of the terminal and impact this has on the rest of the NTS. These include:

Options to improve interoperability between Feeders 3 & 5 and 2 & 4 at Bacton Terminal

5.1.3 From an operability point of view, Bacton is required to facilitate flows from the north and centre of the NTS towards the southeast of the network during peak winter conditions. It also needs to facilitate the flow of gas from southeast of the network during supply surplus conditions (during high Isle of Grain terminal supply inputs along with low southeast demand) towards the centre and north of the network. This requires the terminal to seamlessly support the interoperability of flows between Feeder 3 and 5 (into the southeast of the network), and Feeders 2, 27 and 4 (into the centre and north of the network). Operational experience has highlighted some technical difficulties, such as having a high differential pressure across the terminal which can hinder this required interoperability of flows. NGT is planning to make the necessary impact assessment and potentially submit necessary asset requirements as part of the RIIO-T3 submission.

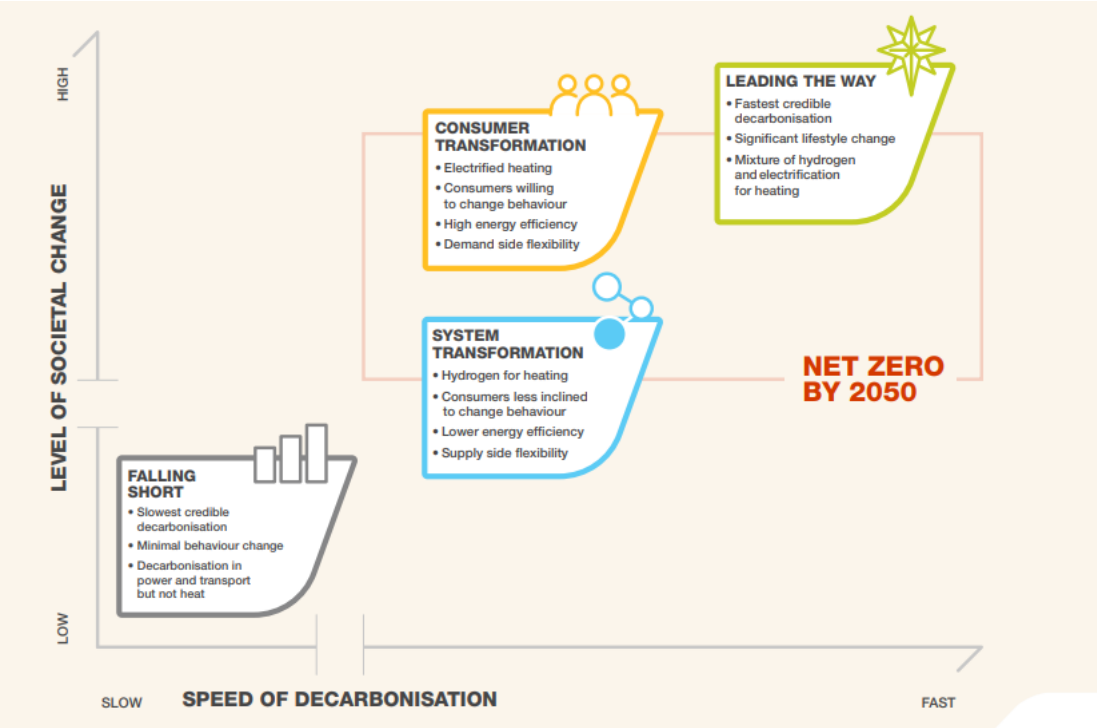
5.2 Supply and Demand Scenario Discussion and Selection

5.2.1 To fully assess the project, a network assessment to define the capability boundaries was completed. This utilised data sourced from the Future Energy Scenarios (FES) and information direct from ESO. The output from this was then used in a risk and constraint assessment and detailed within the completed RAM study.

5.2.2 The gas landscape has changed considerably in the last 20 years. With the continued decline of UK Continental Shelf (UKCS) supplies and the need to decarbonise, National Gas Transmission expects gas supply and demand patterns to continue to be volatile going forwards. Therefore, is impossible and inappropriate to forecast a single energy future over the long-term planning of the gas network.

5.2.3 The project originated when FES 2018 was the basis being used for network modelling and risk assessment and has been revalidated against the latest FES scenarios.

Figure 3 – FES 2023 Scenario Framework



5.2.4 Figure 3 shows the four scenarios as described in the National Grid ESO FES and provides ESO's views of different pathways to meeting the net zero target. These range from the Falling Short (FS) scenario, that falls just short of the net zero target, to Leading the Way (LW) which achieves net zero ahead of 2050. Each scenario is dependent to varying degrees on a series of changes to government policy and legislation, energy delivery and consumption, consumer behaviour, technological change and government incentives and investment. In many ways, these different pathways also represent different potential extremes of energy industry change. As such, FES on its own provides no validation of the most appropriate investment option for the gas network or its assets (including Bacton). Instead, it provides a broad envelope of energy backgrounds where each scenario is equally credible, against which the merit of alternative investments may be appraised rather than to assess the need for the investment in the first place.

5.2.5 The two low natural gas scenarios, Customer Transformation (CT) and Leading the Way (LW), meet the targets via electrification either at a transmission or distribution level and involve changes in consumer behaviour along with steep improvements in energy efficiency. The significant use of hydrogen is considered in LW and System Transformation (ST) scenarios. With LW hydrogen is produced predominately from green sources and with ST hydrogen is produced from a more balanced combination of green and blue sources, which is the reason for the higher long term natural gas need for ST. In many ways, ST is a balanced scenario with a mixture of electrification, conversion to hydrogen and increased energy efficiency and demand led consumption.

5.2.6 Considering the factors discussed above, we have used the Peak Falling Short scenario as the base case scenario for this FOSR to model credible maximum supplies coming into the network, particularly where these include interconnection to the EU and interaction with LNG from Grain LNG.

5.3 Key Flows and Boundaries

5.3.1 Figure 4 shows the FES 2023 flow forecasts for Bacton Entry for the Interconnectors and UKCS. This provides a background on Bacton capacity provision, the Obligated Entry Capacity baseline at Bacton UKCS of 44.8 mcm/d and at Bacton Interconnector point obligated capacity of 119.8 mcm/d.

5.3.2 UKCS supplies enter Bacton from both Perenco and Shell sub terminals. Perenco sub terminal also processes gas from the ENI sub terminal which used have a separate incomer coming into Bacton. [redacted] The FES flow for UKCS supply shows a significant reduction leading up to 2040. The peak Interconnector Entry flows (across both BBL and Interconnector UK), in Figure 4, shows an enduring entry flow across the period to 2050 staying at more than 90 mcm/d.

Figure 4 Bacton Entry peak flows based on FES 2023 forecast

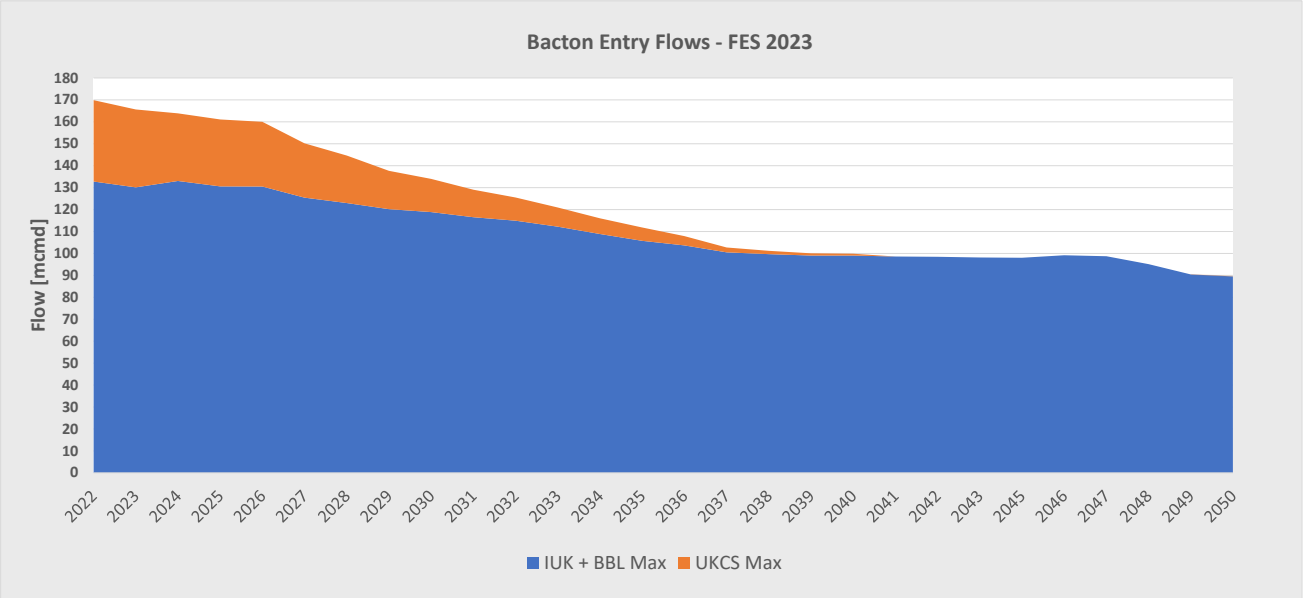
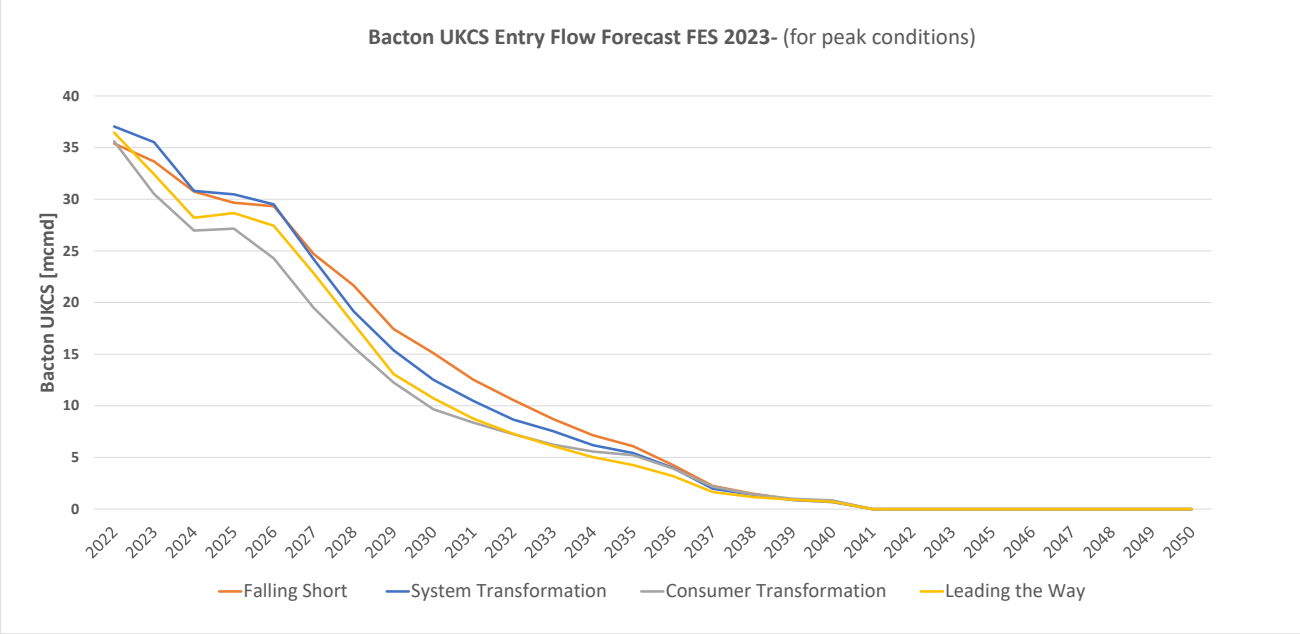


Figure 5 Bacton Entry UKCS peak flows based on FES 2023 forecast



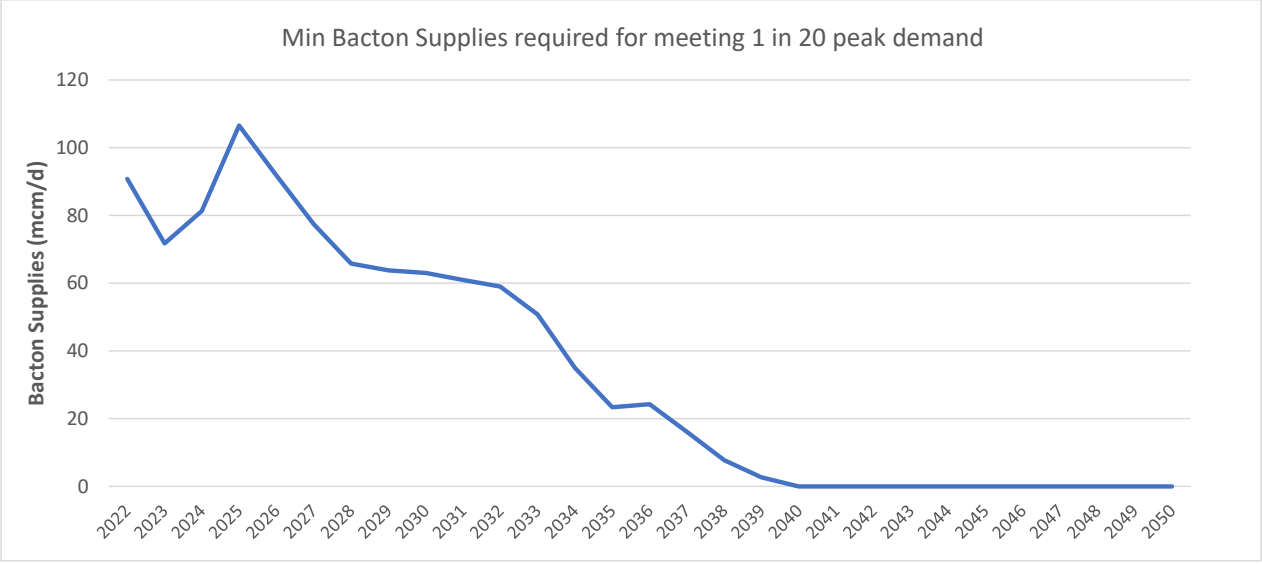
5.3.3 Figure 5 shows the UKCS peak supplies for various scenarios within FES 2023. [redacted] The cessation of UKCS supplies into the terminal would be driven by the UKCS upstream parties [redacted], which may lead them to request disconnection, however this is uncertain. This process would be consistent across all options considered in this FOSR and therefore is not a differentiator between the options considered, given the preferred Asset Health option cover the investment required for continued safe operations to 2035 and beyond. Additionally, we are aware that [redacted] FES flows do not include additional supplies which may come from producers maximising existing fields in the North Sea or from the new gas exploration licences recently issued by the government.

[redacted]

[redacted]

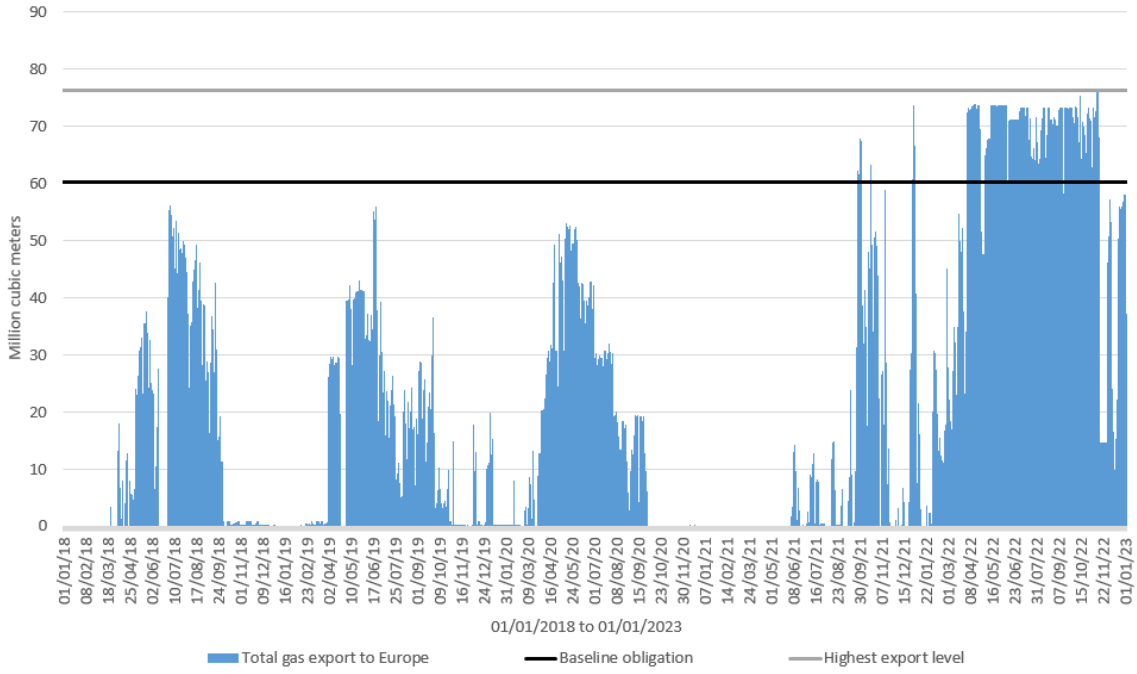
5.3.4 Bacton Entry flows are key in meeting the 1 in 20 demand requirements within the NTS. Figure 8 indicates the requirement of minimum supplies from Bacton to meet peak 1 in 20 demand requirements (net supply required specifically from Bacton terminal to meet the South East 1 in 20 peak demand). This assumes baseline supply from the Isle of Grain terminal of 65 mcm/d even with maximum flows expected from other Aggregated System Entry Points (ASEPs), including maximum NTS storage at an availability of around 100 mcm/d. Therefore, there is an ongoing requirement of needing gas flows from Bacton to meet NTS 1 in 20 demand requirements.

Figure 8 Bacton Minimum flow requirement to meet peak 1 in 20 demand conditions



5.3.5 Figure 9 shows the Bacton export flows seen in recent years, with a significant export of gas from the UK to Continental Europe. There is an expectation Bacton will experience high exports in the short to medium term, due to the energy situation in Europe and the need to fill EU storage facilities, driven by the geopolitical conflict in Ukraine.

Figure 9 Bacton Exit flow seen in recent years



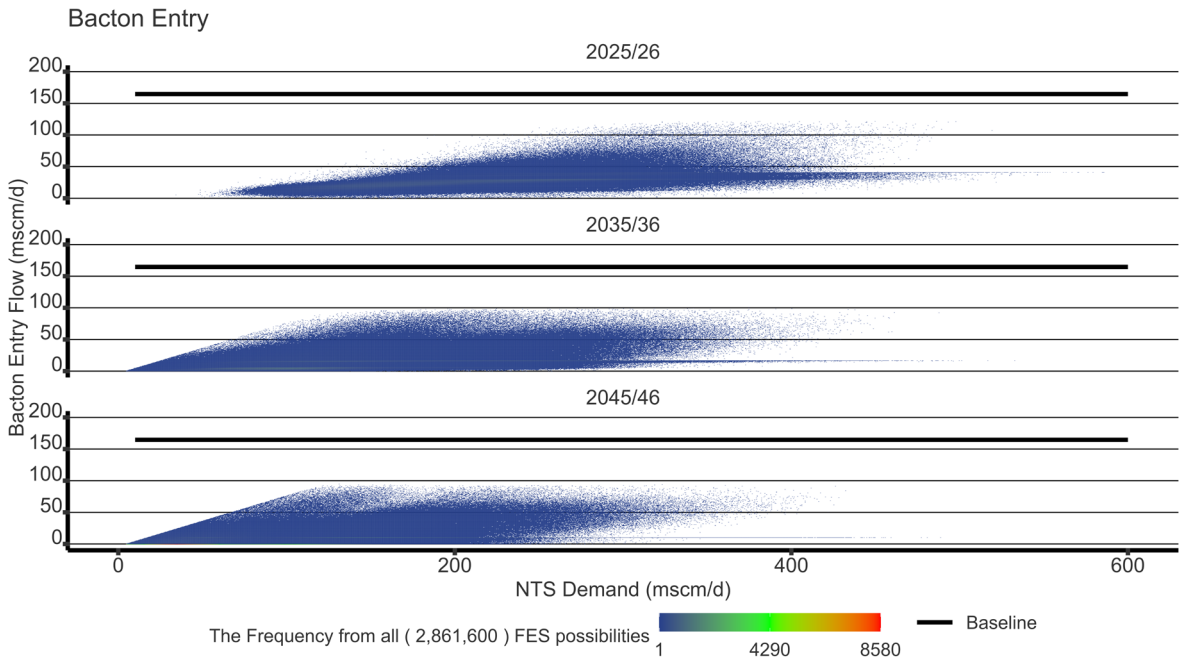
5.4 Capability and Availability

5.4.1 A key requirement for Bacton is to meet Entry commitments, with Obligated Entry Capacity of 44.8 mcm/d and Interconnection point obligated capacity of 119.8 mcm/d. The flame charts shown in Figure 10 and Figure 11 depict terminal entry and exit flow potential using FES 2023 data within NGT modelling output. The flow data is represented by having dots plotted onto the chart where one dot is associated with one day in that year. For every day there are 7,840[6] alternative supply and demand patterns across the four FES Scenarios and associated high and low LNG Sensitivities[7]. The frequency of a particular flow point is represented by the colouring on the chart, as defined in the chart key. Charts are shown for years 2025, 2035 and 2045, showing how we expect supply and demand patterns to vary over time. As shown in Figure 10, although the expected Entry flows are forecast below the baseline Entry capacity level at the terminal, due to the on-going requirements for flexibility and resilience as detailed in section 6, there is limited scope for rationalisation in the short to medium term.

[6] For each FES scenario there are 980 supply / demand flows considered, for both high and low LNG import cases. This gives 7840 possible supply/demand patterns per day equating to 2,861,600 possibilities per year. These are mapped as points onto our flame charts as dots colour coded to reflect frequency range at a location on the charts. Refer to our annual ANCAR publication for more information.

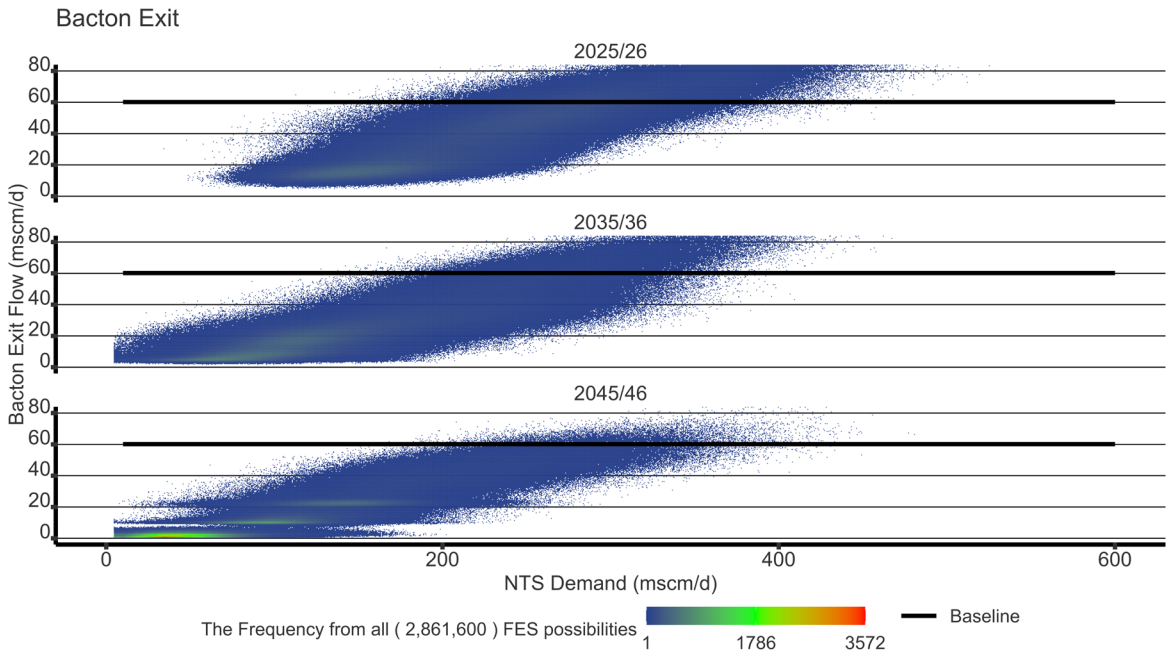
[7] Within each FES scenario, sensitivities for high continental and high LNG imports are also included, and these are included in the flame charts in this section.

Figure 10 Bacton Terminal Entry Forecast possibilities FES 2023 NGT internal modelling output



5.4.2 The terminal is also required to meet NGT's Exit capacity commitments. Figure 11 shows exit flows from FES 2023 using our internal modelling output. In recent years, we have seen Bacton Exit flows well above the obligated capacity level of 60 mcm/d, this has been facilitated with the release of non-obligated Exit capacity subject to NGT discretion, based on operational risk assessments.

Figure 11 Bacton Terminal Exit Forecast possibilities FES 2023 NGT internal modelling output



5.4.3 Bacton provides significant flexibility in the operation of the NTS in the south and east of England. Below are details of some of the key functionality it provides:

- Bacton is utilised to meet NGT's Exit commitments (including assured pressures and pressure cover commitments) in the southeast of the network along with maintaining

the required operational flexibility. This is currently provided by the terminal's ability to maximise flows into NTS Feeders No.3 and No.5, the main feeders to supply London and southeast demand, with higher pressures and flows when required.

- It is required to manage the changing flows patterns and within day swings of supplies into and out of the terminal, including import/export requirements from the EU interconnectors, along with the ability to meet the ramp rate requirements.
- At Bacton there is a requirement for process separation of individual suppliers as each has different processing capability to prevent unwanted process interactions such as back flows, issues of liquids coming into our network and potentially going out into key demand points such as the interconnectors. The terminal is also required to blend gases (co-mingling) from the upstream supplies on a reasonable endeavours basis to manage the gas quality issues from some of UKCS sub-terminals.
- Bacton has to accommodate the Cadent Gas offtake into the Local Distribution Zone and Great Yarmouth Power Station demands, [redacted] (based on the obligated baseline and the expected flows at these sites beyond 2040).

5.5 Stakeholder Engagement on FES data

5.5.1 In addition to the analysis of FES data flows, we have also undertaken stakeholder engagement [redacted] Stakeholder engagement [redacted] has indicated that UKCS supplies into Bacton could continue well beyond 2040. Operators are looking to extend economic field life through reduced operational expenditure (Opex), achieving high oil prices and improved technology. Furthermore, recent government decisions to award further UKCS exploration and production licenses could result in higher input at the terminal[8]. In Appendix J we have included a recent update on potential licence awards in the Southern North Sea and their production potential. Details from our Stakeholder Engagement can be found in Appendix H.

5.5.2 Key findings and feedback from engagement:

- Upstream oil and gas customers have and plan to undertake significant investment in their own infrastructure associated with the Bacton.
- Informal feedback from customers and stakeholders highlights the potential for additional methane flows through Bacton beyond that published in the FES data.
- [redacted] are supportive of the work we are proposing to secure the safe and continued operation of the facility and local economy.
- The following site requirements were identified:
  - Low and consistent pressures when flowing onto the NTS enabling:
    - Reduced cost of offshore compression
    - Field life extension, and opening more offshore fields

[8] https://www.gov.uk/government/news/hundreds-of-new-north-sea-oil-and-gas-licences-to-boost-british-energy-independence-and-grow-the-economy-31-july-2023

        - Planning for an uncertain future with regards to change in the energy landscape and ability to adapt to it.
    - High pressures during export to EU.
    - Minimal disruption to flows in or out of the terminal during construction work:
        - Possible to agree/align up to 2-week outages per year.
        - More than this has significant financial impact of 73p/therm (or ~£274k/mcm)
    - Our stakeholders also informed us that we need to be able to manage an increase in shorter term capacity bookings and flow volatility
        - Wider gas market is more volatile, there are less long-term interconnector capacity/flow bookings and we need to be able to manage volatile upstream UKCS supplies
        - Baseline entry capacity requirement not reduced.

5.6 Reliability, Availability, Maintainability (RAM)

5.6.1 To support our options selection process NGT have developed, [redacted], a detailed Reliability Availability Maintainability (RAM) model of the Bacton Terminal. This predicts the performance of the site assets. The model includes all specific discreet assets (E.G valves, pipework, electrical switchgear) at the terminal. A range of gas flow patterns were applied to the model including supply and demand scenarios, within day flow profiles, disruptions, planned maintenance, turndown and demand changes to obtain a balanced view of reality.

5.6.2 The study considered five flow scenarios that are likely to be seen across a typical year and considered the effect of existing terminal reliability and deterioration in both 2025 and 2050, looking at a range of outputs:

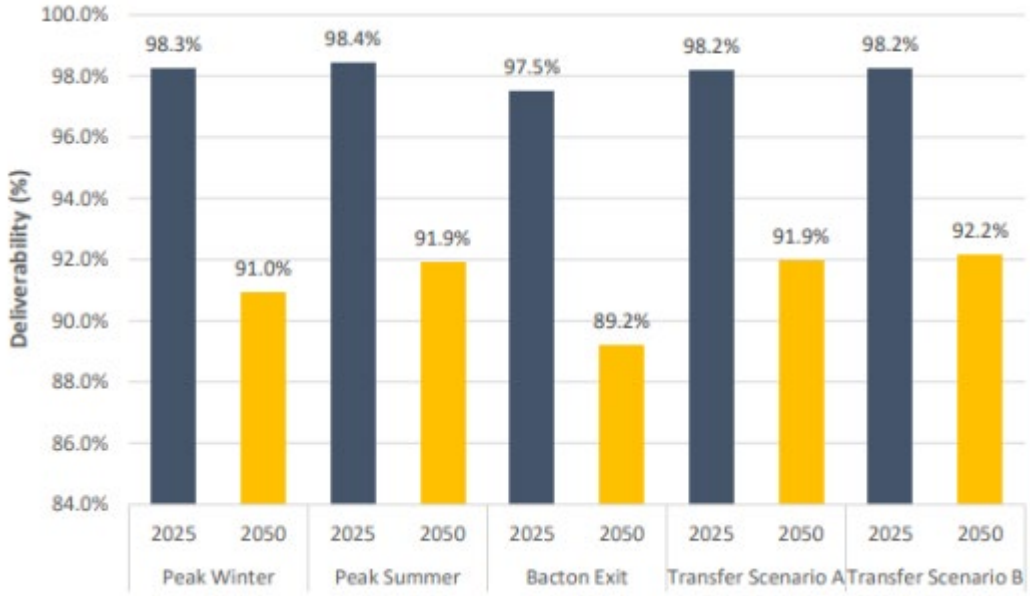
- Forecasted Terminal gas throughput. Likelihood and duration of terminal supply interruptions
- Annual Terminal availability results for 2025 and 2050
- System and Equipment criticality.

5.6.3 Across the two assessment years (2025 and 2050) five flow cases were considered to represent entry and exit configurations that are likely to be seen at the site across a typical year. The five flow scenarios defined were:

- **Peak Winter Conditions** – High UKCS and High INT and BBL flows into UK. Flows from the terminal into the NTS along Feeders 2,3,4,5 and 27.
- **Peak Summer Conditions** - High INT and BBL flows to EU with high flows on Feeder 2, 4 and 27 from the NTS into the Bacton Terminal and minimum flows from the terminal to Feeder 3 and 5.
- **High Bacton Exit** - same as peak summer option with Feeder 27 looped around. The loop is where Bacton terminal will send gas towards Kings Lynn via Feeder 27 which is then filtered, sent back to Bacton, then filtered again at the terminal before existing via INT and or BBL leading to double filtration.
- **Low Bacton Inputs 1 (Transfer Scenario A)** - Feeders 2, 4 and 27 flowing gas towards and through Bacton onto Feeders 3 and 5, in order to meet South East pressures and security of supply obligations.

- **Low Bacton Inputs 2 (Transfer Scenario B)** - Feeders 3 and 5 flowing gas towards and through Bacton onto Feeders 2, 4 and 27 towards Kings Lynn (to demonstrate all possible scenarios have been considered).

Figure 12 RAM Bacton Terminal Deliverability 2025 and 2050 by scenario



5.7 RAM Study

5.7.1 A RAM Study was undertaken [redacted] to predict the performance of the site, considering factors such as future flow scenarios (FES) and ongoing equipment deterioration (predicted failures for various asset types and age). The output of this RAM study was used to support our decision making regarding the terminal redevelopment and our optioneering process, such as whether to maintain the existing operations, scale down Bacton or rebuild an alternative site.

5.7.2 Deliverability is the ability of the terminal to receive and process the total gas demand from the Operators to the NTS and Interconnectors.

5.7.3 An assessment was undertaken on the impacts to deliverability considering 'typical flow scenarios' in 2025 and 2050, and a reduction in UKCS incomers and loss of the Ring Main, due to predicted asset failures on key contributors to Deliverability.

5.7.4 The 'Base Case' assessment concluded that without asset interventions, Deliverability would be reduced by 1.76% in 2025 and 8.75% in 2050, which translates to a predicted 1 in 16 year 'unplanned supply interruption' (partial or full loss of supply once every 16 years) in 2025, increasing to once per year by 2050. This is further broken down into sub-system contributors to identify critical systems and the need to maintain sub-system deliverability.

5.7.5 The data suggests that higher contributors are 'more critical', e.g. a reduction in or loss of high flows through Interconnector UK present a greater reduction in Deliverability. This is valid data, however the commercial impacts and potential reputational damage associated with reduction in, or loss of any Operator flow would be hugely significant. In summary, the predicted reduction in Deliverability, should the proposed investments not be made, presents an intolerable level of risk. This is difficult to quantify in monetary terms, as individual asset or sub-system failures and multiple flow scenarios are too numerous to assess. This is discussed further in Section 6 under 'Resilience', together with narrative supporting Bacton to remain in its current configuration.

5.7.6 The 'Base Case' also considers how Deliverability is maintained at required levels through maintenance of 'All' assets, which are key contributors to Deliverability. The preferred asset health option presented in this FOSR seeks to address the known issues that are key contributors to Deliverability. A range of additional asset health investments, driven by age, obsolescence and defects shall be needed at the site but are not included within our preferred option. This does not affect the outcome of our options analysis, given all evidence supports the same Asset Health solution out to at least 2035, with FES flow predictions supporting this solution to beyond 2045.

5.7.7 Our Asset Health option targets on assets which are key contributors to Deliverability and have known defects. These being Critical Valves and Electrical Power Supplies (Low Voltage Electrical Distribution System). Additionally, the Cathodic Protection (CP) system replacement, which is identified in the [redacted] report. Additional CP funding is required for delivery of the full system replacement, therefore is included in the scope of our preferred Asset Health option. Other key asset contributors to reductions in Deliverability were identified, but do not have existing defects. It is intended these will be captured for proposed investment as part of future business plan submissions for RIIO-T3 and beyond.

5.7.8 The RAM study demonstrates that the current terminal configuration provides excellent flexibility and resilience. This, together with the outputs from our Remnant Life works (see 'Remnant Life' section 5.8), support our proposed Asset Health solution, with continued use of most existing primary assets (above and below ground pipework and valves) to 2050. As previously stated, the other short-listed options have the same scope of asset health interventions to at least 2035 and were discounted primarily due to the uncertainty of opportunities to rationalise the site based on forecasted flows, and the additional Capex investment over and above the Asset Health solution, which cannot be justified as they provide the same levels of Deliverability / Resilience, but at higher Capex cost.

5.7.9 Potential for Opex savings were identified in the [redacted] FEED Feasibility Study (discounted short list options), but these were predicated on the possibility to rationalise UCKS incomer related assets, by mid-2040's when these flows are predicted to cease. However, as previously stated this would be subject to customer disconnection requests, which are uncertain. As an Upper Tier COMAH site, Bacton is required to always have minimum levels of full-time personnel on site. Based on these factors, a reduction in Opex is not currently considered feasible, without confirmed opportunities to rationalise.

5.7.10 The Bacton site specific RAM study can be found in Appendix B of this report.

5.8 Remnant Life

5.8.1 A Remnant Life assessment was completed predominantly focussing on two main areas outlined below and from which a number of key observations were made:

- **Threat Assessment** - To identify relevant pipework degradation mechanisms that may limit the future operation of the main pipework.
- **Fatigue Life Assessment** – To allow a quantitative estimate of the remaining fatigue life of the pipework on the site.

Key observations:

- Pipeline threat analysis established all above ground equipment was in good condition with no major external corrosion damage or loss of coating.
- Assessments discovered that much of the CP system is ineffective, it is assumed that 20 years of active corrosion would be needed to reach the allowable wall thickness loss - showing a significant margin to failure.
- In assessing pipework, Fatigue cyclic duty includes 53 years past usage (assuming commissioning ~1969), plus a 40-year design life from 2022.

5.8.2 The conclusion from this assessment was that the majority of the terminal is within IGEM/TD/12 limits in as far as belowground pipe sustained stress, shakedown stress and fatigue usage is concerned. The Bacton site specific Reliability study can be found in Appendix C.

5.8.3 One point of note and exception here is that there are five pipeline tee sections located at Bacton where the wall thicknesses needs to be further verified and stress analysis to be concluded. This work is expected to conclude that these pipeline elements are acceptable and don't need to be replaced but at this stage as this must be confirmed, costs would likely be allowed for in our RIIO-T3 and AMP submission. We intend to close out this scope item ahead of the re-opener submission.

5.9 Remnant Life Study

5.9.1 In November 2021, stage 1 of the [redacted] FEED Feasibility study provisionally concluded that an Asset Health option was the preferred solution for the Bacton Terminal to continue safe operations out to 2050. However, several uncertainties were identified with insufficient data available to ascertain whether the condition and reliability of the assets on the existing Bacton Terminal were credible enough to support the base case Asset Health option, which was of additional significance as this formed the basis for all short-listed options. To address these uncertainties, several workstreams were implemented:

[redacted] Bacton Remnant Life Study

5.9.2 The objective of this desktop study was to estimate the fatigue usage and assess the significance of other integrity threats, to determine the remaining life of the main terminal pipework. The two main tasks carried out were:

- **Threat Assessment** - A high level assessment to identify relevant and credible pipework degradation mechanisms that may limit the future operation of the main pipework.
- **Fatigue Life Assessment** - A quantitative estimate of the remaining fatigue life of the pipework, using stress analysis software, according to the requirements of IGE/TD/12 ED2. The analysis considered cyclic stresses arising from pressure and thermal effects, based on collated monitoring data.

The Threat Assessment

5.9.3 This task primarily looked at potential for various types of corrosion and cracking on above and below ground pipework. It was concluded that there is a low risk associated with above ground pipework, with it being adequately protected through external coating systems. These were fully renewed in RIIO-T1, including full site bolting replacement, flange protectors and wind & water line coating.

5.9.4 For below ground pipework, the primary defence against corrosion is pipework coating. At the time this study was commissioned, it was recognised that limited data was available on below ground pipework coating condition, therefore a separate physical site survey workstream was instigated for Below Ground Pipework Coating Assessment.

5.9.5 The secondary line of defence is Cathodic Protection (CP), to protect the pipework where coating effectiveness has been compromised. At the time of commissioning these additional 'Remnant Life Studies', the last full site CP System function survey had been undertaken in 2019. As CP system effectiveness is known to degrade over time, it was concluded a full site CP system function survey should be undertaken to ascertain current and ongoing pipework protection from CP, to inform the [redacted] Threat Assessment. The CP system function survey was undertaken in 2023, and results provided [redacted] to undertake the Threat Assessment.

5.9.6 It was concluded that there is a medium risk associated with corrosion to below ground pipework, given the historic and ongoing degradation of the CP system (confirmed through 2023 CP surveys). However, preliminary results from the physical surveys of below ground pipework coating indicate coating is in good condition, therefore primary protection is still effective. Final reports on below ground pipework coating will be fed back [redacted] so the threat (currently medium) to below ground pipework can be reassessed (expected to reduce risk from medium to low).

5.9.7 In summary, the Threat Assessment concluded through remaining life calculation, based on an assumed worst case unmitigated corrosion rate of 0.25 mm/year, that the remaining life of the below ground pipework is at least 56 years assuming that intervening actions are taken with items such as the CP system replacement. This will be validated with the output from physical investigation works which at the initial review suggest a figure of 0.5mm / year. This is discussed further in section 8.

The Fatigue Life Assessment

5.9.8 This task looked at various load cases of pipework system fatigue associated with pressure and temperature cycling over its life, to predict anticipated damage and remaining life.

5.9.9 The main findings from the assessment were that the majority of the terminal is within IGEM/TD/12 limits and categorised as low risk, however some stress exceptions were noted at various manifolds, bends, tees and sweepolets for the sustained and shakedown cases. Only these stress exceptions were categorised as high risk.

5.9.10 As detailed material thicknesses were not available at the locations of these exceptions, less conservative analyses using improved geometry and thickness data, taken from design drawings/material certificates or measurements, or detailed Finite Element Analysis (FEA) could be undertaken for these locations to determine if they are within acceptable limits. Based on these preliminary results and recommendations, a current workstream is in progress to obtain physical geometry and thickness measurements to re-run the assessment of the current exceptions. Regardless of the removal of these stress exceptions or not, the conclusion that most of the terminal pipework is within limits, supports the preferred final option Asset Health solution, even if additional physical remediation is deemed necessary to remove any remaining stress exceptions.

5.9.11 In summary, the majority of pipework fatigue usage corresponds to a minimum remaining life of 40 years. For those specific locations where fatigue usage is shown to be an exception, it is possible that a less conservative analysis result could be obtained using physically measured data, which is in progress.

CP Surveys

5.9.12 These surveys were carried out in parallel to the Remnant Life study. They comprised Close Interval Potential Surveys (CIPS) and below ground intrusive Pipework surveys which can be found in Appendix D.

5.9.13 To confirm the current and ongoing performance of the CP system, which is required to protect below ground pipework, a CIPS survey was undertaken in 2023. The results of this independent contractor survey confirmed that ~95% of the CP system is not providing the minimum levels of required protection. This means that where below ground pipework coating is compromised, corrosion has or will occur. On this basis, and as pipework protection is mandated under PSSR, the independent contractor's recommendation is full system replacement. As such, it is included in the scope of our Asset Health solution.

5.9.14 The CIPS survey identified numerous locations where CP performance was particularly poor and of highest concern. These locations were selected by National Gas SMEs as positions to excavate on the below ground pipework to assess pipework coating condition and install Electrical Resistance (ER) probes for remote monitoring of CP performance and ongoing deterioration in these areas. These works were completed in late 2023, with finalised reports on the condition of the below ground pipework coatings in these locations are still in progress. However, results at the point of inspection, witnessed by National Gas indicated that coatings were in good condition. Inspections were carried out at a limited number of locations but provide a good yard stick for the overall coating condition. These results, together with further below ground coating condition results from RIIO-T1 works, generally indicate site wide coating to be of a good standard and has not shown any site-coatings to be in a detrimental condition giving rise to concern.

5.10 Security of Supply

5.10.1 Bacton Gas Terminal is a critical site to support UKCS Supplies and European Supply/Demand through Interconnector UK and BBL interconnectors. Failure to provide the correct level of capability and resilience has the potential to impact on UK Energy Security through the need for net Bacton Imports and European Energy Security through the need for net Bacton exports. It also has the has a high influence level on UK / EU gas markets so a failure of the assets can lead to a direct impact on UK PLC.

5.10.2 Furthermore, under NGT's Gas Transporter Licence we have an obligation to ensure cross border capacity is maintained 'The licensee shall build sufficient cross-border capacity to integrate cross-border transmission infrastructure accommodating all economically reasonable and technically feasible demands for capacity and taking into account security of gas supply'. In later sections of the document, we consider rationalisation and why this supports NGT's desire not to rationalise Bacton Gas Terminal.

5.11 Project Scope Summary

5.11.1 Our Final Preferred Option is for the Base Case Asset Health solution at Bacton. The process for determining this is presented through the FOSR in the following chapters 6, 7 and 8.

5.11.2 Based on the FES scenarios, Remnant Life and RAM studies completed during FEED, the terminal must retain its current configuration until at least 2035 to allow required gas flows and maintain existing entry and exit point capabilities. Around 2035, gas flows from UKCS are predicted to reduce significantly, but continue to flow beyond 2045.

5.11.3 To maintain required operability and resilience, an asset health investment programme is required within the boundaries of the existing terminal fence line. No changes in terminal flow capacity (pipework sizing) are required. Therefore, the Base Case Asset Health programme consists of replacing critical defective assets on a 'like for like' basis, but in line with current standards and specifications. The primary assets to be replaced out to ~2033 include 56 critical valve / actuator assemblies, 2 critical valve actuators, the Low Voltage Electrical Distribution System and the CP System. Additionally, due to ongoing deterioration and obsolescence, a programme of Control System and Instrumentation replacement / refresh will also be necessary for continued safe operations out to 2050, along with other minor Capex investments for other essential infrastructure such as buildings and roads. Other potential significant Capex investment out to 2050 could include replacement of other assets as they deteriorate and not provide adequate safe function. These may include such assets as critical valves, filters, heat exchangers etc, which have limited design and operational life.

5.11.4 As there is limited opportunity to rationalise the terminal in the foreseeable future and given the uncertainty of the transition to net zero, each short list option has the same level of investment required to ~2035 (Base Case Asset Health). The non-preferred short list options beyond 2035 identify possibilities to rationalise UKCS related assets, such as the [redacted] incomers and associated downstream assets. This would be subject to customer requests to disconnect which is currently very uncertain. Given FES predictions and the UK Governments current Policy on Licensing of new Oil & Gas fields in the UKCS, the likelihood is that future UKCS flows could be higher than current FES scenarios would indicate.

Table 6 Bacton Future Operating Strategy Project Scope Summary

Final Preferred Option	Base Case Asset Health Solution
Location	Existing NGT Bacton Gas Terminal
Scope Boundaries	The scope of this project is for costs associated with maintaining the existing terminal configuration (within the existing fence line) and flexibility through asset replacement / refresh to extend required safe operations up to 2050.
Availability Required	The optimum level of availability is primarily determined by NGT's obligations as a methane transporter and customer commitments supplemented by the bulk cost comparison analysis in coordination with our RAM study, demonstrating what the site needs to achieve in 2050.
Supply & Demand Scenario	All four supply and demand scenarios contained in FES 2021 and 2023 were detailed as part of the scope to examine the effectiveness of each investment option against a wide envelope of future energy backgrounds for example advent of Hydrogen and CCUS.
Project Scope	Base Case Asset Health to maintain terminal operations to 2035 and beyond comprises three key asset areas in priority order: • Cathodic Protection – whole system design and replacement including, Transformer rectifiers, groundbeds and text posts. • Low Voltage Distribution Systems – including cable runs, Distribution boards and circuit breakers • Critical Valves and actuation – covering 56 Valves, actuator assemblies and 2 new actuators
Programme	The works for this project are proposed to commence in 2025 with the three identified asset packages spanning up to 2032.

6 Options Selection

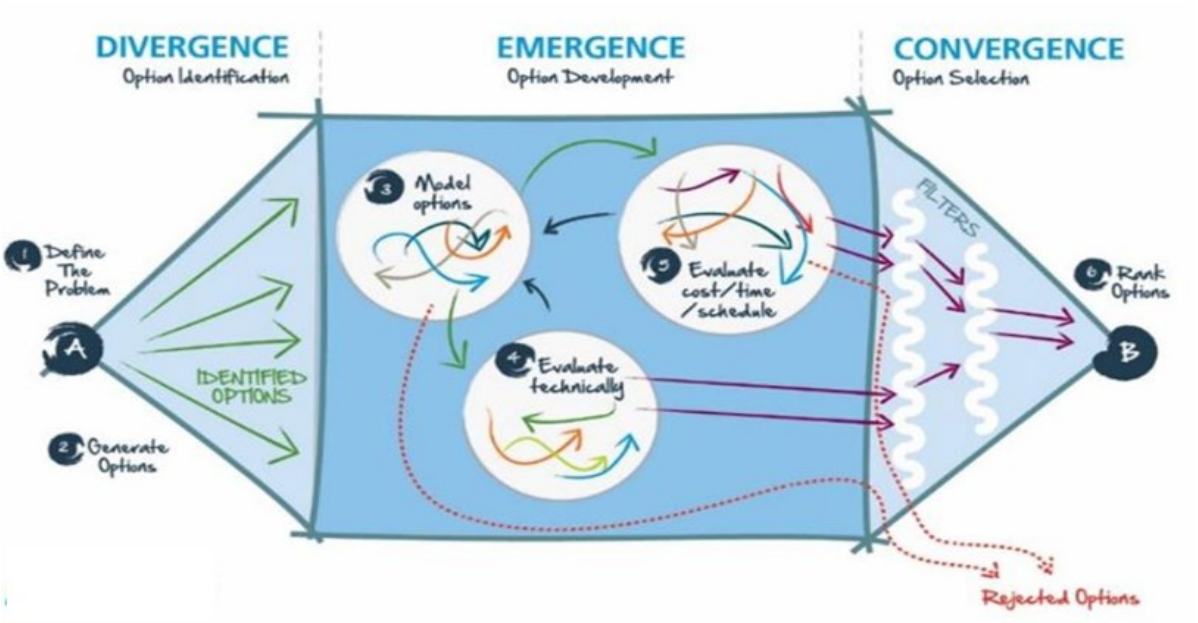
6.1 Options Considered

6.1.1 As part of our RIIO-T2 submission in December 2019, we proposed to undertake a brownfield terminal redevelopment at the site. However, as part of Final Determinations, Ofgem recognised that there was still uncertainty around the final solution and therefore provided funding to continue project development.

6.1.2 The options described within the Bacton Terminal Redevelopment EJP that supported the RIIO-T2 business plan have been investigated in more detail as part of this Option Selection process, including previously discounted options along with additional options not previously considered through our RIIO-T2 submission development. As outlined previously in detail within Section 4, we have considered the full suite of solutions to enable Bacton to operate efficiently and reliably now and up to 2050.

6.1.3 This section focuses on the engineering options and commercial rules and tools available to solve the problem described in Section 4.1 and uses the predicted flow data in Section 5 as the basis to generate plausible engineering solutions. This section describes the option selection process used to identify the Final Preferred Option for this investment, starting from option identification, through option development, to option selection. Figure 13 serves to identify the various stages involved in a typical option selection process.

Figure 13 Typical option selection process



6.2 Stakeholder Engagement

6.2.1 We realise the strategic importance of Bacton to the wider industry and country and our stakeholder engagement for the Future Operating Strategy of the site has focussed on following a robust process aimed at capturing the views of this wide range of interested parties.

6.2.2 During the development of options, NGT held 1-1's and group workshops with key stakeholders. These included:

- Sub Terminals at Bacton
- Interconnectors
- Producers and Offshore Pipeline Operators
- North Sea Transition Authority (NSTA) formerly Oil and Gas Authority (OGA)
- Local Offtakes – Cadent and Great Yarmouth Power Station
- Local councils, authorities, and residents (via the local councils)

6.2.3 Key findings and feedback from this engagement is that:

- Customers and upstream stakeholders have undertaken (or are planning) significant investment in their own infrastructure associated with and reliant upon the Bacton Terminal.
- Informal feedback also highlights the potential for additional methane import (volume and timing) beyond that within published FES data given the award of offshore oil and gas licences and the UK Government has stated the intention to maximise North Sea oil and gas production for energy security purposes.
- The local planning authority (Norfolk District Council), the East of England Energy Group and offshore operators are supportive of the work to secure the safe and continued operation of the Bacton Facility and the employment and local economy it supports.

6.2.4 The following site requirements were identified:

- Low and consistent pressures when flowing onto the NTS enabling:
- Reduced cost of offshore compression
- Life extension, and supporting the opening of more offshore fields
- Planning for an uncertain future
- High pressures during Exporting gas to EU
- Minimal disruption during work including In Line Inspections can be maintained
- Possible to agree/align up to two two-week outages per year
- More than this has significant financial impact of between £4.7m to £50m per day.
- Our stakeholders also informed us that we need to be able to manage an increase in short term bookings and flow changes

- Market is more volatile, there are less long-term interconnector capacity bookings, and we need to be able to manage volatile supplies.
- Capacity requirement has not reduced

6.2.5 A log of our stakeholder engagement is located in Appendix H.

6.3 Initial Option Selection and Justification

6.3.1 In April 2021, NGT selected an Option Selection Consultant, [redacted] to support us in quantifying and evaluating the feasibility of our potential investment options. It is normal practice for NGT to engage consultant support in development of projects like these, using the information to support our own expertise as the asset management organisation. As opposed to relying solely on information provided by consultants, NGT applies its own thought process and layers in the wider business context and interlinks when considering complex projects like this. In consultation[redacted], we have considered the full suite of solutions to determine the most effective long-term option for Bacton.

6.3.2 Option development has occurred in two phases; an initial Phase 1 involving development of a long List of options and following an evaluation, a Phase 2 short list assessment of 5 strategic options for more detailed consideration.

6.3.3 This section of the report explains the process we have adopted, and the options assessed.

6.3.4 Phase 1 long List work developed **26** strategic options that were grouped into families of options (see Figure 15) including asset health, future methane/hydrogen blend, electricity generation, abandonment, site redevelopment and continuing use as a methane terminal. The list of options was developed through a range of workshops [redacted], generating, reviewing, and evaluating options, as per the plan shown in Figure 14.

Figure 14 Long list options review stages

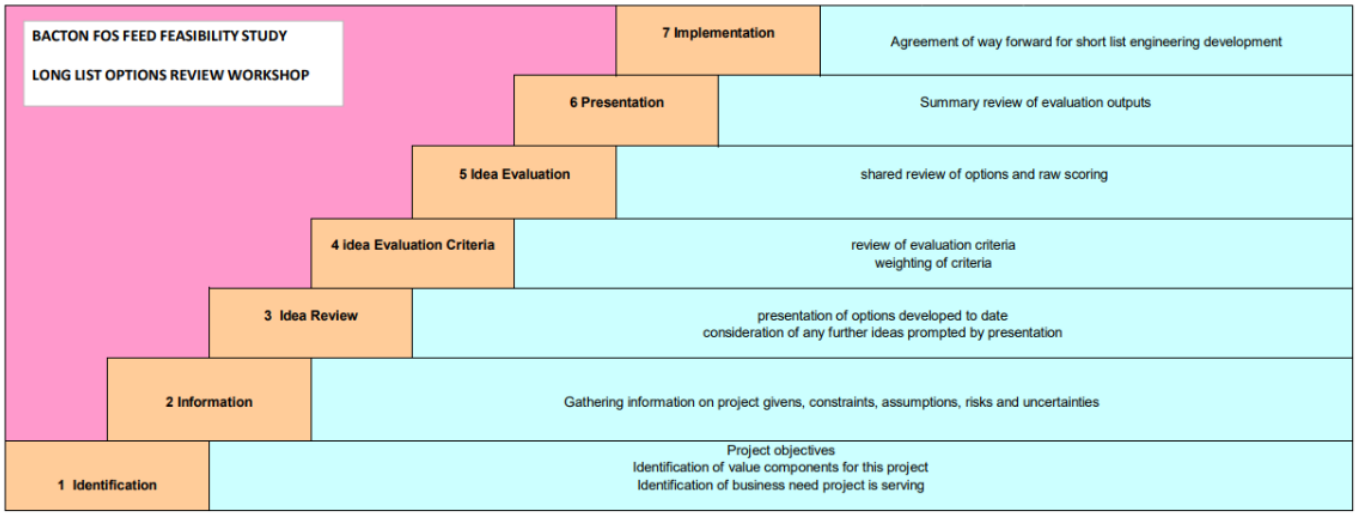
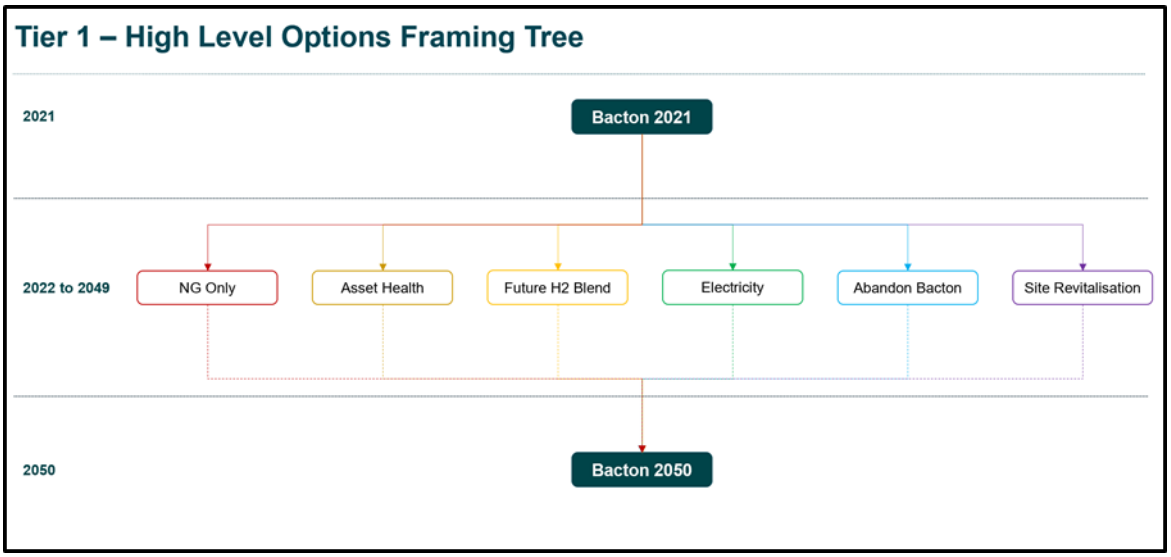


Figure 15 Long List - Options Framing Tree



6.3.5 An options selection criteria was developed to assess the long list using criteria comprised of the following 12 factors identified as being the most important for decision making:

- Constructability
- Allows for 2050 terminal IC flows of 100-120 mcm/d
- Capex
- Future operations align with net zero
- Complexity of option (schedule not excessive)
- Supports future customer operating requirements
- Allows for reuse of existing assets
- Carbon neutral construction
- Potential to reduce Opex
- Brownfield development – reduced planning
- Allows for gas blending with hydrogen
- Allows for hydrogen compatible design

6.3.6 A full list of all 26 options that comprised the long list, along with a full description of the optioneering process during Phase 1 can be found within the FEED study reports included in Appendix A. In summary, a qualitative and quantitative assessment of these options was undertaken against a range of option selection criteria. This included metrics environmental and sustainability. At this point the process started to move away from the original RIIO-T2 Brownfield site redevelopment plans with these being discounted fully at the next stage.

6.3.7 This process of short listing also included the reopener guidance issued by Ofgem. This directed the study to focus on options for Bacton as a methane terminal up to 2050. This removed many wide ranging and more ambitious options from the original long List. Noting the uncertain nature of Hydrogen deployment at this stage, only a light touch review of Hydrogen was undertaken via and presented in the NGT Hydrogen Statement that is included in Appendix F.

6.4 Final Option Selection & Short-Listing

6.4.1 Following on from the Phase 1 option selection evaluation, a short list of three main options were defined, together with several instrumentation and control alternatives which could be applied to any option. These options were subjected to a greater level of conceptual engineering including general arrangement drawings, process safety and environmental and sustainability assessments. Material take-offs were then generated as the basis for the cost and Carbon estimates for each option. Outputs from these assessments were then used for the evaluation of the short list options and selection of our preferred option based on agreed criteria and weighting. Table 7 details the options selection criteria weightings used at short listing stage:

Table 7 Short list selection criteria weighting.

Criteria	Weighting (%)
Allows for hydrogen compatible design	2.13
Capex	19.16
Constructability Risk (less SIMOPS)	17.02
Greenfield development – planning conditions	14.89
Opex should be reduced	8.51
Permits reuse of existing assets	8.51
Reduces current gas inventory (COMAH)	1.06
Terminal operations simplified	5.32
Minimal environmental impacts	14.89
Above ground piping is minimal	8.51
	100

6.4.2 A summary of the Short List Options is given in Table 8.

Table 8 Short list option summary

Option Number	Option	Option Variant	Applicable time period reflecting site maximum gas flows	Description
1	Base Case Asset Health		1.1 2021-2035 (site capacity up to 160 mcm/d)	Continue current site operations with ongoing operational and maintenance for equipment. From current up to when site gas flow capacity will diminish with the cessation of flows from SNS [redacted] at Bacton.
			1.2 2035-2050 (site capacity up to 120 mcm/d)	From 2035 – 2050 when Bacton site will flow only gas from /to INT and BBL lines to/from Feeders 2/3/4/5/27 at a maximum site capacity of 120mcm/d approximately. The abandonment of [redacted] assets at Bacton will permit continuation of the site operations with the minimum O&M expenditures.
2	Major Rationalisation and Reduce Inventory		2035-2050 (site capacity up to 120 mcm/d)	At 2035, modifications are made to the existing piping at Bacton including a new ring main, to permit direct feeding of gas from/to INT AND BBL lines to /from Feeders 2/3/4/5/27 following the redundancy of [redacted] assets.
3	New build (above ground, modular build, minimal reuse of assets)	3.1 Fits within existing site	2035-2050 (site capacity up to 120 mcm/d)	Following redundancy of [redacted] assets and their removal, the available area will locate a new facility to distribute gas from/to INT and BBL lines to/from Feeders 2/3/4/5/27
		3.2 Requires site extension/offsite development		Following redundancy of [redacted] assets, a new facility will be built on new land outside the southwest corner of the site to distribute gas from/to INT and BBL lines to /from Feeders 2/3/4/5/27.

Noting there are 3 short-listed options (with option 3 having a subset of two variants) a detailed description of the options has been included below:

Option 1 – Base Case Asset Health

6.4.3 Retain the Bacton Terminal in its current configuration and undertake essential asset replacements for continued safe operations to 2050. The main scope of asset replacement includes, Critical Valves, Low Voltage Electrical and Cathodic Protection Systems and Instrumentation. These works would be completed prior to 2035.

6.4.4 This option requires the lowest Capex of the short list options, and has benefits with least disruption to operations, and no requirement for planning permission, as works can be undertaken under permitted development (no change to landscape, emissions, or transport requirements).

6.4.5 FES indicates UKCS gas flows ceasing around the mid 2030's, and this could present opportunities to rationalise (this is included in the other short-listed options). The future of UKCS methane production and the route to net zero is uncertain. This option has the natural benefit of minimal 'no regrets' Capex to around 2035, by which time future investments to support the developing energy markets may be clearer. Additionally, this option retains the area currently occupied by disconnected ENI Sub-terminal related assets (North-West corner of the Terminal, to be decommissioned in RIIO-T2), for potential alternative use to support the energy future. Refer to Figure 16 for process Flow Diagram.

Option 2 – Major rationalisation and reduce inventory

6.4.6 This option is only applicable from 2035 following completion of the Option 1 Base Case Asset Health scope and the cessation of UKCS gas flows allowing the decommissioning of UKCS related assets. It uses the opportunity to simplify the site with some major investments in simplified piping and valve arrangements, including a modified ring main concept to maintain required operational flexibility and resilience. This option has higher Capex than option 1 (post 2035) but provides the same level of resilience based on gas flow requirements 2035-50. As per option 1, as all works are inside the terminal fence-line, there is no requirement for planning permission or negative impacts on communities. Freeing up the north of the site has potential benefit of alternative use to support the energy transition. Refer to Figure 17 for the process flow diagram for this option.

Option 3 – Partial New Build brownfield (3.1) / Greenfield (3.2)

6.4.7 Option 3 is also only applicable post 2035 following completion of the option 1 Base Case Asset Health scope and cessation of UKCS gas flows. These sub-options are based on a largely new build terminal, designed appropriately for the prevailing gas supplies and demands of the period 2035-2050, when all gas supply is coming from the interconnector supplies. Option 3.1 positions the new terminal within the existing boundary of Bacton fence-line, whilst Option 3.2 would be outside of the fence-line on new land currently being farmed to the south-west of the existing site (and partly used as a temporary NGT construction welfare facility).

6.4.8 Both sub-options propose minimal use of existing assets, with the majority of new assets being above-ground modular build, which lends itself to off-site fabrication and reduced on site construction. New replacement assets include mixing manifolds, metering, and pig-traps for pipeline inspection. Both variations of Option 3 would be much more disruptive to operations compared with Options 1 and 2, as they require significant outages. They also both have higher Capex than Options 1 and 2 (post 2035) but provide the same level of resilience based on gas flow requirements 2035-50. The options have arguably additional benefit in increased reliability (new assets), but option 3.1 would present several T/PM/G37 proximity / site layout compliance issues and 3.2 requires additional land take. Also, increased above ground pipework with these options presents increased safety risk, through loess of containment compared with below ground pipework in Option 1 and 2. Engagement [redacted] has indicated that a pre-requisite to any potential planning permission would be the return of land in the locality currently used for processing methane.

[redacted]

6.5 Additional technical studies

6.5.1 As our RIIO-T2 Business Plan option was no longer viable, and all short-listed options had the same base case asset health investment requirement until at least 2035, it was critical to confirm the condition of the underground assets at the terminal that could not have been investigated during the initial optioneering stage. As some of the oldest assets on the network, certainty was required on the short list option feasibility, and with approval from Ofgem we postponed the submission of this FOSR to complete the necessary work.

6.5.2 As part of the final assessment of the proffered solution(s) a number of key tasks were reviewed to confirm and help support selection of our preferred solution:

- Defect Review – A detailed review of all open defects at Bacton Terminal, with assessments undertaken on defects proposed to be closed due to investment from existing RIIO-2 baseline funding alongside which defects would be remediated by undertaking either the works in the FOSR proposal or future 10-year AMP, RIIO-T3 and RIO T4 submissions.
- Asset Review – Based on the assets in our Asset Register [redacted], we conducted a review of the status of these assets across the different options (Asset Health, Greenfield terminal Option etc) and assessed the interventions required to ensure the terminal remains operational up to at least 2050.

- RAM Analysis – Developed a RAM model to improve our understanding of the condition, availability, and gas throughput at Bacton and how this may change over the next 20-30 years. This would help us ensure that we properly focus on the assets that are most important to maintain gas flows through the site under a range of future gas supply and demand scenarios. Determine the plant availability for the current configuration.
- Remnant Life Analysis – A pipe stress model was developed, and load cases applied to reflect pipework previous usage. Analysis was undertaken to determine current fatigue usage and hence predict the remaining pipework fatigue life.
- Cost Estimate - Developed +/-30% total installed cost (TIC) estimates for each short-listed option.
- Deliverability of solution – Review of the programme aspects of each short-listed option to consider how interactions at the site would be managed.

6.6 Rationalisation and Resilience

6.6.1 As outlined in the FOSR, Bacton forms an integral part of facilitating UK / EU gas network interconnection for gas transportation as well as processing and managing UK domestic supply including balancing and blending. Bacton was purposefully designed with built-in resilience and redundancy that has allowed the UK gas network to develop over several decades. Multiple Feeder inputs, subsea interconnectors and offtakes have all developed from the site due to the flexibility and redundancy that is present at site and in the components / configuration that was selected in the 1950's.

6.6.2 In light of the short-listed options; at this stage in the process, the next logical step would be to consider if there is potential to rationalise the terminal in an attempt to further reduce overall Capex and Opex costs. In doing this, we need to consider the existing setup of the terminal and assets in service.

6.6.3 To set context, there are three main groupings of assets at the site that provide flexibility and allow multiple gas paths through the site at any one given time based on the operational requirements of the NTS:

Group 1 - Incomer Feeds (UKCS [redacted])

6.6.4 There are six incomer feeds into site which can be operational at any time dependant on site configurations; these flow through the primary protection 1 valve into the filter header (connection off these onto the ring main) through the filters, heat exchanger and flow controlled by Flow Control Valves (FCV's) into the manifold area; the manifold area provides the site with the flexibility to flow onto the Feeders 2, 3, 4, 5 and 27.

6.6.5 The incomer lines provide the means to move and relocate the upstream UKCS gas to allow for maintenance, inspections, and overhauls. The flexibility of the incomers in conjunction with the ring main provide a pivotal part in our site's resilience and reliability to maintain flows 24/7/365 with no disruption. This functionality has been present for several decades and regardless of flow patterns entering the site, allows for wider site operations to be managed in a flexible way – allowing for outages to conduct project and operational maintenance, deal with component failure by diverting and interchanging between streams as and when issues arise.

6.6.6 Filtration is located on the incomer feeds within the terminal site that allow dry gas to be filtered. These are the filters that we use when there is requirement to 'double filter' the gas if there is suspected dust present in the NTS. This is a process whereby up to, but not exceeding, 24mcm/d out of the 63mcm/d obligated capacity for export via the interconnectors can be filtered (limited by the capacity of the ring main) to prevent onward dust issues to customers.

Group 2 - The Terminal Ring Main

6.6.7 This comprises 1,472m of 24" (600mm) diameter pipework that runs the perimeter of the site and interlinks all Feeders, incomers, and interconnectors in and out of Bacton.

6.6.8 The ring main is an essential part of the terminals original design and 50 years on still forms a critical role in providing the site operations flexibility and resilience to ensure all UKCS supplies are maintained into site and onto the NTS. The ring main allows site to flow off one incoming line onto another in the event part of site is on outage or undergoing maintenance. In addition, since April 2022 the ring main played a significant role in maintaining flows to both interconnectors by flowing gas off both Feeders 2 and 4 via the ring main onto an incomer line to double filter the NTS gas. Without this flexibility the flows to continental Europe would have been disrupted.

6.6.9 The ring main can also be used to connect feeders to allow them to work at the same pressure (Often referred to as 'common'ing up') Feeders, this being an important feature in the winter months to ensure we maintain a higher pressure on Feeders 3 and 5 for supplies into the Southeast of the country and in more recent months the ability to manage high inputs of LNG from Isle of Grain. The ring main will continue to support site operations with the ability of flexible flow paths and resilience well into the 2050's.

6.6.10 The ring main also proves site with flexibility and resilience for the upstream UKCS suppliers during outages and maintenance downtime. An upcoming example is when [redacted] filters are due their 10 yearly PSSR inspection; the filters will require isolation to undertake this work and without the ability to flow gas onto the ring main for the duration of the work, [redacted] gas would have to be stopped/offline for approximately 10 days. This would mean approximately 54 mcm of gas not being able to flow into the UK, [redacted].

6.6.11 During the period between April 2022 and September 2023, the ring main was a critical part of site operational set up to ensure security of supply to the interconnector INT. It was pivotal in providing double filtered gas ensuring energy security to Europe following the geopolitical situation in Ukraine. During this period, 20% of Europe's gas storage was supplied from Bacton. Without the ability to flow around the ring main and onto a spare incomer line, this would not have been achievable leading to a shortfall of storage of natural gas in Europe. The ring main continues to support the flows now across to continental Europe whenever exports are greater than 20 mcm/d.

Group 3 - Feeders, Interconnectors, and offtakes

6.6.12 Bacton integrates and facilitates NTS Feeder pipelines, two offtake connections and two Interconnectors to the EU and as such these are fixed location assets on the site. The way the site has been set up over time has allowed cross linking of pipework and via the terminal ring main to allow all these interfaces to work harmoniously. Removal of one or more of these aspects will have the effect or removing additional gas path manoeuvrability or interchangeability based on operating conditions and scenarios that can manifest, hence adding more risk to operations at the site

6.6.13 Similar to the terminal ring main, we do not propose to rationalise any of these key inputs now that it has been confirmed that below ground pipework is in good condition via the RAM and Remnant Life studies. By proposing to keep the mechanical process and civil assets associated with the income streams in situ, this removes the costs and risks associated with taking and managing outages, the associated decommissioning costs and removal of flexibility. These works, if requested now, would be passed on to UK consumers as there is no need case being generated by upstream suppliers to remove the stream.

6.6.14 Noting the significance of the inherent site resilience that has delivered for UK consumers over several decades and based on demonstration of a 2050 need case in this paper, NGT have limited plans to rationalise the terminal design at Bacton.

6.6.15 As stated in the paper there is a defined need case that shows Bacton operating to meet customer requirements to the late 2040's and noting that there are more recent developments in the Southern North Sea licencing arrangements, this supports requirement to maintain existing assets under the proposed Asset Heath solution.

6.6.16 All non-preferred short-listed options also contain an element of decommissioning and de-construction works in the long-term at a holistic level, bringing some elements of these forward would result in costs incurred for less flexibility and adding risk to delivery of site operations, subsequently reinforcing the need to maintain the assets in their current arrangement, delivering the best solution for consumers.

6.6.17 The prime assets that deliver installed resilience at site are mechanical and civil, which generally have much longer physical asset lives than items such as electrical and instrumentation systems. As such the consideration not to rationalise has been based on this. There is however opportunity to rationalise both electrical and instrumentation systems as part of the re-life proposals as these items have developed over time at the site, based on transient changes which has given rise to in some cases redundant circuit boards, duplicate power supply feeds and switching. As such our intention is to ensure that the optimum new arrangement is derived at the design stage to limit requirement for maintenance and to ensure that modern standards have been met, which will have a natural effect on reducing Opex where possible at the terminal to 2050.

6.7 Resilience

6.7.1 The original inherent design of the terminal provides a high level of operational flexibility allowing Bacton to deal with a vast range of network conditions and scenarios. There are however several key risks present at the terminal which are discussed in more detail below:

Black Powder / Dust

6.7.2 In 2022 Bacton experienced issues with volumes of naturally occurring dust and black powder arriving from the NTS, which in turn led to intercontinental supply issues between the UK and EU. In 2023, we put forward two formal submissions to tackle the dust issues being experienced at site; a need case Engineering Justification paper in January 2023 followed by a full cost submission in the June 2023 Asset Health re-opener window. We later submitted an Addendum Document in July 2023 to provide further information. These papers focussed on options to install feeder filtration at Bacton to counter the dust and black powder issues.

6.7.3 Whilst the EJP and cost submission have not been approved by Ofgem in its draft minded-to position for the June 2023 Asset Health Uncertainty Mechanism submission, we still perceive dust as a threat and risk to operations at Bacton and the surrounding network.

6.7.4 NGT have been operating an enduring double filtration process and managing dust locally since 2022 and although smaller quantities of dust have been experienced, we maintain that this issue is not closed and anticipate future requirements to investigate the issue again. In lieu of a permanent engineering solution, we propose to enhance short-term management of this issue with additional in line inspection (ILI's) via Feeders 2 and 4 and plan to extend monitoring of dust levels on Feeders 3 and 5 as well as these pipelines are of a similar vintage to Feeders 2 and 4.

6.7.5 We are proposing to include allowances for additional ILI runs in our RIIO-T3 business plan to allow these to be conducted more frequently. As explained in our previous submissions for Feeder Filtration, there is no perceived requirement to conduct annual ILI runs on Feeder 27 as this is perceived to be nominally clean. As such, this will continue to follow its scheduled formal ILI run plan. Based on previously known history of dust issues the running order of the ILI runs can be seen in Table 9.

Table 9 Repeating ILI run sequence

Feeder:	ILI run Year:	Start Location:	Finish Location	Notes:
04	2024	Bacton	Wisbech	Temporary PIG traps at Bacton and Wisbech
02	2025	Bacton	Wisbech Nene West	Temporary PIG traps at Bacton and permanent at Wisbech Nene West.
03	2026	Bacton	Roudham Heath	Permanent PIG traps at Bacton only– Not perceived as high risk so potential to defer based on monitoring outcome
05	2027	Bacton	Yelverton	Permanent PIG traps at both locations – Not perceived as high risk so potential to defer based on monitoring outcome

6.7.6 In parallel, NGT will be required to refurbish and revalidate temporary pipework that is used at Bacton for the sole purpose of conducting ILI's on Feeders 2 and 4. An increased frequency of ILI runs being carried out across the feeders creates a business case for revalidating this pipework, which is due in 2025, including pressure testing and NDT. Table 10 presents a short summary of the Capex costs that will also form part of the re-opener to allow this work to be conducted in RIIO-T2.

Table 10 Temporary Pipework refurbishment and validation costs

Activity	Budgetary cost	Accuracy	Notes
Transport & lifting	[redacted]	±30%	Freight costs to take to fab shop for controlled conditions
Blasting & coating	[redacted]	±30%	Shot blast to get back to stable material surface ready for re-coat
NDT of welds	[redacted]	±30%	Ultrasonic testing
Pressure test	[redacted]	±30%	Hydrostatic Testing
TOTAL	[redacted]	**±30%**	To be refined at final cost reopener

6.7.7 We have considered the installation of permanent Pipeline Inspection Gauge (PIG) traps for Feeders 2 and 4 as an alternative to refurbishing the temporary pipework. This work concluded that due to the location and proximity of other NGT and customer assets, sterilisation of roadway access, and limited spacing to site the two PIG traps, the optimum arrangement would be to plan for annual inspection using temporary traps. Only Feeders 2 and 4 require temporary PIG traps. Feeders 3 and 5 have permanent PIG traps already installed.

6.7.8 These costs have not been included in our preferred option costs at this stage but given that the works would need to happen in RIIO-T2 to facilitate the ILI runs starting on schedule in RIIO-T3. We are proposing include in the accelerated cost re-opener as this is the optimal way of requesting the funding and allowing these preparatory /enabling works to happen in RIIO-T2.

6.7.9 We will continue to monitor dust in RIIO-T2 and T3, gathering more data and supporting information to supplement the need case. Our intention would be to return later to seek investment through an appropriate mechanism if the situation escalated further.

Liquids Management

6.7.10 The natural gas production process upstream of NGT utilises a series of chemical products and processes to ensure that the gas meets the required quality standards prior to entering into the terminal and ultimately the NTS and connected third parties.

6.7.11 There have been previous incidents where upstream liquids have entered the terminal via the incomers and at that point, full-scale clean-up operations were deployed. There are two such incidents known over the last two decades – one incident in 2000 and a more recent one in 2020.

6.7.12 The incident in 2020 led to ~50,000 Litres of Monoethylene Glycol commonly known as 'MEG' entering NGT's system [redacted] The MEG permeated out into the wider NTS network as well the Local Distribution Zone (LDZ) via Feeders 3 and 5 and caused severe disruption. A major incident was declared at the time and the resultant clean-up costs were ~£900k to ensure that both NGT's system had been cleaned as well as the interconnected parties at Bacton and the wider network.

6.7.13 In 2022, NGT installed new 'line view' technology on Shell 3, A1 and A2 which captures real time video imagery of gas flowing in via the incomers. This system is currently in development as part of an innovation project and provides qualitative information. The system has an audible warning which is based on human judgment / learning and can only be used as an indication tool viewed from a separate screen in the control room with three separate windows.

6.7.14 Whilst this new process and system does provide indication that there may be potential liquid or vapour entering the system, it does not enable the control room user to establish the quantity of liquid being input which then makes it challenging as to whether a Transportation Flow Advice (TFA) notification should be issued or not. Additionally, because of the physical layout of the pipework at Bacton, even if a TFA notice is issued to a sub terminal, liquids can become entrained behind the closed valve which would then mean as soon as the process has been cleaned up, liquids present behind the isolation valves are then released into the system when opened, if low point drains have been unable to remove all liquids.

6.7.15 Noting that this is predominantly a commercial issue to manage between NGT and the incomer contracts, there is limited need case to install a bank of coalescers where the dry gas filters currently exist. There is a requirement to review the effectiveness of the line view system and ascertain if this situation can be improved. As this is a complex area, we are proposing to continue developing investigatory works into simplified systems for managing liquids using baseline FOSR funding with a view that if further investment is required this would be part of a future request either in RIIO-T3 or T4 supported by the appropriate need case. In parallel to this, we are also reviewing investments associated with Gas Quality RIIO-T3 proposals to address development of simple, low-cost additions to the process to ensure improvements.

6.8 Option Cost Estimate Details

6.8.1 Capex estimates for each of the considered short list options are provided per Table 11. All costs are provided in 2018/19 price base year and should be considered accurate to +/-30%. At this stage we have therefore not included a 30% Unallocated Provision (UAP). A summary and detailed cost breakdown for our preferred Option 1 can be seen in Table 12.

Table 11 Capex Estimates for each of the considered short list options

2018/19	2025-2035 (£m)	2035-2050 (£m)	Total
Option 1			
Option 2			
Option 3.1			
Option 3.2			

Table 12 Summary and detailed breakdown for our preferred Option 1

18/19 prices (£m)	FY25	FY26	RIIO-2	FY27	FY28	FY29	FY30	FY31	RIIO-3	FY32	FY33	FY34	FY35	FY36	RIIO-4	Totals
Valves																
LV																
Instrumentation & Cabling																
CP																
Civils & Painting																
Total																

18/19 prices (£m)	FY25	FY26	RIIO-2	FY27	FY28	FY29	FY30	FY31	RIIO-3	FY32	FY33	FY34	FY35	FY36	RIIO-4	Totals
Materials																
Mains Work Contractor																
Design																
Specialist Services																
Direct Company Costs																
Indirect Company Costs																
Risk/Contingency																
Total																

Table 13 Detailed breakdown for our preferred Option 1 by discipline

Valves

18/19 prices (£m)	FY25	FY26	RIIO-2	FY27	FY28	FY29	FY30	FY31	RIIO-3	FY32	FY33	FY34	FY35	FY36	RIIO-4	Totals
Materials	[redacted]															
Mains Work Contractor																
Design																
Specialist Services																
Direct Company Costs																
Indirect Company Costs																
Risk/Contingency																
Total																

LV

18/19 prices (£m)	FY25	FY26	RIIO-2	FY27	FY28	FY29	FY30	FY31	RIIO-3	FY32	FY33	FY34	FY35	FY36	RIIO-4	Totals
Materials	[redacted]															
Mains Work Contractor																
Design																
Specialist Services																
Direct Company Costs																
Indirect Company Costs																
Risk/Contingency																
Total																

Instrumentation

18/19 prices (£m)	FY25	FY26	RIIO-2	FY27	FY28	FY29	FY30	FY31	RIIO-3	FY32	FY33	FY34	FY35	FY36	RIIO-4	Totals
Materials	[redacted]															
Mains Work Contractor																
Design																
Specialist Services																
Direct Company Costs																
Indirect Company Costs																
Risk/Contingency																
Total																

CP

18/19 prices (£m)	FY25	FY26	RIIO-2	FY27	FY28	FY29	FY30	FY31	RIIO-3	FY32	FY33	FY34	FY35	FY36	RIIO-4	Totals
Materials	[redacted]															
Mains Work Contractor																
Design																
Specialist Services																
Direct Company Costs																
Indirect Company Costs																
Risk/Contingency																
Total																

Civils & Painting

18/19 prices (£m)	FY25	FY26	RIIO-2	FY27	FY28	FY29	FY30	FY31	RIIO-3	FY32	FY33	FY34	FY35	FY36	RIIO-4	Totals
Materials	[redacted]															
Mains Work Contractor																
Design																
Specialist Services																
Direct Company Costs																
Indirect Company Costs																
Risk/Contingency																
Total																

Cost estimate methodology

6.8.2 The Nov-2021 [redacted] FEED Consultant provided estimates for the short-listed options. These estimates were produced on a AACE International RP 18R-97 Class IV (4) cost estimation basis, with a target ±30% cost accuracy.

6.8.3 In 2023 [redacted] were provided conceptual level scoping documents for elements of our preferred Option 1, namely Valves, Low Voltage Electrical and Cathodic Protection (CP) System replacements. [redacted] who completed 36 valve replacements at the Bacton Terminal in RIIO-T1, and CP system replacements at the St Fergus Terminal in 2023. With their recent experience of similar construction works at the NGT Terminals, they were well positioned to provide credible cost and programme estimates.

6.8.4 [redacted] estimated these elements of the preferred Option 1, including quotations from the supply chain for such items as valves, actuators, and low voltage electrical equipment. Although the [redacted] estimate is budgetary (formally a Class 3 estimate), and not capable of acceptance, the estimating methodology is consistent with a Class 2 'bid or tender' estimate.

6.8.5 The additional technical and economic assessments that were undertaken during the study also highlighted that there are several additional investments which in all the options under consideration at the final short list and also the final preferred option would be classed as 'common investments'. These are items that regardless of the AH solution would also be required to be undertaken and hence have been highlighted in Table 14.

6.8.6 These investments are proposed to be included within our RIIO-T3 submission, developed through our 10-year Sies Asset Management Plan.

6.8.7 Our rationale for the split of interventions has been based on the split between addressing issues on key known issues that cannot wait for investment until RIIO-T3. The option to build either a new build or greenfield terminal presents timescales that span several years, over which the asset health works would still need to be undertaken.

Table 14 AMP and RIIO-T3 'Common Investments'

Asset group / Area
Fire & Gas System
Above Ground Pipework Coating
Civil Investment
Pre-heating & Heat Exchanger Intervention
Redundant Assets
Filter Interventions
Cyber Analyser Investment

7 Business Case Outline and Discussion

7.1 Key Business Case Drivers and Summary

7.1.1 Bacton is one of NGT's two Upper Tier, Control of Major Accident and Hazard (COMAH) sites. As such we must effectively manage process safety and demonstrate compliance with COMAH regulations via the submission of a safety case to the Health and Safety Executive to ensure diligent management of the Major accident hazard plant and equipment to continue safe operation of the terminal.

7.1.2 Section 5 outlined that a valid need case for the terminal to remain operational well into the early 2040's with commercial gas flows expected from our customers and potential for new licences in the Southern North Sea to be reviewed and granted. Whilst new licences are not guaranteed to land gas at Bacton, it is clear there is a valid need to maintaining a fully operational terminal that meets current customer demands and contractual demands.

7.1.3 In section 6 we outlined our options selection process and how each stage of this process has allowed a further refinement until a viable grouping of shortlisted options was derived. At this stage in the process, four core options were confirmed and could then be developed further. Supported by the evidence from our FEED condition surveys and assessments, all comparable options demonstrated an element of Asset Health is required to achieve continued terminal deliverability into the 2030's and beyond.

7.1.4 Upon confirmation of a base case asset health investment requirement, NGT then set about reviewing these options to understand more about how a successful comparison could be made and ultimately agree on a final preferred option. The following criteria helped steer initial comparisons:

- Does the option maintain terminal capability – Noting that NG's intention was to maintain the Terminal Operations and deliverability to existing and current levels, including process flexibility each option was assessed against how well it could perform in this context.
- Does the option provide benefits in Opex reduction – Assessing any difference in Operational staffing at the site was done to see if any savings could be made with the shortlisted options, acknowledging NGT have legislative compliance requirements to ensure minimum levels of safe staffing are maintained at an Upper Tier COMAH site. An additional staffing assessment was conducted which illustrated the need to maintain existing staff for normal, transient and emergency condition on all of the options including options that sought to rationalise the exiting plant.
- Does the solution provide the lowest cost to consumers – a fundamental objective, so had a high influence on the process.

7.1.5 This process allowed NGT to crystalise that at this stage, given the requirement for a base case asset health investment justified with condition data, relatively marginal changes to the Opex costs of each shortlisted option, that a more simplified CBA could be undertaken to ascertain the preferred option. In short this took the form of a cost comparison.

7.1.6 During engagement with Ofgem, NGT discussed this proposition to understand perception of the proposal as it was evolving. In general terms it was agreed that a more simplified approach could be adopted in this case. NGT outlined that unlike other FOSR submissions undertaken to date, in this situation as the base case asset health works become 'no regrets' and require intervention in the short to medium term, coupled with the fact that no additional capability is being proposed at the terminal a full detailed CBA ass minimal value to the options selection process.

7.1.7 Building on this unique set of circumstances further, NGT also assessed the need case to rationalise elements of the terminal. After careful consideration of the operational flexibility and capability the site already has and noting that there was no desire to enhance capability, a view was taken that there is limited scope to rationalise the main process gas system, noting the following key drivers:

- **Licence obligations to manage cross border gas transmission** – although not all streams get used at any one time, it would increase risk levels to remove functionality that allows NGT to manage, multiple outages, construction and project work, maintenance and operational challenges that can arise on the NTS. This additional functionality is required.
- **Cost to decommission** - Additional costs borne by the consumer as there are no signals from the upstream operators at this stage to relinquish capability. Under disconnection request, these would traditionally be borne by the requester as opposed to consumer funded so avoiding this situation made logical sense.
- **Increased risk to site operations** – During delivery of the decommissioning works under outages, NGT would be trying to manage the proposed asset health works which in their own rite necessitate outages. Contextualising this – if there was a problem with an outage and a constraint arose at site due to the situation, the constraint costs at ~ £274k/mcm could come in to play.

7.1.8 In light of the above risks and noting that a cost comparison of the options in the simplified CBA, there would be marginal savings to be made via rationalisation and as the lowest cost option is the main driver for option selection.

8 Preferred Option Scope and Project Plan

8.1 Preferred Option and technical Justification

8.1.1 As outlined earlier in the report, it was established that there are some key asset areas which require investment to ensure continued reliability levels and operation to at least 2050. The areas that are deemed to require the most work have been identified as Cathodic Protection (CP), Low Voltage Electrical Systems and Critical Valves/Actuators. The subsequent sections set out more detailed information regarding the assets and systems that are in situ and advise on the condition information obtained via the FEED work and provide evidence why intervention is needed.

8.2 Cathodic Protection (CP) Systems

8.2.1 Since its construction in 1968, Bacton Terminal's CP was provided by an impressed current system utilising two transformer rectifiers with local groundbeds. Over the following years the system was expanded, and additional rectifiers were added. Subsequent monitoring of several electrical resistance (ER) probes indicated accelerated corrosion rates at several locations, generally located near concrete chambers. This led to a system modification in 2007. Since then, the CP system has deteriorated with failure of distributed anodes and connecting cables. A 2018 CIPS survey concluded the CP had reached the end of its design life. By 2023, further surveys where undertaken, and energised pipe-to-soil potential measurements were found to be non-compliant for about 95% of the site pipework. It is concluded that the CP system has reached the end of its life, not providing adequate protection, and complete replacement is necessary.

8.2.2 A series of CP CIP's reports have been provided in Appendix D.

8.2.3 CP Assets at Bacton:

- **Distributed anode system** – This system involves strategically placing multiple anode groundbeds at locations selected around the site to optimise current distribution whilst minimising cathodic interaction with other structures and pipelines to provide a balanced and compliant level of protection to all the buried pipe around Bacton. Distributing the current in this way can allow individual control over current output of the anodes provided in each zone. This ensures uniform protection against corrosion whilst managing the detrimental effect of over polarisation to the coating system. The anodes are consumed in place of the pipe thus preserving its integrity. Anodes are below ground assets, therefore provided below is a 'typical' diagram indicating their function and connection to the current sources.

- **Reference electrodes** –These are used to measure the structure to electrolyte potential. As the buried pipeline is only half an electrochemical cell, another half electrolyte to metal cell is required to measure the voltage across the cell. Using a reference electrode type suited to the electrolyte is key in maintaining the pipe within the protection criteria. By maintaining the potential of the pipe within criteria set out in normative documents it can be considered protected from corrosion. Reference electrodes are essential in the assessment of understanding the effectiveness of the CP system.

- **Transformer rectifiers (current sources)–** These convert alternating current to direct current. The current is applied to polarise the structure to a potential sufficient to remain cathodically protected. Figure 20 shows the location of the existing TR's. Figure 21 presents contents of a typical TR cabinet.

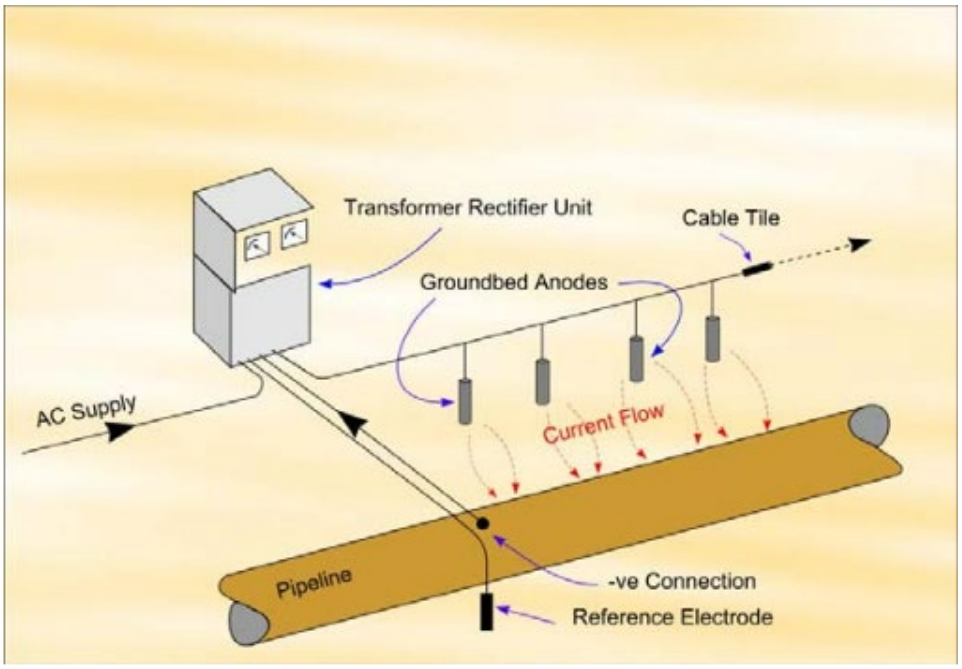
Figure 20 Existing TR Locations

Figure 21 View inside a typical current TR cubicle

- **Electrical resistance probes** – Are used to monitor corrosion rates. The probe simulates a coating defect. By measuring the resistance of the exposed coupon element with reference to the shielded coupon, corrosion rates can be predicted using mathematical algorithms.

- **Insulation Joint's (IJ's) -** are installed to separate assets into manageable common CP electrical sections. They isolate equipment and pipelines and can also be the demarcation where ownership changes. This is needed to manage the CP System effectively without unwanted electrical interference which can be detrimental to the operation and maintenance of the asset or other buried structures. Figure 22 shows a typical connection arrangement and function for all the assets and components listed in section 8.1.2.1:

Figure 22 Typical CP system arrangement and functionality



8.2.4 Since the systems restoration in 2007, the system has greatly deteriorated and recent (2023) independent CP Surveys including, Close Interval Potential Survey (CIPS), Integrated Security System (ISS) Interaction, Major Test Post Survey and Pipeline Current Mapping surveys were undertaken. A summary of these surveys is included below, and the actual reports are in Appendix D:

- CIPS Survey 2023– Concluded the existing CP system is in poor condition (over 95% defective) and not providing adequate protection of below ground pipework, with the recommendation being immediate full system replacement.
- ISS Interaction – This survey confirmed the National Gas Bacton terminal can be considered continuous, therefore one 'holistic' CP replacement system will be required. Additionally, the survey confirmed that due to failed or disconnected IJ's, Shell and Perenco are also part of the continuous system (to be addressed in design of the new system), and all other Third Parties (Cadent, GYPS, BBL and Interconnector) systems isolation is functional.
- Switching Survey – Confirmed 7 of 14 IJ's to be functioning correctly (7 to be retained as part of the new CP system and others remediated or replaced),

- Pipeline Current Mapping Survey – Results of this survey were inconclusive with the recommendation to repeat the survey once the new system is commissioned, to confirm and / or allow optimisation of CP system performance.

8.2.5 In parallel to undertaking the CP surveys and to validate the CP surveys and actual physical condition, a set of intrusive investigatory works were undertaken in 2023. These works comprised of:

- Excavation on 3 locations with very low CP protection readings to undertake pipework coating inspections.
- Install ER Probes at the same three locations to collect data on ongoing CP system degradation and corrosion rates.

8.2.6 Generally, all these investigations found that the very low CP readings from the CIPS survey in these locations, were due to local current drain/interactions with below ground steel, namely re-bar in concrete structures. This supports that the CP system is not providing adequate protection and reinforces the data gathered and provided as part of the CIPs surveys.

8.2.7 A common finding in the reports is there is a measured (actual) corrosion rate present at site that is higher than that of NGT's standard conservative estimates. Normally NGT utilise an aggressive rate of 0.2mm/year to ensure that worst case scenarios planned for. However, the actual average rate readings through ER probe verification is 0.5mm/year, which is considered very aggressive, and indicates that if the CP system is not replaced and functioning to required levels of protection, and coating breakdown occurs (which is inevitable), pipeline corrosion/damage will occur over the period of proposed end of life 2050. Upon receipt of the final ER probe reports, NGT intend to update the Remnant life study.

8.3 Critical Valves & associated actuators / equipment

8.3.1 There are over 300 valves at the Bacton Gas Terminal ranging from 50 mm in diameter to 1220 mm at the largest size. There is a general blend of valve manufacturers and OEMs at site and, generally driven by historic changes and work completed at the site as opposed to a standard valve type manufacturer being used.

8.3.2 There are two main types of valve use on the terminal process pipework:

- Plug valves - are generally tapered plug within a valve body which can be rotated through 90°closed to open to allow gas to pass through the plug within the valve body. Plug valves are only a single block type valve and are very good for high differential pressures.

Figure 23 – Example of a Plug Valve

- Ball valve - consists of a hollow ball (cavity) within a body which can be rotated 90° closed to open to allow gas to pass through the ball cavity within the valve boy. One advantage ball valves have over plug valves id the ability to vent the cavity down to provide a double block and bleed on a single valve.

Figure 24 – Example of a Ball Valve

8.3.3 There are numerous critical valves that play a vital role in ensuring the safe and efficient operation of Bacton and a number of these are over 50 years old. Several attempts to maintain them to an enduring state have been undertaken and consistently failed as shown in the valve list which shows previous unsuccessful interventions Appendix D. Numerous operational issues including loss of sealing capacity, inability to turn (seize), severe corrosion and stem seal leaks have been reported. These valves are strategically located to allow for isolation, routing, regulation, or emergency shut down and should be replaced at the earliest opportunity.

8.3.4 The requirement for valve/actuator replacement was driven primarily by the purpose and criticality of the valve and the severity of the fault identified. Valve availability and ability to function as expected will be key to securing the safety and operability of the Terminal. Included in Appendix D is a critical valve index that presents the defective critical valves requiring replacement, their function and criticality.

8.3.5 When considering the valves themselves it is worth noting that criticality to operation of the site is linked to the flow paths and streams that pass through the mechanical system. In Appendix D, a simplified Process Flow Diagram (PFD) has been provided detailing where the 56 number of valves/actuators are sited within the terminal and which flow path they sit on. As we are not proposing to rationalise Bacton (see the Rationalisation and Resilience sections) all valve/actuator replacements are considered critical to maintain required operations (valves located on critical flow paths routing gas from Incomers/Interconnectors to Feeders and Ring main).

8.3.6 56 actuators assemblies associated with the valves targeted also require replacement along with two sole actuators. These have been identified as part of the wider defect review at site covering all work scopes. As such, given the requirement to replace the valves is the most economical option to ensure continued operation, efficient delivery is to bundle these items at the same time. These Items are also shown on the critical valve index in Appendix D.

8.3.7 In our June 2023 Asset Health re-opener, we outlined the case for St Fergus critical valves that require replacement. Similar to the situation at St Fergus, due to the way the terminal operates on a 24/7/365 basis, it is not always possible to work on the assumption that a valve can be taken out of service, sent away and repaired within an outage period. This is because of the inherent risk that if a valve is irreparable and due to the long lead time associated with it, NGT would be at risk on extended plant outages having detrimental impact to the running of the terminal. As such we are proposing replacing valves with new assets, given the proposed long-term life of Bacton to 2050.

8.3.8 Although refurbishing existing valves for the Preferred Option 1 at Bacton is not considered feasible, NGT have partnered with key strategic valve stockists that can refurbish valves. It is intended that where economically viable, valves which are removed from Bacton as part of the works, could be refurbished and held in stock for future use across the NTS.

8.3.9 Replacing with new allows the risk profile to be managed with delivery of the works and will take time for a programme of refurbished valves to be available for NTS use.

8.4 Low Voltage (LV) Electrical Systems

8.4.1 Low Voltage (LV) Electrical Systems are the first stage of power distribution on a terminal. At Bacton, much of the LV distribution system with the associated equipment was built and installed up to 50 years ago. Most of the standards are outdated with lesser safety requirements. As such, the LV installation is obsolete, unsupported, and suffering from a degradation of condition. Additionally, the nature of the coastal environment has over time had an adverse effect on the external equipment condition, which is now causing severe maintenance issues for the site team. An outline of the electrical equipment in situ and some of the challenges being experienced is covered in this section.

8.4.2 The NGT site operations teams have extensive knowledge of the electrical assets at site and their condition so this has been narrated in the following section to help articulate the complex topic.

11kv Transformers

8.4.3 Annual oil samples are taken on site from the transformer to determine condition and wear. The 2018 report seen in Appendix D gave indication that the asset was degrading, the report states “extensive degradation of the paper insulation is evident. New paper insulation has a degree of polymerisation (DP) of approximately 1100, as the paper starts to age or degrade the DP reduces. A DP of 250 it is considered to be end of life (EOL)’; the HV transformers currently have a DP estimated to be at 380”.

8.4.4 The report stated “Slight heating is indicated, resample in 6 months to monitor and trend the gas concentrations” which led the site to remove the load on the ONAN TX2 transformer; this had a large impact on site as Bacton is an Upper Tier COMAH facility and requires sufficient redundancy and backups in the event of an emergency. If the site lost transformer TX1 as well, it would be reliant on the UPS systems and standby generator.

8.4.5 The transformers are oil filled and are situated within 1 metre of each other, as well as 6 metres from the office building and the maintenance technician office posing a significant Hazard. A potential explosion due to the degradation of TX2 would have significant impact on TX1 and would impact the structural integrity of the office building, leading to potential injuries and incidents. Both transformers require constant maintenance regarding corrosion.

Standby generator

8.4.6 The 625 kVA standby generator has required significant investment on mechanical overhaul over the last 7 years and has problems with fuelling and frequency hunting over the last 3 years. This in turn has caused voltage and frequency problems that affects the Air Circuit Breakers (ACB) within the main LV switch board which supplies the whole site. If a failure was to occur, this would lead to safety functions such as the Site Wide Isolation Page (SWIP) and Over Pressure Protection (OPP) being unable to function. The UPS battery systems will run for 8 hours before the site is then left without power. In this event, the site will be in a vulnerable position,

8.4.7 The standby generator control panel has had significant alterations over the years as part of ongoing maintenance. The control panel is obsolete and so replacement parts are no longer supported.

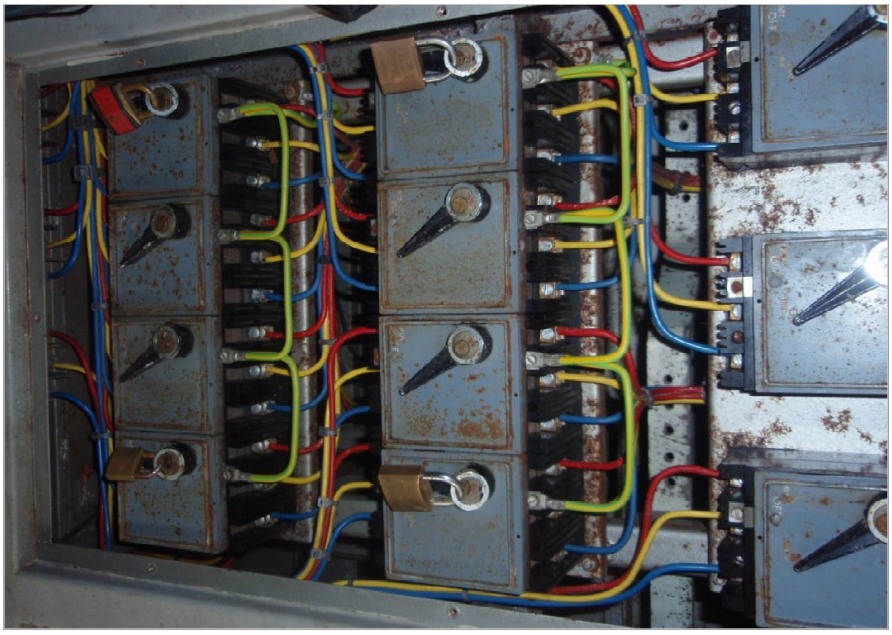
8.4.8 Since the generator control panel is an old design, it does not meet the requirements of NGT spec T/SP/EL/50 regarding alarms generated and current safety standards. The 24V battery charger unit failed in 2023 resulting in batteries losing charge and not being readily available to start the generator. As the charger was obsolete, this caused the generator to be down for several months whilst we had difficulty finding a third-party company capable of replacing/repairing the unit.

Electrical Kiosks

8.4.9 Kiosks C, D, E, F and G supply up to 56 actuators each; these control the manifold and feeder actuators. Due to the age of these assets, isolators are failing monthly and having to be retro fit with new MCB's.

8.4.10 The panels are affected by damp, as can be seen by the corrosion in Figure 25 causing very low insulation resistance reading on the cables and across the isolators; heaters within the kiosks to remove the moisture have had minimal impact and investment is required.

Figure 25 distribution panel



8.4.11 Failure of these boards would result in the loss of electrical function of the 56 actuators, the CP power supply, lights, and sockets, as well as street lighting. This would cause a significant issue for the site, leading to limited process operation and safety functions. One board failing has potential to cause a quarter of the site's flow capability to be compromised.

8.4.12 All actuators are fed via aluminium cables from the distribution boards which run to above ground resin cable joints which are not ATEX certified; from these joints, copper cable is used to gland into the actuators. These resin joints replaced local isolators for each actuator to reduce required maintenance; as actuators are rotating machinery, they are required to have a local point of isolation and so the resin joints are not fit for purpose and may not comply with T/SP/EL/50.

UPS Systems

8.4.13 During standard maintenance procedures, required maintenance is compromised for activities on the UPS boards due to the single point of failure on the 2x60 kVA transformer rectifiers supplying the UPS systems. There are eight UPS distribution boards, seven of which rely on the function of UPS DB 1; If a UPS board develops a fault, a critical site system may be lost such as the site Human Machine Interface (HMI) or Star Watch system, which is integral for the emergency muster system and safety.

8.4.14 60 kVA Rectifiers have surpassed the manufacturers recommendation of replacement of a period of 12 years; these are therefore obsolete and need immediate replacement.

8.4.15 Main circuit boards within the system have failed, resulting in one of the 60 kVA board shutting down; this led to having new main circuit boards fitted along with replacement capacitors and UPS fans.

External lighting and all associated cables

8.4.16 There are several lighting columns around the site which we are unable to lower due to age, corrosion, and associated damage. This requires hiring an all-terrain lifter to perform maintenance procedures, which is costly and time consuming.

8.4.17 At the base of the lighting columns, there are Ex-d isolators which are obsolete and fed via aluminium cables. These are unable to replaced due to the age of the columns and so have failed their DSEAR inspections, subsequently leading to isolation of the lights themselves. By isolating one lighting column, several others on the same circuit are also isolated unnecessarily creating hazards to personnel. Aluminium cabling cannot be replaced as these are buried directly into the ground instead of using ducting.

8.4.18 The centre walkway lights have also failed DSEAR inspections and are required to be emergency lights due to the nature of the pathway. [redacted] These lights and columns are original to site and are approximately 57 years old. Furthermore, many of the site lights are no longer suitable for use as they are not directed appropriately for the current site layout.

Component reliability

8.4.19 Equipment has reliability issues as shown in Figure 26 with the defect tags which is preventing most equipment from performing their intended functions, the distribution board isolator shown in Figure 26 is currently not in use, resulting in a loss of circuit redundancy.

Figure 25 26 - Distribution Board Isolator

8.4.20 Non availability of spares for most Distribution Boards and circuit protective devices – Most circuit breakers in the distribution boards were installed in the 1960's and are no longer being manufactured.

8.4.21 Asbestos presence within circuit breakers originally used as insulation is no longer up to standard, creating a maintenance safety risk. In some cases, these are still in use however due to asbestos cannot be maintained or inspected.

8.4.22 Lack of segregation and appropriate electrically safe enclosures for fault protection. This means that any impacts of faults on any part of a circuit may not be minimised to affect adjacent or interconnected circuits.

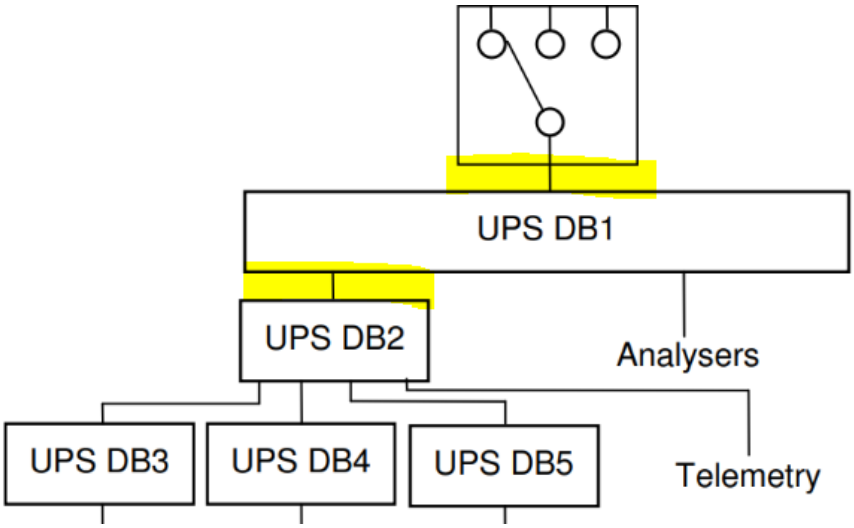
8.4.23 Figure 27 shows isolators for multiple circuits contained within the same electrical cabinet on the same distribution board. This is not in line with current standards as it carries the risk of the one circuit failing compromising multiple systems.

Figure 2726 Isolators for multiple circuits

8.4.24 Redundant and oversized circuitry due to changed requirements Over the years, some equipment has had to be disconnected from the LV electrical system due to changes in requirements and regulations. This has led to redundancy of some circuitry and distribution boards.

8.4.25 Figure 28 shows the circuit diagram for the UPS' which has a single point of failure from the feed which should it fail will compromise every UPS system on site. This requires a complete overhaul to bring up to standard. Addressing and mitigating this will enhance the reliability and resilience of systems it supplies.

Figure 2827 UPS Circuit Diagram



8.4.26 During RIIO-T1, several condition assessments were conducted that identified that various aspects of the electrical systems are beyond their working lives and needed to be replaced at previous price control review periods – supplementary evidence supporting condition assessments can be found in Appendix D.

8.4.27 The FEED Study report "20485-AI-RPT-100-0001_Rev 0 - Existing Equipment Condition Assessment", included in Appendix D and conducted by Penspen, outlined findings that concurred with the previous inspection and condition surveys citing "As the electrical installations and equipment on Bacton site is becoming obsolete and unsupported, do not meet current safety requirements and are showing severe signs of age, a significant amount of refurbishment work is required, to ensure the continued safe and reliable operation of the Bacton Terminal site."

8.4.28 The findings for the LV systems demonstrate that wholesale replacement is required as ongoing maintenance does not bring the system up to latest DSEAR, ATEX and other regulations and in some cases the existing assets pose hazards which require significant and urgent investment to resolve.

8.4.29 As noted in section 6, there is potential for rationalisation of the electrical system, as this has been extended over the years as Bacton has developed. We would look to outline this in more detail in our future Engineering Justification Papers and FOSR cost submissions in July 2024.

8.5 Project Spend Profile

8.5.1 The spend profile for the preferred option is included in Table 15 Project Spend Profile. Noting that we are advocating acceleration of the cost re-opener to July 2024, the spend profile shows Capex spend in the remaining years in RIIO-T2 as the work load is planned to increase.

Table 15 Project Spend Profile

18/19 prices (£m)	FY25	FY26	RIIO-2	FY27	FY28	FY29	FY30	FY31	RIIO-3	FY32	FY33	FY34	FY35	FY36	RIIO-4	Totals
Valves	[redacted]															
LV																
Instrumentation & Cabling																
CP																
Civils & Painting																
Total																

8.5.2 Costs in RIIO-T2 are comprised primarily of the full works associated with the CP system design and replacement, along with the LV system design and initiation of the design works and long lead procurement associated with the critical valves to be replaced.

8.6 Efficient Cost

8.6.1 The Preferred Option cost estimates were based on engineering inputs involving material quantities of equipment lists taken from up-to-date site drawings. Labour and construction timelines were considered in comparison with similar previous projects delivered on the NTS. This work was undertaken [redacted], the engineering consultant used for the option selection phase. Additionally, an experienced Tier 1 Main Works Contractor was also engaged to produce bottom-up estimates including quotations from the supply chain.

8.6.2 Following approval by Ofgem of the final preferred option for Bacton, we will develop the delivery strategy, engineering design and cost estimates of +/-15% accuracy through pre-FEED and FEED stages. Contracting strategies will be identified with our Procurement and Contracts teams. [redacted]

8.6.3 [redacted]

8.7 Project Plan

8.7.1 We have progressed CP System replacement into GNDP 4.3 Stage to proceed with Conceptual and Detailed Design using current RIIO-T2 Baseline Asset Health funding. Progression of this project into the build phase will be subject to funding provided following the re-opener submission. Current planning assumes our re-opener submission in July 2024 subject to Ofgem approval, an accelerated window of ~12 months to allow works to ramp up and start in RIIO-T2, then continue into the RIIO-T3 period. Our assumption at this stage is that Ofgem's review of the cost submission would run until approximately November 2024. This timeframe would allow NGT to set targets for award of contract in January and February 2025, further targeting a start on site in March 2025. Working within this timeframe also allows for successful outage planning to be undertaken. Typically, outages for 2025 would be agreed and locked in the October and November of the prior year.

8.7.2 In terms of deliverability assumptions, our plans look to develop a delivery vehicle that executes all three of the scopes for CP, LV Electrical works and Critical Valves by bundling to drive efficiencies but recognise that there may be a phasing to the draft and final determinations associated with each. Should submissions be reviewed in series then NGT's priority order for delivery execution based on condition would remain as CP, LV Electrical Systems and then Critical Valves.

8.7.3 As LV System and Critical Valves replacements currently do not have any baseline funding, progression of these into detailed design and build would also be subject to funding provided as part of the re-opener submission, with current planning being on the same time frame as CP (July 2024 submission, and Ofgem determination by November 2024).

8.7.4 [redacted]

8.7.5 To provide assurance and credibility to the project plan and associated costs, [redacted] were engaged to produce very detailed project programmes and bottom-up costs estimates. [redacted] replaced approx. 32 valves at Bacton in RIIO-T1, and have recently completed CP system replacement at St Fergus, which should provide assurances of their ability to deliver to time cost and quality metrics expected of NGT.

8.8 Key Business Risks & Opportunities

8.8.1 Maintaining the existing Bacton configuration is essential to at least the mid 2040's, investment in the Preferred option 1 has no risk of stranded assets.

8.8.2 Investment in our preferred Option 1 is the lowest Capex of all shortlisted options and doesn't require additional land take or use of existing site footprint within the terminal boundary. There is an opportunity where the area that was originally part of our original RIIO-T2 brownfield submission, located in the legacy ENI Incomer area, was decommissioned in RIIO-T1. Leaving this free of development at this stage may have potential future benefits when facilitating the energy transition, for example Hydrogen and CCUS facilities.

8.8.3 UK Supply chain capacity and capability is always a factor in successful delivery of a project. The scale of the works proposed are sizable and as a prime mitigation, early Contractor engagement and visibility will be vital to ensure that the market can respond accordingly.

8.8.4 The current delivery strategy for the preferred Option 1 is to bundle works with one Main Works Contractor. To maximise efficiencies, this would be with one Contract as opposed to multiple Contracts / amendments, where the Contractor would have a stronger negotiating position. The added benefit here also ensure that a single entity take on design liability, reducing interface and integration risks. The timing and outcome of our associated cost re-opener for the preferred option will be a critical driver in this regard.

8.8.5 Delivery of the works will require outages to sections of the Bacton system. However, similar works were delivered in RIIO-T1 with tolerable disruption to operations. Replication of this through very detailed planning and third-party engagement will be critical to avoid intolerable disruption to operations and/or associated project delays with increased cost through prolongation.

8.8.6 As outlined earlier in the FOSR there are no credible circumstantial changes in the methane world that impact the selection process of the FOSR, meaning an asset health approach is the optimum solution. There are examples of where NGT would need to revalidate the need case if situations arise, but these are noted as challenging to predict. The asset health solution is progressive and undertaken in stages meaning there is opportunity to pivot with changes and flex investment if these situations arise. Examples being:

- Significant changes in European markets
- Consolidation of operators could mean that a reduced number of UKCS incomers are required.
- Changes in global gas (inc LNG) markets.
- Changes in world markets.
- Unforeseen Technical challenges

8.8.7 Given the project is a multiyear programme there is opportunity to continue to look for efficiencies and NGT's intention is to utilise new and emerging technology and ways of working to continually improve and outperform on the delivery, thus striving for additional consumer value.

8.9 Outputs and Allowances in RIIO-T1/RIIO-T2

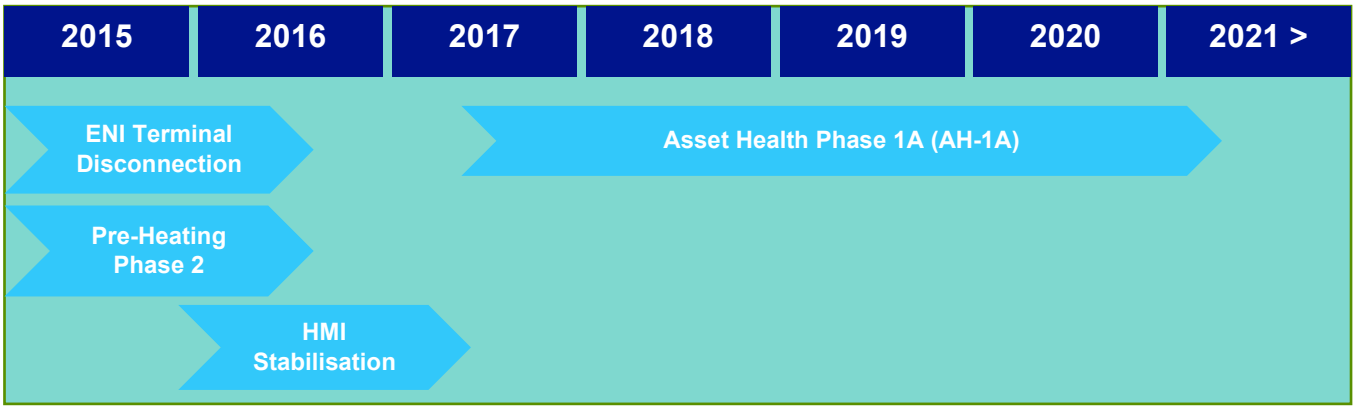
8.9.1 In RIIO-T1 NGT had no outputs or allowances for Bacton Terminal Site Redevelopment. A programme of asset health work at Bacton began in 2015 to 're-life' aging plant with condition issues delivered under Baseline Asset Health allowances in RIIO-T1.

8.9.2 In RTIIO-T2, asset health works associated with items that may be considered at risk due to Future Operating Strategy (FOS) uncertainties were deferred. However, asset interventions were still undertaken where safety critical risks were identified for example Over Pressure Protection HSE Action legal, which was subject to the June 2023 Asset Health re-opener.

8.9.3 Non-critical asset health issues were deferred until the decision on the FOS had been finalised. For assets not deemed to be required these were either left in situ, or isolated pending investment in RIIO-T2. This initially focussed on the disconnection of the ENI sub-terminal and Pre-heat Phase 2 works.

8.9.4 Phase 1A of a major programme of works to address valves, actuators and corrosion issues was undertaken alongside other schemes and then followed by Human Machine Interface (HMI) project and pre-heating phase 3 works. Subsequent lower priority phases of Asset health works, Figure 29, were deferred into RIIO-T2.

Figure 28 Phase 1 A Works



8.9.5 In RIIO-T2 NGT has a Bacton Terminal Site Redevelopment Price Control Deliverable (PCD) as detailed in Special Condition 3.10 Bacton Terminal Redevelopment Re-opener and Price Control Deliverable Part C. The PCD is to ensure that NGT delivers a Final Option Selection Report and Re-opener submission for Bacton Terminal. The received Baseline allowances are £10.5m (18/19 prices). The current spend profile against this allowance up to the point of submission is shown in Table , this is currently excluded from the cost of preferred Option 1.

Table 16 Feed Spend to date.

£m (18/19 Prices)			
Category	2021/22	2022/23	2023/24
Bacton Terminal Redevelopment Spend Profile	1.44	1.25	1.25

8.9.6 The PCD follows the GT Project Assessment Process (GTPAP), which is a two-step process whereby NGT submit the FOSR as part of the first step, and a cost submission once the project has gone through a full FEED for the preferred option and tender process, as a second step. The outcome of the second step will be to amend the licence to incorporate the PCD outputs associated with delivery of the selected option set by Ofgem's Final Determinations in December 2020. As noted in earlier sections, NGT's intention is to accelerate the re-opener submission from August 2025 to July 2024.

8.9.7 Following Ofgem's review and approval of our Proposed Final Option for the Bacton Terminal Site Redevelopment FOSR, we will continue working to develop our preferred option further in readiness for our Re-opener submission at which point we will propose a revised PCD to be included in the Gas Transporter Licence to reflect the delivery of our preferred option.

8.9.8 Acceleration of the re-opener is based on the findings of the FEED and noting that all options considered and short-listed have a common asset health element. As such all short and medium term 'no regrets' asset health work should be undertaken at the earliest convenience to reduce operational risk and maintain reliability. Works starting within the RIIO-T2 regulatory period would continue in to RIIO-T3 allowing a mobilisation ramp up and efficient deliver with no requirement to de-mobilise and re-mobilise.

9 Conclusion and Next Steps

9.1.1 Our final preferred option is the progression of a Base Case Asset Health Solution at Bacton. This recommendation is based on a review of options against the RAM, Remnant Life and CBA. The associated cost of this preferred option is [redacted] (18/19) of which [redacted] will be the basis of our re-opener submission. This excludes the £10.5m baseline allowances received to develop the FOSR and Re-opener submissions. The Baseline funding will be subject to true up following our re-opener submission.

9.1.2 Our recommendation has been justified based the necessity to maintain current levels of capability at a critical site on the network, security of supply, customer obligations UK/EU market etc. No foreseeable option to rationalise until 2035 at the earliest. Evidence of recent events pointing to need for operational flexibility of current set up.

9.1.3 The FOSR demonstrates that all short-listed options require base case asset health investment up to 2035 noting that the proposed works will extend terminal life into the late 2040's when gas flows are predicted to continue. The option provides the least cost option to consumers and is one that allows the flexibility to manage current and future operational needs but also to accommodate future potential changes in the energy landscape.

9.1.4 Noting this basis for all options, NGT class the investments proposed within this FOSR as 'no regrets' and as such are proposing within this submission to accelerate works and bring the re-opener submission forward to July 2024 subject to Ofgem approval. This will enable us to maintain our current project timeline to mobilise works in 2025 and deliver the asset health investments that are essential in delivering the preferred option and ensuring that Bacton continues to fulfil its critical role in the UK energy system.

9.1.5 Due to the nature of the investment and our strategy at Bacton, we are also proposing to also true up existing asset health UID's that fall under the Plant and Equipment category where existing baseline allowances are subject to an uncertainty mechanism. These were omitted from our January 2024 Plant and Equipment Submission to ensure a consistent position in achieved for funding requests at Bacton.

9.1.6 We will continue to engage all associated stakeholders with the outcome of this FOSR and the implications of our preferred final option. We will continue to keep Ofgem informed of progress leading up the re-opener submission.

9.1.7 Following Ofgem's decision on the final preferred option, NGT will utilise the remaining FOSR baseline allowances to continue to develop the details associated with the technical solutions and to ensure that suitable level of granularity can be provided within the re-opener submission. As the detailed design stage starts, we will undertake additional work to finalise technical parameters for designs and in-turn review how works can be bundled to drive the most efficient delivery sequence at site during execution of the works.

10 Appendices

Appendix A – FEED Study Outputs, reports and supporting information
Appendix B – RAM Study
Appendix C – Remnant Life Study
Appendix D – Technical Justification Data
Appendix E – Tables included in FOSR
Appendix F – Hydrogen Statement
Appendix G – Assurance Letter
Appendix H – Stakeholder Engagement
Appendix I – Mapping of Ofgem Requirements
Appendix J – SNS Future Production Potential
Appendix K – RIIO-T2 Original Submission
Appendix L – 2023 Bacton Investment Strategy

11 Glossary

Glossary	
1-in-20	The 1-in-20 peak day demand is the level of demand that, in a long series of winters, with connected load held at the levels appropriate to the winter in question, would be exceeded in one out of 20 winters, with each winter counted only once.
ANCAR	Annual Network Capability Analysis Report
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
Capability	The physical limit of the NTS to flow a volume of gas under a given set of conditions, this may be higher or lower than the capacity rights at a given entry or exit point
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
DESNEZ	Department for Energy Security and Net Zero
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.
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

Glossary	
GDN	Gas Distribution Network
Greenfield	Construction on land that is outside of the existing perimeter site boundary, where there is no need to demolish or rebuild existing structures
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
LNG	Liquified Natural Gas, Natural gas that has been cooled to a liquid state (around -162°C) and either stored and/or transported in this liquid form.
MCPD	Medium Combustion Plant Directive, A directive to reduce emissions from combustion plants with a net thermal input between 1-50 MW.
MTO	Material Take Off
MWC	Main Works Contractor
NBP	'National Balancing Point' is a marketplace for the procurement of gas within the United Kingdom
(G)NDP	**Network Development Process:** The process by which NGT identifies and implements physical investment on the NTS.
NEA	Network Entry Agreement
NGT	National Gas Transmission
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.
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.

Glossary	
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