national gas transmission

Low Voltage Assets and Control and Instrumentation EJP - Bacton FOSR Cost Re-Opener

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1.0	August 2024	First draft
2.0	October 2024	Internal Review
3.0	October 2024	Final

Contents

1 Executive Summary

1.1.1 National Gas Transmission, hereafter referred to as NGT, are requesting funding to manage Asset Health requirements related to identified Low Voltage (LV) assets and Control and Instrumentation (C&I) equipment at Bacton Terminal. This is aimed at maintaining the ongoing safe, secure, and reliable operation of the UK Gas National Transmission System (NTS).

1.1.2 Due to the age of the site and its coastal location, Bacton has encountered operational issues related to asset deterioration of its electrical assets' integrity, safety, and functioning. In general, electrical assets standards and legislation have also changed over the years and there is need to ensure compliance.

1.1.3 A program of limited replacements and refurbishment were carried out in in the RIIO-T1 and RIIO-T2 price controls. However, in order to safeguard the site for future energy requirements up to 2050, detailed LV assets studies as shown in Section 2.3 of the FEED Study Report (Appendix A), were done to ascertain the performance of all LV assets. The proposed interventions as detailed in Section 2 of the Bacton [redacted] Electrical Report (Appendix C) will address both current asset health issues and future requirements. For Distribution Boards (DBs) assets, this was further enhanced by NGT engineering assessments to confirm asset condition as detailed in Distribution Boards Maintenance Records, (Appendix F).

1.1.4 The electrical assets covered in this Engineering Justification Paper (EJP) are Transformers, Standby Generator, Uninterruptable Power Supply (UPS) and Battery Systems, Electrical Kiosks and Distribution Boards (DBs) and External lighting.

1.1.5 This paper also includes associated C&I equipment. Such as pressure switches and various transmitters. Further details on the scope and volumes are detailed in Section 3 of this EJP.

1.1.6 This Engineering Justification Paper (EJP) emanates from the Bacton Final Option Selection Report (FOSR) submitted to Ofgem in February 2024. The FOSR provided 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.

1.1.7 Most of the LV distribution system with the associated equipment, was built and installed up to 50 years ago. Whilst some assets have had varying levels of intervention over the years, i.e., main transformers were replaced in 1991, the assets in scope are nevertheless defective and in a state of advanced deterioration. If these assets are not functioning correctly, there is a risk of loss of critical assets and potential security of supply issues. This in turn leads to a network unable to meet customer needs.

1.1.8 Due to the critical nature of these electrical supplies, without a managed programme of investment, the LV assets could rapidly become a major risk to the continued safe and efficient operation of Bacton Terminal.

1.1.9 As an Upper Tier, Control of Major Accident and Hazard (COMAH) sites, NGT has an obligation to effectively manage process safety and demonstrate compliance with COMAH regulations at Bacton. A mandatory safety case must be submitted to the Health and Safety Executive to demonstrate 'all measures necessary' have been taken in the management of the major accident hazard plant and equipment in order to ensure continued safe operation of the terminal.

1.1.10 The investments in this EJP are required now (RIIO-T2 horizon). This paper requests direct cost estimate including escalator of [redacted] **(18/19)** which is composed of LV Assets and C&I costs baseline funding for asset health investment on our electrical infrastructure assets. Investment have been developed across all asset class themes aligned to the approved Final Option Selection Report (FOSR).

1.1.11 Table 1 sets out key information about the Electrical Assets Investments project.

Name of Project	Bacton LV Assets and C&I Equipment
Scheme Reference	
Primary Investment Driver	Asset Health
Project Initiation Year	FY2026
Project Close Out Year	FY2035
Direct Cost Estimate (£m, 2018/19)	[redacted]
Direct Cost Estimate with Escalator applied @ (1.23069)	[redacted]
Cost Estimate Accuracy (%)	+15/-10%
Project Spend to date (£)	0.000
Current Project Stage Gate	ND500 (4.3) Develop and Sanction
Outputs included in RIIO-T2	• Tendering contractor award and conceptual design (Site surveys) • ECI X22 [redacted] Contract award - design and build • Initiate Long lead item order for year 1 delivery.
Outputs included in RIIO-GT3	Detailed design and delivery
Outputs included in RIIO-GT4	• Delivery, commissioning • Project closure

Table 1: Summary table for LV Assets

1.1.12 Table 2 below sets out the cost summary for delivering the selected final option for this project.

	RIIO-T2		RIIO-GT3					RIIO-GT4					
£m 18/19	**FY25**	**FY26**	**FY27**	**FY28**	**FY29**	**FY30**	**FY31**	**FY32**	**FY33**	**FY34**	**FY35**	**Total**	**Total plus Escalator**
Direct Cost Phasing (£m)	[redacted]												

Table 2: Bacton Low Voltage Switchgear and Control and Instrumentation Cost Summary

2 Introduction

2.1.1 The Bacton site originally went into service in 1968. The site is now beyond its design life of 40 years. Since then, there have been several significant additions and up-grades to the site including the facilities owned and operated by Interconnector which share the same site as NGT. The Terminal is both a key system entry and exit point on the National Transmission System, which has proved pivotal to securing Europe's gas supplies particularly during the current conflict in Ukraine.

2.1.2 Electrical Infrastructure assets generate, distribute, convert, control, or utilise electrical energy to enable the safe operation of sites across the Bacton Terminal. A considerable proportion of assets on site rely on the safe, secure, and reliable supply of electricity to fulfil their function, including critical electrical supplies for Gas Quality and Metering systems required for ensuring compliance with GS(M)R and wider billing processes.

2.1.3 Bacton Terminal has complex electrical systems such as Transformers, Standby Generators, Low Voltage Switchgear, Uninterruptible Power Supplies (UPS) and connected electrical equipment such as Site Lighting. Smaller assets such as Above Ground Installations (AGIs) have simpler electrical infrastructure systems involving a LV Electrical connection, single or multiple distribution board and single digit connected loads, such as Lighting.

2.1.4 Bacton terminal located on the Norfolk coast is strategically important to the UK National Gas Transmission Network. It is a key dynamic swing node because it is required to manage changing gas demand patterns within daily swings of supply into and out of the network including import/export requirement from the EU interconnectors. It bridges Great Britain with the European Union and controls flows into the Southeast ensuring security of supply for London.

2.1.5 Electrical Assets on the terminal are used to supply power to several circuits for different assets, such as lighting and Instrumentation (e.g., Gas Quality and metering). Low Voltage (LV) Electrical Systems are the first stage of power distribution on the terminal.

2.1.6 Surveys have been completed to ascertain the condition and performance of the LV assets as detailed in Section 2 of the Bacton [redacted] Electrical Report (Appendix C) and the findings have revealed that the assets in this scope are defective and/or obsolete and have opportunities for rationalisation if replaced. Funding to make the necessary interventions is now required to deliver replacement works across RIIO-T2, RIIO-GT3 and future regulatory periods.

2.1.7 The existing C&I equipment is also being addressed in this paper because of its pertinence to the LV assets. Its condition assessment is presented in detail in section 8 of the FEED Study report (Appendix A). The findings in the report are substantiated with an obsolescence study and results extracted from both findings are detailed in Section 4, Problem Statement.

2.1.8 Upon implementation of the proposed investments, the envisaged risk of failure and associated safety risks will be reduced to As Low As Reasonably Practicable (ALARP). This is a requirement aligned with the Health and Safety Executive (HSE) guidance which states the need to make sure risks are reduced to ALARP through weighing the risk against the sacrifice needed to further reduce it.

2.1.9 Without investment in the LV assets and C&I equipment, the existing safety risk to site personnel will continue to increase. It also significantly impacts the site's resilience and increases the risk on security of supply as there is an increased risk of long plant outages should there be a major failure resulting in loss of flow capability.

3 Equipment Summary

3.1.1 LV equipment is used to supply power to various systems within Bacton Terminal. The scope of this EJP covers asset types shown in Table 3 below.

3.1.2 The assets also include several types, sizes and lengths of power and instrumentation cable required for the installation and commissioning of different assets.

Asset Type	Quantity
LV Transformers	2
Standby Generator	1
UPS and Battery systems	3
External Lighting Columns	100
Kiosks	6
Distribution Assets	28

Table 3: Asset types in scope

3.1.3 C&I equipment enables the terminal process measurement and process control, back to the terminal Distributed Control System (DCS) and control of a majority of LV assets in this scope as identified in the Feed Study (Appendix A). The C&I scope in this EJP has been reviewed and confirmed by NGT Engineers as shown in Table 4 below.

3.1.4 Works associated with the C&I scope includes the complete replacement of all associated field cable, glands, field junction box, transition, and internal cable termination / barrier and connection onto the DCS. Furthermore, all valves to be replaced in the Valves EJP will also require the necessary control and instrumentation assets to be replaced. Installation of new instrumentation systems and cabling will require dedicated and segregated cable management via a mixture of above and below ground solution.

Type of Instrument	Manufacturer	Model	Quantity to Be Replaced
DP Transmitter	[redacted]	[redacted]	11
Pressure Transmitter	[redacted]	[redacted]	30
Temperature Transmitter	[redacted]	[redacted]	31
Pressure Transmitter	[redacted]	[redacted]	12
Pressure Switch	[redacted]	[redacted]	6

Table 4: Volumes for Control and Instrumentation

Transformers

3.1.5 Two 11KV cables enter the National Gas site on the north side of the terminal and terminate within the HV Switchroom. On leaving the HV switchgear the supply enters the two 11KV/415V transformers. The location of the transformers relative to the other site buildings is shown in Figure 1 below.

[redacted]

Figure 1: General site location of Transformers

3.1.6 The technical specifications of the two identical transformers commonly known as TX1 and TX2 are shown on their name plate in Figure 2. During normal operation, the site will run with both transformers online sharing site load. However, if one transformer is not available, there is capacity for the site load to be supported by a single transformer with the bus coupler closed, as such the two transformers form the redundancy for each other.

[redacted]

Figure 2: LV Transformers Technical Specifications (left) and Transformer picture (right)

Standby Generator

3.1.7 Bacton is equipped with a 625KVA standby generator which is a back-up power source in the case of sudden loss of electrical power. Due to the strategic importance of the terminal described in Section 3 above, there is always need for a reliable contingency plan to provide alternative power supply in the event of typically low probability but high consequence scenarios such as power blackouts. Section 2.7 of Appendix C of the FEED Study report recommended the complete replacement due to maintenance difficulties linked to obsolescence.

If the terminal loses mains power from either TX1, TX2 or both, the generator will automatically start to take the full load of the site via the LV switchgear. The generator will only take full load when it is at the required speed, voltage and frequency which gives a time delay. The process of switching supplies from mains to generator and vice versa is fully automated and requires no manual intervention.

3.1.8 An LV single line diagram showing the relative positioning of the standby generator relative to the transformers is shown in Figure 3

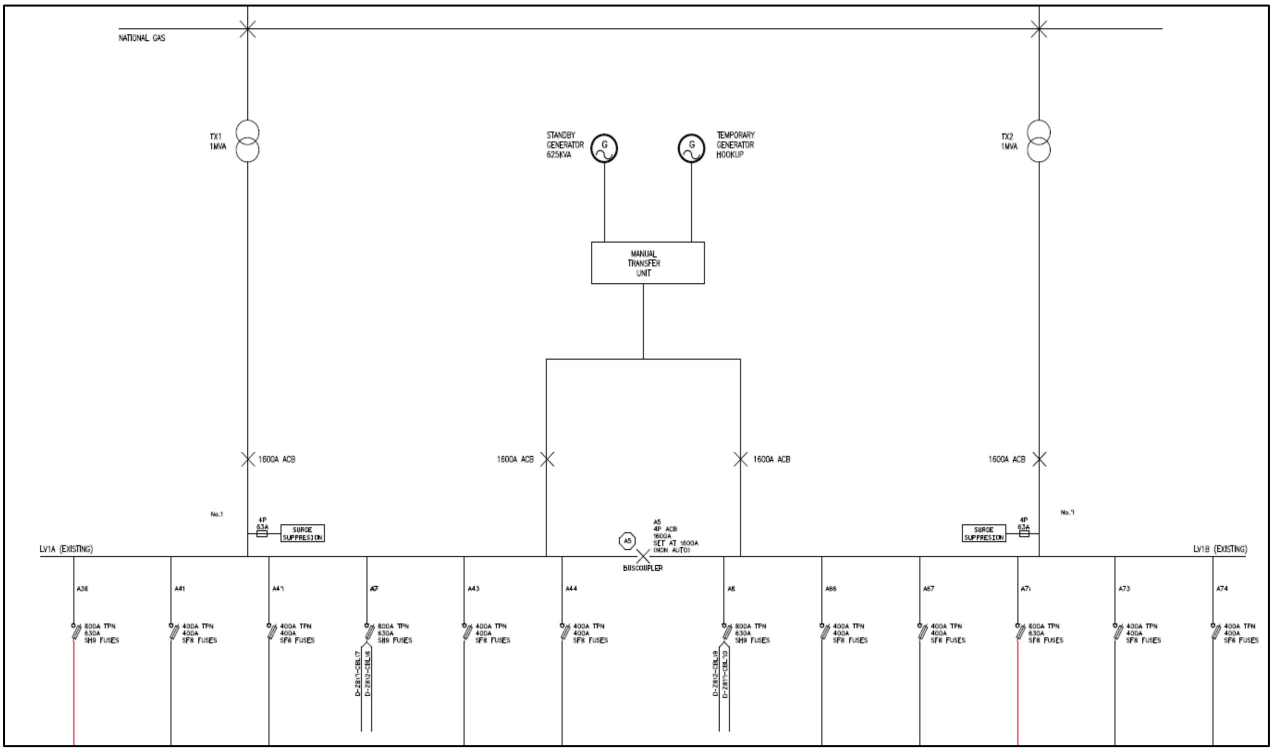

Figure 3: LV Single Line Diagram

Uninterruptible Power Supplies/Battery systems

3.1.9 As highlighted above, there is a time delay from the time normal power supplies from transformers are lost to the time the standby generator takes over supplies. This time delay is approximately 60 seconds. To ensure the site remains operational during this time delay, several battery and UPS systems have been installed on site. These ensure essential supplies to process and safety systems are maintained. , shows the different systems available and the critical assets they supply power.

Available System	Critical Assets Supporting Standby Power
Mains UPS	[redacted]
Instrument UPS	
Fire & Gas	
LV Switchboard Tripping Batteries	
Standby Generator Starting Batteries	
Fire Pump Starting Batteries	

Table 5: UPS and Battery systems

3.1.10 **Main UPS** - The current system consists of two separate 60KVA UPS units that run in parallel with an N+1 redundancy. This means a single unit is capable of taking the full load of supplies connected to the UPS distribution boards. The system is designed to be fault tolerant so in most cases no operator intervention should be required. On failure of one of the units, the system will automatically disconnect the failed UPS and the system will continue to operate on the remaining UPS.

3.1.11 The Main UPS units were supplied and installed in 2002 with a design life of 15 years as part of a larger control system and gas quality upgrade. After the installation, the battery banks have been upgraded twice but the UPS units remain as part of the original installation. The output voltage from the UPS' feed a series of distribution boards that feed all critical supplies.

3.1.12 **Instruments UPS** – The current 24V DC system was installed during the same project as the main UPS in 2002. The batteries have also been replaced twice since the original installation. The system consists of seven PSS30 switch mode rectifiers working on an N+1 redundancy. Each unit provides a 3-kW output and are configured to provide even current sharing across each module.

3.1.13 The rectifiers are centrally controlled by a signalling and monitoring unit which is used to collect system information such as voltages and current from individual rectifiers, error signalling, boost charging and discharge testing.

3.1.14 The output from the Instruments UPS system feeds a 24VDC distribution board. From these individual MCB's feed goes to all cabinets for the control system and gas quality systems. It is further distributed out into the field and the end circuits which consist of various analogue and digital instruments as shown on the schematic diagram in Figure 4.

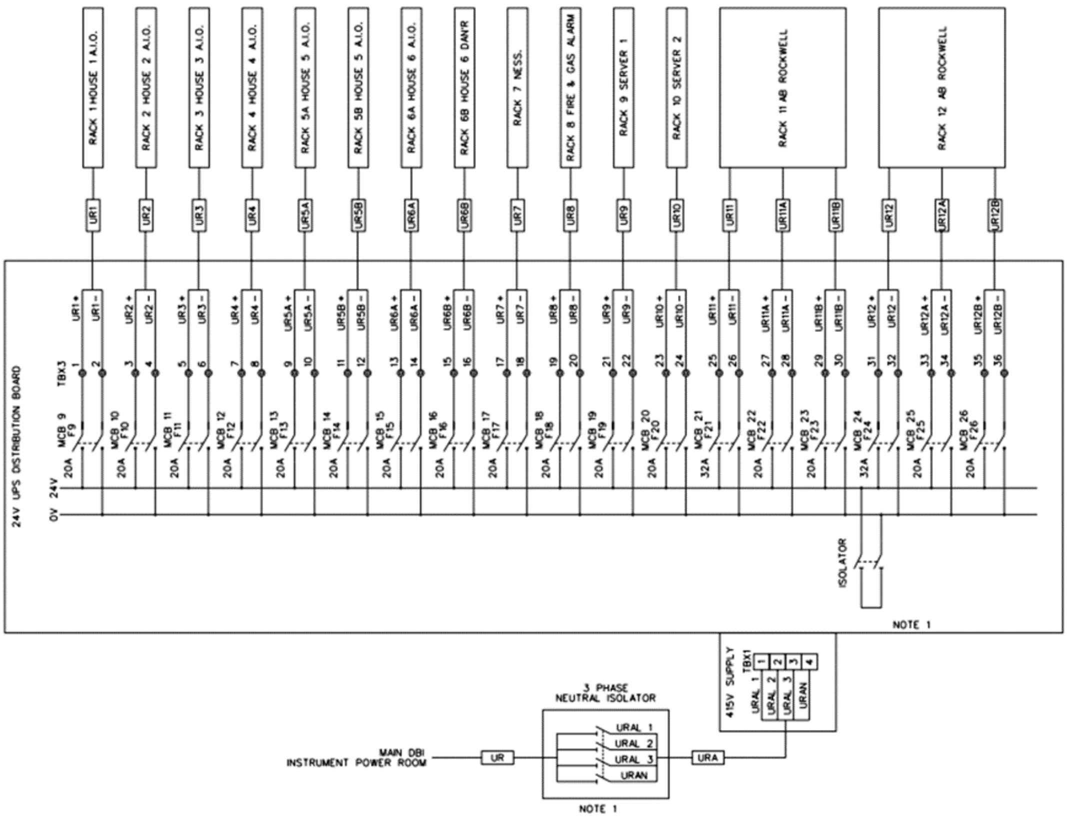

Figure 4: Instruments UPS schematic diagram

3.1.15 **Fire and Gas Battery Charger -** The fire and gas system is supported from a separate dedicated battery charger. As a safety system the batteries provide a standby time of 24 hours. The cabinet is located within the Instrument Room and supplies the Crowcon Fire and Gas panel that it located in the same room and the main site fire and gas panel that is located in the Control Room.

3.1.16 **LV Switchboard Tripping Battery Charger -** The Main LV switchboard contains a 110V DC control circuit which manages the operation of the main air circuit breaker on the loss of power, generator starting and switching between various sources. To support the operation of this process during power loss a dedicated 110V DC battery charger is installed in the Main LV Switchroom. The installation was carried out in 2012

3.1.17 **Standby Generator Starting Batteries –** The standby generator starting batteries are used to start the standby generator when it is required to run.

3.1.18 **Fire Pump Starting Batteries -** Two off 24V DC systems feed the fire pump house engine starter motors, located in the fire pump house. The charger units are from the original fire pump installation with the batteries being replaced in 2012 lead acid batteries were replaced with a NiCad. The battery sizing is in accordance with the engine/pump manufacturers requirements. With the fire pumps being part of an emergency response system there is a requirement for them to be installed in line with National Fire Protection Association (NFPA) 20 Standard for the Installation of Stationary Pumps for Fire Protection.

Electrical Kiosks/Distribution Boards

3.1.19 The site has several Kiosks that contain electrical distribution panels located around the site that supply various pieces of electrical equipment. Specifically covered in this scope are Kiosks C, D, E, F and G which have known asset health issues. These kiosks house supplies to about 56 actuators each, Cathodic Protection power supplies, lights and sockets making them critical to site operations. Figure 4 shows an example of a distribution panel housed in one of the Kiosks.

3.1.20 By design and purpose, electrical kiosks have no redundancy and should be refurbished or replaced once they lose their weather-resistant and fire-retardant properties which protect internal assets.

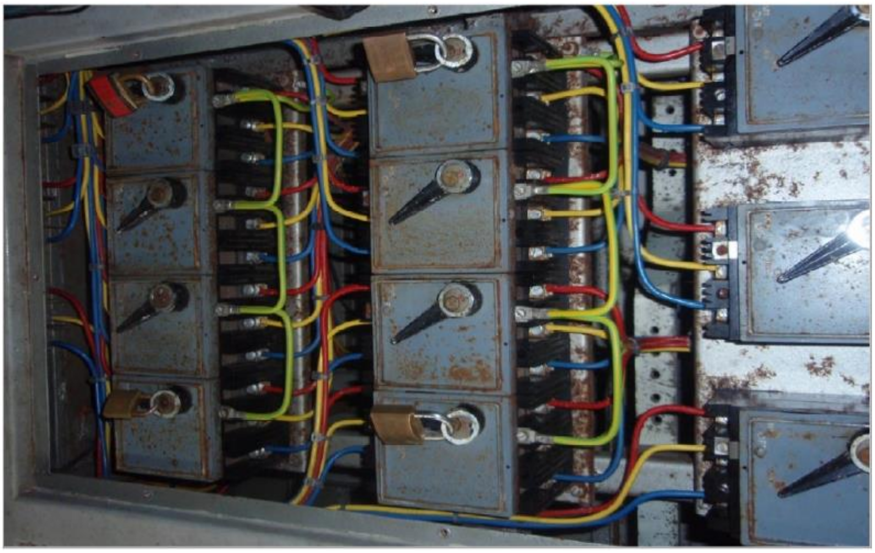

Figure 4: Typical Distribution Panel

External Lighting

3.1.21 There are several lighting columns around the site which are aged and corroded making it impossible for them to be lowered for maintenance. Effective maintenance now requires the hiring of an all-terrain lifter which is costly and time consuming.

3.1.22 These lights and columns were constructed approximately 57 years ago with a design life of 25years. At the base of the lighting columns are Ex-d isolators which are fed via aluminium cables.

3.1.23 By isolating one lighting column, several others on the same circuit are also isolated presenting no redundancy benefits. It is therefore important that all the column lights be available for adequate lighting.

3.1.24 There is evidence of significant corrosion across the terminal lighting columns. There has been corrosion identified within the cam pivot section of the columns, this has led to the columns being unsafe to lower. When a lamp / light fitting requires maintenance or repair, the activities are carried out with the use of Mobile working elevation platform (MWEP) which presents an added safety risk of working at height. This adds additional OPEX cost to all activities associated with lighting columns.

4 Problem Statement

4.1.1 Elements of the LV assets are deteriorating due to age, corrosion, and wear. This has resulted in several defects being recorded, some of which are classified under Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR). For instance, transformers have exhibited degradation of insulation paper as shall be further discussed below. If the transformers fail, this will result in loss of site capacity as critical assets will lose electrical supply. NGT must comply with DSEAR and by having defective assets in zone-rated locations, we risk an explosive atmosphere (through a gas release / leak) finding an ignition source leading to a fire / explosion scenario.

4.1.2 Old cables may result in major failures of high cost newly procured assets. Already, the site is experiencing an increased number of DSEAR defects which will be significantly addressed by the installation of new cables. As of August 2024, Bacton had a total of 603 electrical defects. Further details of the defects are shown in Appendix E.

4.1.3 Table 6 below shows a summary of current defects and typical description of the fault. Without intervention, it is highly probable that the quantity of severe defects will escalate, negatively impacting daily operations of the Terminal.

Defect Type	Quantity	Typical Description	Risk
Safety	363	Asbestos fibre detected on the distribution board and needs removal and replacement. Distribution Board isolator is cracked along the side of breaker and requires replacement. Lighting columns unable to lower due to corrosion and isolators at base of column hard to inspect and replace due to confined location.	Management of Asbestos is mandatory for NGT to remain compliant with Health and Safety Legislation. Lack of investment in managing asbestos will lead to a higher risk of incidences of asbestos related illnesses. Proactive management of asbestos mitigates health impacts and compliance with the Health and Safety Executive (HSE). Defective DB manual isolators can snap during switching operations causing injury or potential electrocution.
Availability and Reliability	238	Water present inside transmitter and has corroded terminals. DSEAR defect - EX 46624 Flame path damaged. Actuator only moves to 97% and then stops.	Corroded terminals can cause major electrical incidences such as an arc flash resulting in injury to personnel, impacting critical operations. Failure of an actuator to close or open when required can hinder timely emergency operations resulting in safety risks to personnel. Such defects could result in site outages which in turn impact on customers as well as financial costs to NGT.

Table 6: Current LV Assets Defects

4.1.4 As an Upper Tier COMAH establishment, we must take all measures necessary, which relates to the use and adaption of best-practice standards and codes of practice. The key drivers for investment into the various assets this scope are:

- **Health and Safety** - Through degradation of internal components, the likelihood of a failure occurring increases, this could result in a high energy incident, which would have an adverse impact on the health and safety of operatives.
  Control of Asbestos Regs - deterioration of assets containing asbestos represents a significant risk to site personnel maintaining and operating routinely such assets.

  Electricity at Works Regs - The noted asset degradation represents a significant risk again to personnel operating and maintaining such assets. Many of these assets were built to codes which are not in line with current standards, which incorporate a multitude of more modern fault diagnostics and protection concepts, which in turns reduces risks to site personnel to more acceptable levels of safety.

  Management of Health and Safety at Work Regs 1999 (employer must suitably assess work-based activities and implement any appropriate controls to manage potential risks to the health, safety, and welfare of employees).

  The Regulatory Reform (Fire Safety) Order 2005 (governing fire safety in buildings in England and Wales, given we have switchgear in the main terminal building and degraded / obsolescent / defective assets all across the Terminal, which in themselves could lead to a fire)

- **Legislation** - Inspections done on some assets have shown the need to upgrade them to maintain compliance with the Electricity at Work Regulations (EAWR). This will be remediated as part of the scope in this EJP to achieve compliance. With these regulations, employers are given duties and responsibilities to make sure that all work activity that uses or may be affected by electricity is done safely. EAWR aim to prevent death or injury to any person from electrical causes while operating in a work environment. This can include electric shocks or burns, electric arching and fires or explosions.

  General legislation including DSEAR places requirements on ensuring risks as so-far as is reasonably practicable. COMAH Regulations are to a higher threshold, where the concept of 'All Measures Necessary' and reduction of risks to as low as reasonably practicably (ALARP).

  Asset Deterioration – For example, UPS assets have a finite life of up to 20 years (Appendix G) due to mechanical and EC&I failure modes such as corrosion and electronic component failures. Some UPS have shorter lives due to known obsolescence issues and are no longer being supported by Original Equipment Manufacturers.
  Similarly, transformer degradation due to environmental conditions was first noted during a 3 yearly maintenance activity in 2016. We identified that the transformers needed patch painting, and a subsequent defect was raised. Patch painting was done

again in 2017/18 and as part of the one yearly visual, functional inspection, painting has been an on-going maintenance activity to date, however with Bacton being on a coastal location the assets have continued to deteriorate to a condition whereby they need to be replaced.

Furthermore, the DBs in scope have been recently assessed and confirmed to be incompliant with maintenance regulations (MAINT/11001), posing an operational risk to the terminal. This is detailed in the Distribution Boards Maintenance Records, (Appendix F).

- **Rationalisation** – Furthermore, Section 8 of the Bacton [redacted] Electrical Report (Appendix C) demonstrated an opportunity to rationalise some LV assets. For instance, due to the decommissioning of [redacted] 1 & 2, the current obsolete Kiosks C and D can be companied into a new single elevated (Glass Reinforced Plastic (GRP) kiosk with a Form 4 Type 7 panel board which is compliant with current standards and legislation. This has the added benefit of reducing maintainable components and resultant maintenance costs (Opex).
  Following completion of the detailed design, there will be an opportunity to rationalise external lighting columns taking advantage of modern technology with improved luminaire.

- **Reliability and Availability** – Some of the assets are a single point of failure on the site electricity distribution and can catastrophically fail. For instance, most of the DBs have no redundancy hence their failure will affect supplies to their auxiliaries. Transformers are complex equipment with a mixture of electronics and metals materials and can take between 1 to 2 years to manufacturer. The availability of such spares is further exacerbated by obsolescence issues.

  As a critical national infrastructure, lack of reliability and redundancy risks the 24/7/365 availability of the Terminal and associated customer requirements, resulting in potential gas supply issues, constraint costs and reputational impact.

What is the outcome we want to achieve?

4.1.5 By carrying out the interventions recommended in this scope, NGT aims to ensure that:

- All the assets are safe, fit for purpose, secure by design, reliable and maintainable by complying to the applicable standards and regulations. There are also opportunities to rationalise some of the assets as the current design from the 1970s incorporated a second generator and alternative control room which is no longer required due to decommissioned reliant auxiliaries over the years.
- All LV assets are fully functional with all known issues resolved and compliant to key legislation such as Electricity at Work Regulations and the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR), British and International standards and all relevant NGT standards.
- The availability of Bacton terminal is optimum through ensuring the availability of all LV assets. All currently identified obsolete assets and spares will be replaced.

- The standby generation and UPS assets are available when required and perform their duty to a high reliability to provide power to the site in the case of loss of the Public Electricity Supply.

How will we understand if the spend has been successful

4.1.6 To comply with all relevant LV assets internal and external technical standards, codes of best-practice and company management procedures, as well as wider health and safety legislative requirements. The proposed design, installation and commissioning are in line with T/PM/G/35: Management Procedure for the Management of New Works Modifications and Repairs & T/SP/EL/50 V02: Gas Transmission Electrical Specification.

4.1.7 The replacement of the assets in this scope will resolve the present high number of noted critical defects as detailed in Table 6. Additionally, by doing this, it will improve maintenance, but also asset reliability, availability (and maintainability). This will in turn reduce time and cost of maintaining the assets and extend the asset life to 2050.

4.1.8 The investment will also be considered successful if the project delivers its scope within its forecasted program, investment funding allocation and re-entry into service.

Real life examples of problem

4.1.9 **Transformers** - Based on the 2024 oil diagnostics reports of TX1 and TX2, the onset of transformers insulation paper degradation has been confirmed by their Degree of Polymerization (DP) values. Results of the tests done in August 2024 revealed that TX1 and TX2 had a DP of 396 and 355, respectively. New paper insulation has a DP of above 1000 which gradually reduces as the paper ages. At a DP of 250, a transformer is considered to be at its end of life (EOL) within 5 years, at which point both assets would still need replacing. Without intervention, sudden transformer failure will result in loss of supplies to critical auxiliaries resulting in loss of terminal capability

4.1.10 NGT have continued with regular oil sampling tests taken each year with the DP being closely monitored. The DP reading has followed a near linear decrease in value since the 2018 reading with an end-of-life date being around 2030. With the end-of-life date in mind and the criticality of the electrical supply to Bacton, these transformers must be considered as already nearing end of life and need to be replaced. Further details on the Transformer oil diagnostics reports are shown in (Appendix D).

4.1.11 **Pump Control Panel 1** – This control panel was manufactured more than 40 years ago by [redacted] who are no longer trading thereby presenting obsolescence issues. The panel has been heavily affected by the unavailability of spares and is currently in a status shown in Figure 7. Failure of the pump control panel would result in inoperability of the fire-water system, which is a critical component of both our own and Interconnectors Safety-Case Commitments.

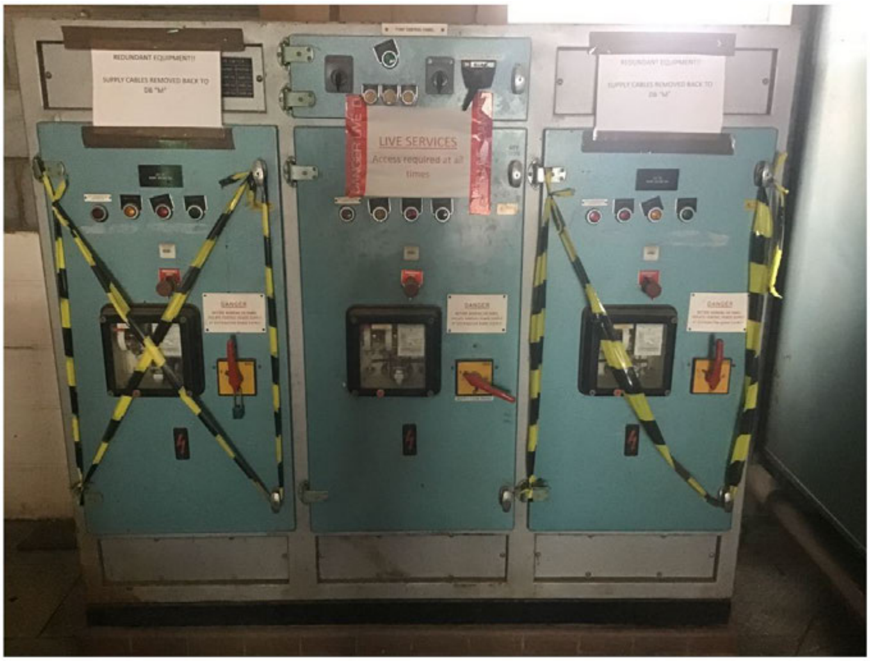

Figure 5: Pump control panel 1

4.1.12 **Kiosk F** - It is a panel board split into two with a single feed from switchboard A and another from DB B. It currently feeds several valve actuators, small power, and external lighting. BPG Engineering are no long trading so no further technical assistance can be obtained. Water ingress to kiosk and signs of condensation and rusting are significantly evident. The current status of the kiosk is shown on Figure 8. If no investment is done, the continuous ingress on moisture in the kiosks will result in electrical failures on the panels and failure to supply power to the outgoing circuits to the safe control and operation of Terminal gas flows.

4.1.13 Section 8 of the Bacton [redacted] Electrical Report (Appendix C) gives detailed findings of the condition of each kiosk covered in this EJP. If the valves cannot be operated, we are notable to safely control, isolate or regulate gas flow through the terminal, as they will not automatically go into a safe state as they need motive electrical power to do so.

Figure 6:Kiosk F (left) and panel (right)

4.1.14 **External Lighting -** The current [redacted] base hinged columns are in poor condition and have been condemned by the manufacturer. Light fittings are SON/MH lamp type, and the majority of the underground cabling is direct buried. Figure 7 shows one of the lighting columns which is heavily corroded. DSEAR defects, such as flame path damage and armour cable showing are prevalent across all the lighting columns. DSEAR defects increases the likelihood of a gas release being ignited which poses a safety risk to site personnel. Cable defects also present a substantial risk of electric shock.

Figure 7: Typical lighting column

4.1.15 **Control and Instrumentation –** Bacton Terminal's existing C&I equipment condition assessment is presented in detail in section 8 of the FEED Study report (Appendix A). The findings in the report are substantiated with an obsolescence study. Results extracted from both findings are summarised below.

4.1.16 Most of the field instrumentation is obsolete or entering the end-of-life cycle for the product. Although we have undertaken a lot of recent upgrade projects, such as:

- o Upgrade of the existing DCS hardware and associated HMI's.
- o Upgrade of the utility boilers.
- o Upgrade of some flow meters in 2015.
- o Partial upgrade on incoming feeder instrumentation.

4.1.17 There remains a large number of field instrumentation which are either obsolescent and / or defective, which again impacts on and risks the need for continued safe and reliable terminal operations.

4.1.18 [redacted]

4.1.19 Several visibly obsolete systems at the Bacton Terminal site have yet to be upgraded such as the FGS in the control room.

4.1.20 The existing marshalling rack panels although still operational the original panel doors have been removed thus creating a Hazard and exposing the entire operations to risk.

Spend Boundaries

4.1.21 This investment covers only LV assets and does not cover any High Voltage assets. At a high level, the covered assets are:

- Transformer.
- Standby Generator.
- UPS and Battery Systems
- Lighting Columns.
- DBs and Kiosks.
- Pump Control Panels.
- Control and Instrumentation.

4.1.22 The scope also covered deferent sizes and lengths of power and instrumentation cables associated with the assets in scope.

4.1.23 This also includes the rewiring of all new panels and cable containment scope within NGT site boundaries. This is also aligned to the RIIO-GT3 plan.

5 Probability of Failure

5.1.1 All the assets in this scope have been surveyed internally and a Main Works Contactors was also engaged to carry out a specialist assessment. Survey findings have revealed information which has been used to determine the likelihood of failure of each group of assets. Details of survey findings for each asset are presented in Section 8 of the Bacton [redacted] Electrical Report (Appendix C). [redacted] below summarises t he key findings which determine the probability of failure.

Asset	Major Findings	Probability of failure statement
Transformers	TX1 and TX2 have confirmed paper insulation degradation or 389 and 437 respectively, which is approaching the design limit of 250.	Paper insulation is an integral part of a transformer and allowing DP to approach the limit is highly risky. It is highly likely that the transformers will be end of life before 2030.
Standby Generator	The Standby generator spares are now obsolete and affecting maintenance.	With the confirmed unavailability of maintenance spares from the OEM, there is high a probability of the having the generator unavailable due to a major defect.
UPS	Damage to sensitive downstream electronic equipment or control systems	Most of the UPS systems are affected by the unavailability of spares due to obsolescence issues. In the event of the Main UPS failing, there will be no power to critical assets such as Control Systems, Radio Communications, Flow Metering, Security & Access Control, Fire Sirens, Over Pressure Protection safety systems to name a few.
Distribution Boards	All the DBs are manufactured by [redacted] are no longer supported by the OEM and obsolete.	There are no longer spares support which increased the probability of failure.
External Lighting	The current [redacted] base hinged columns are in poor condition and have been condemned by the manufacturer. Light fittings are SON/MH lamp type, and the majority of the underground cabling is direct buried.	The external lighting is already compromised and needs improvement. There is evidence of significant corrosion across the terminal lighting columns. There has been corrosion identified within the cam pivot section of the columns, this has led to the columns being unsafe to lower.
Kiosks	Most of the kiosks in scope have showed signs of water ingress and moisture affecting the panels.	The kiosks have already started failing. Water ingress to kiosk and evidence of condensation as well as rusting observed.
C & I	Maintainability of field C&I assets is affected by the unavailability of maintenance spares and components.	The performance of the assets such as valves is already being affected by the current condition of C&I equipment due to the unavailability of spares to carryout maintenance activities.

Table 7: Probability of failure summary table

6 Consequence of Failure

6.1.1 As detailed in the equipment summary section, the LV assets in this scope are utilised to enable other systems to perform their primary function, ultimately providing a safe and compliant operational site.

6.1.2 Without appropriate level of investment, the LV assets will not be able to operate as expected and in turn present consequences as detailed in Table 10. It will also fail to conform to the legislative requirements and safety standards.

6.1.3 Table 8 shows Bacton constraints volumes and fees based on the 2024 Future Energy Scenario.

[redacted]

Table 8: Bacton Terminal Constraints Fees

6.1.4 The consequence of failure has varying impacts on safety, availability, environment and financial. Failure of the different assets can impact the capability of the terminal.

Sub Asset	Impact / Consequence			
	Availability	Environment	Financial	Safety
Transformers	Sudden transformer failure will result in loss of supplies to critical auxiliaries resulting in loss of terminal capability. Failure results in the need to run the standby generator to support auxiliaries which is not sustainable for extended periods of time. The lead time for the replacement of a catastrophic transformer failure can be more than a year due to the complexities of the manufacturing process. Fire on one transformer may impact on the second transformer due to their proximity.	Catastrophic failure is likely to throw oil further than the extent of the bunds. Impact on flows of gas in the network if the plant trips leading to inefficient operation of the compression fleet and high emissions across the network. Potential for LNG to be required to balance the network if flows are interrupted from the terminal with associated increases in GHG emissions from the use of LNG instead of pipeline gas.	Running a Standby Generator to maintain supplies would result in increases in running costs, such as cost of fuel.	Catastrophic failure of the transformers could result in explosion that could have serious implications to personnel on site.
Standby Generator	Failure to run the generator when needed results in the unavailability of the Terminal until normal supplies are availed.	N/A	Consequential damage to site equipment at the end of the autonomy period.	Harm to personnel due to impact of consequential events, e.g., loss of lighting, loss of communications, loss

Sub Asset	Impact / Consequence			
	Availability	Environment	Financial	Safety
	Damage to sensitive loads across the site (C&I equipment) that will impact on the operation of the site.		Potential need for capacity buy backs if loss of Terminal creates sufficient constraint against supply & demand.	of the site security systems.
UPS	Damage to sensitive downstream electronic equipment or control systems	N/A	Failure to maintain electrical equipment in a safe condition is a non-compliance with the Electricity at Work Regulations and may result in HSE interventions or prosecution	Loss of containment risk and associated fire / explosion implications from inability to remotely control critical terminal plant and equipment, leading to unsafe operating condition
Distribution Boards	Failure of a distribution board can lead to non-functionality of downstream connected assets including metering and telemetry affecting the efficient operation of the network.	N/A	The financial risk of non-compliance with legislation, such as DSEAR could be significant	Asbestos fibre detected on some of the DBs causes asbestos related illnesses, hence should be managed in line with the Control of Asbestos regulations 2012. Failure of distribution boards could lead to a loss of site electrical systems such as lighting impacts on the health and safety of site personnel, through safe access/egress to all parts of the site
External Lighting	Failure of permanent lighting assets may result in insufficient illumination being available. Although this is unlikely to have an immediate impact on service, consequential impacts may arise. For example, temporary lighting may be required to conduct maintenance activities which may delay completion or result in other work being postponed.	Failure of lighting may result in needing to rely on diesel generator powered lights, thereby increasing emissions of noise and carbon.	The consequence of lighting failing presents a risk of non-compliance with safety legislation, such as EAWR and / or DSEAR which would have financial implications through possible enforcement actions, fines and / or personal claims (if resultant personal injury occurred)	Poor illumination is often cited during investigations into trips, slips and falls alongside uneven terrain. If lighting is not in a suitable condition and / or suitably zone-rated in accordance with EAWR and / or DSEAR, additional consequences could occur which may pose a significant risk to health and safety. Due to corrosion at the cam pivot point, there is an added risk of lampposts falling And injuring personnel or damaging live assets
Control & Instrumentation and Power Cables	Damage to cabling results in the unavailability of connected assets. For example, if LV cables from the LV transformer	N/A	Potential disruption of the supply of electricity to the connected asset	Cable failures can result in a risk or fire and electrocution to

Sub Asset	Impact / Consequence			
	Availability	Environment	Financial	Safety
	to the LV switchgear are damaged, several auxiliary assets will be affected. Damage to C&I cabling results in the unavailability of critical assets such as Pressure Transmitters.		impacting on network operations	site operatives (Health & Safety) Failure to control assets connected to site safety control systems.
Kiosks	The continuous ingress of moisture in the kiosks will result in electrical failures on the panels and failure to supply power to the outgoing circuits.		The unavailability of affected assets may reduce the capacity of the site which has financial impact	Electrical assets affected by moisture increases the risk of personnel electrocution.

Table 9: Consequence of Failure Summary

7 Options Considered

Table 10 details the investments considered to address the issues outlined in the problem statement for all LV electrical assets. The investments are based on assessments reviewed as part of NGT's asset health plans and was enhanced by external condition survey reports

Assets	Options Considered	Option description	Pros	Cons
Transformers	Do Nothing	No specific intervention to be undertaken save for the normal transformer maintenance using Operational Expenditure.	Relatively low or no capital spend (but with increasing OPEX spend for more intrusive and re-active maintenance as asset continues to deteriorate	Risk of a major failure as the transformers continue to operate without resolving defect risk. Sudden transformer failure will result in loss of supplies to critical auxiliaries resulting in loss of terminal capability. Failure results in the need to run the standby generator to support auxiliaries which is not sustainable for extended periods of time. The lead time for the replacement of a catastrophic transformer failure can be more than a year due to the complexities of the manufacturing process. Fire on one transformer may impact on the second transformer due to their proximity.
	Refurbishment	Entails the major upgrade of the existing transformer. Involves major works such as repair of windings internal connections and tap changers, replacement of transformer electrical protection system, external coating and replacement of transformer oil.	Reduces the risk of equipment failure for the short term as the key internal components have been refurbished.	High initial cost and potentially higher cost than a replacement. The availability of specialized contractors or service providers experienced in refurbishing such legacy equipment is limited.

	Replacement	Involves the replacement of the two transformers with new units including upstream and downstream cabling. The civil and drainage assets will also be upgraded and/or redesigned to comply with NGT standards thereby addressing the environmental impact of the transformers	Will meet the terminal's long-term strategy where the transformers should be functional to 2050. This option significantly reduces the likelihood of equipment failure leading to the inability to flow gas through the terminal. This option is safer and complies with all the standards and regulations.	Highest cost in the short term, but low whole life cost.
Standby Generator	Do Nothing	No specific intervention to be undertaken save for the normal generator's maintenance using Operational Expenditure. This includes routine servicing, maintenance and start-up and run tests	Relatively low or no capital spend (but with increasing OPEX spend for more intrusive and re-active maintenance as asset continues to deteriorate	Risk of failing to run the generators owing to spares obsolescence. Failure to run the generator when needed results in the unavailability of the Terminal until normal supplies are availed. Damage to sensitive loads across the site (C&I equipment) that will impact on the operation of the site.
	Refurbishment	This entails the replacements of subcomponents of the generator which are causing operational challenges. These can be due to obsolescence and aged based deterioration. The scope may also include the connection of a load bank.	Where feasible, this will be a cheaper option as compared to replacement	This keeps inherent age-based risks as some aged components such as batteries, control system and link box are not replaced. Refurbishment will mean that due to Obsolescence there will be no OEM components used compromising on warranty issues. The existing system is presently inefficient mainly due to decommissioned reliant assets over the years
	Replacement	This entails replacing the standby generator with a new one which is properly sized to the current load requirement.	This resolves the current spares obsolescence challenge. Provides an opportunity for the resurveying of the site to determine the current load requirements and procurement of a properly sized standby generator.	Highest cost in the short term, but low whole life cost.
Distribution Boards	Do nothing	This option entails retaining the distribution boards thus continuing in the current operation		Failure of a distribution board can lead to non-functionality of downstream connected

		mode irrespective of the asset health risks.	Relatively low or no capital spend (but with increasing OPEX spend for more intrusive and re-active maintenance as asset continues to deteriorate	assets including metering and telemetry affecting the efficient operation of the network. The financial risk of non-compliance with legislation, such as DSEAR could be significant. Given that the assets are required to at least 2050, there is a risk of not sustaining the operation strategy.
	Major Refurbishment	This entails completely removing worn out or defective components and replacing them. The aim of retrofitting will be to extend the useful life of the entire DB.	This can turn out to be a cheaper option as compared to complete replacement	Addressing known subcomponents of the DBs does not address impending age and deterioration related failures. Some boards have asbestos contain asbestos fibre which can be distributed if refurbishments are undertaken.
	Replacement	This option involves the complete replacement of identified DBs with new ones.	Reduction of operational risks such as arc flashes to ALARP as well as enabling compliance with latest safety and quality standards.	Highest cost in the short term, but low whole life cost. The replacement process typically involves much long lead times and a more complex installation process as compared to retrofitting.
External Lighting	Do nothing	Entails no immediate investments on the lights, but continuous repair and replacement on failure	Relatively low or no capital spend (but with increasing OPEX spend for more intrusive and re-active maintenance as asset continues to deteriorate	Poor illumination is often cited during investigations into trips, slips and falls alongside uneven terrain. If lighting is not in a suitable condition and / or suitably zone-rated in accordance with EAWR and / or DSEAR, additional consequences could occur which may pose a significant risk to health and safety.
	Replacement of lights	This option focusses on the replacement of lights and fittings with the columns in situ	Improves luminance at a low cost	The risk of column and cable failures due to age-based deterioration is not addressed.
	Complete Replacement	This option entails the replacement of the entire column, lights, and cabling	Opportunity to improve terminal luminance with compliant, latest technology and efficient lighting.	Highest cost in the short term, but low whole life cost

			Opportunity to replace deteriorated cabling and reduce failure risks.	
UPS	Do nothing	No changes to the existing UPS systems. Defects remediation to be done as they arise. General maintenance as per policy.	Relatively low or no capital spend (but with increasing OPEX spend for more intrusive and re-active maintenance as asset continues to deteriorate	Loss of containment risk and associated fire / explosion implications from inability to remotely control critical terminal plant and equipment, leading to unsafe operating condition Damage to sensitive downstream electronic equipment or control systems
	Refurbishment	Partial replacement of defective and obsolete components	Lesser cost as compared to replacement	Does not address obsolescence risks
	Replacement	Complete replacement of the UPS and wiring to the auxiliary assets Rewiring of outgoing circuits.	Resolves spares obsolescence risks	Highest cost in the short term, but low whole life cost
Kiosks	Do nothing	Maintaining the existing kiosk and panels.	Relatively low or no capital spend (but with increasing OPEX spend for more intrusive and re-active maintenance as asset continues to deteriorate	Continued moisture ingress into the kiosks will result in electrical failures on the panels and failure to supply power to the outgoing circuits. Electrical assets affected by moisture increases the risk of personnel electrocution. The unavailability of affected assets may reduce the capacity and availability of the site.
	Refurbishment	Maintenance activities such as painting of the kiosk. Partial replacement of defective panel components.	Reduces the risk of moisture ingress	Does not address compliance and obsolescence issues. Patching of failed kiosks may not completely resolve moisture ingress has the kiosks continue to deteriorate due to age.
	Replacement	Entails the complete replacement of Kiosk and Panel Board. Rewiring of outgoing circuits and removal of redundant cabling Replacement of asbestos containing material where applicable	Ensures the installation of latest technology, kiosks and panels including cooling system to combat climate change. Guaranteed compliance to latest standards. Replacements of obsolete panels	Highest cost in the short term, but low whole life cost

			Guaranteed moisture tight kiosks	

Table 10: Options Considered

Assets	Do nothing	Refurbishment
Transformers	In the event of complete asset failure this will result in loss of power to the various critical assets leading to unplanned shutdown. The average daily penalty for unplanned shutdown of Bacton is highlighted in Table 21	For some context, a limited refurbishment scope to include coating, radiator bank and dissolved gas analyser replacement would [redacted] This option will not address the degraded windings paper insulation which has an anticipated EoL of within 5 years, at which point both assets would still need replacing.
Standby Generator		To refurbish the existing generator a limited scope to include battery, oil tank, alternator and engine replacement would be difficult to complete as the parts are not readily [redacted] this excludes an assumed premium to acquire the parts. Also, this option would not resolve all current defects which continue to require OPEX remediation to manage. And negates the opportunity to rationalise the asset size.
Distribution Boards	The financial risk of non-compliance with legislation, such as DSEAR would be significant. Whilst an indicative cost is not provided at this stage records of historical DSEAR fines in related industries have been up to **£0.500m** per fine.	As above, a limited refurbishment scope to include isolators, feeder cubicle and wiring system refurbishment would incur an indicative cost of circa [redacted] This option will not resolve all current defects which would continue to require OPEX remediation to manage. This also negates the opportunity to rationalise the asset quantity.
External Lighting	In the event of complete asset failure, the OPEX remediation would include significant cost to lease several mobile field lighting equipment, MEWPs to manage existing lighting columns which presents an added safety risk of working at height. Additionally, the cost to fix on fail which will incur a premium on the cost to replace as per the costbook.	For some context, a limited refurbishment scope to include Luminaire and internal cable replacement would incur an indicative base cost of [redacted]. This would not resolve the current height lowering defect which would continue to require MEWPS to manage. Coating to manage corrosion would also be required at an additional cost.
UPS	A failed UPS system can lead to Fire/Explosion due to malfunction of control equipment resulting in a shutdown of operations. The average daily penalty for unplanned shutdown of Bacton is highlighted in Table 21	To complete a limited refurbishment scope for UPS assets, modules, rectifiers, static switches, capacitors, and cooling fans would be replaced and would incur an indicative base cost of [redacted] Whilst this would go some way to improving efficiency, it would not resolve all current defects which would continue to require OPEX remediation to manage.

Table 11: Options indicative Costs Summary

Options Selection

7.1.1 The tables below illustrate the process used to select the optimum option for each asset or group of assets. Each table also highlights the recommended option.

Solution considerations		Option 1 Transformer Do Nothing	Option 2 Transformer Major Refurbishment	Option 3 Transformer Replacement
Cost		No cost. However, the associated risk from failure of the assets and reliance on aged and defected assets for back up is high. This will result in high constraint costs if we are unable to meet our flow obligations.	Medium cost in the short term, but high Whole life cost	High cost, current assets are past design life and from a whole life costing perspective replacement delivers the most value for money due to increased reliability of the asset and reduced maintenance costs
Compliance	COMAH	Non-compliant	Compliant	Compliant
	BS EN 60076-2018	Non-compliant	Non-compliant	Compliant
	T/SP/EL/50	Non-compliant	Non-compliant	Compliant
Environmental Impact		High – High probability of failure resulting in a fire and air pollution.	Medium	Low
Maintenance	Obsolescence	Low – no major obsolescence issues	Low – no major obsolescence issues	Low
	Risk	High - unsafe for personnel to work in the vicinity of highly unpredictable failures.	Medium - risk will reduced through refurbishment	Low – Potential winding failure will be eliminated
Operational Resilience	Single Point of Failure	High since the probability of failure is high and these assets have no direct redundancy	Medium since the probability of failure lower that Option 1	Compliant Transformers have very low probability of failure
	Security of Supply	Very high risk of failure. Site currently running on plant back up assets	Medium. As the site has been returned to run as designed with redundancy in each plant	Low – the impending failure risk will be reduced to ALARP
Overall viability		Not viable	Not Viable	Viable

Table 12: Transformers option selection

Solution considerations		Option 1 Standby Generator Do Nothing	Option 2 Standby Generator Major Refurbishment	Option 3 Standby Generator Replacement
Cost		Lowest in short term but greater overall due to the envisaged constraint costs	Medium cost in the short term, but high Whole life cost	High in short term, but low from the whole-life cost perspective and addresses all investment drivers
Compliance	COMAH	Non-compliant due to maximum risk of imminent failure and risk posed to site staff and equipment	Non-compliant	Compliant

Maintenance	Obsolescence	High - obsolete spares will affect the maintenance function	High - obsolete spares will affect the maintenance function	Low
	Ongoing OPEX	High - continuous OPEX challenge to maintain the generators	Medium – reduces requirement for ongoing OPEX to maintain	Low – significantly reduces requirement for any ongoing OPEX to maintain
Operational Resilience	Single Point of Failure	High since the probability of failure is high and these assets have no direct redundancy	Medium since the probability of failure lower that Option 1	Compliant Standby Generator have very low probability of failure
	Security of Supply	High risk - Any loss of electrical mains supply has high likelihood of loss of terminal capacity	High risk - Any loss of electrical mains supply has high likelihood of loss of terminal capacity	Low – A new generators will significantly improve the reliability and security of supply
Overall viability		Not viable	Not Viable	Viable

Table 13: Standby Generator Option Selection

Solution considerations		Option 1 DBs and UPS Do Nothing	Option 2 DBs and UPS Major Refurbishment	Option 3 DBs and UPS Replacement DBs and UPS
Cost		Lowest	Medium	High in short term, but low from the whole-life cost perspective and addresses all cost drivers
Compliance	COMAH	Non-compliant because of the risk associated with aged assets	Non-compliant because of the risk associated with aged assets	Compliant
	BS7671	Non-compliant	Non-compliant	Compliant
	T/SP/EL/50	Non-compliant	Non-compliant	Compliant
Maintenance	Obsolescence	Very high as its already confirmed and is one of major cost drivers	Very high as its already confirmed and is one of major cost drivers	Low
	Risk	High - unsafe for personnel to work in the vicinity of highly unpredictable failures.	High – due to recurring defects.	Low – Recurring defects are resolved through this intervention
Operational Resilience	Single Point of Failure	High since the probability of failure is high and these assets have no direct redundancy	Medium since the probability of failure lower that Option 1	Compliant DBs have very low probability of failure
	Security of Supply	Recurring maintenance activities would require continuous plant outages	Recurring maintenance activities would require continuous plant outages	Low - addresses all age-related defects and provides maximum availability
Overall viability		Not viable	Not Viable	Viable

Table 14: DBs, UPS and Battery systems option selection

Solution considerations		Option 1 External Lighting Do Nothing	Option 2 External Lighting Major Refurbishment	Option 3 External Lighting Replacement
Cost		Lowest	Medium	High in short term, but low from the whole-life cost perspective and addresses all cost drivers
Compliance	DSEAR	Non-compliant because Standing defects will not be resolved.	Non-compliant because of the risk associated with aged lighting columns	Compliant
Safety		Poor lighting compromises the safety of personnel resulting in trips and falls	Medium	Low
Maintenance	Obsolescence	Very high as its already confirmed and is one of major cost drivers	Very high as its already confirmed e.g., Ex-d isolators	Low
Operational Resilience	Single Point of Failure	High since the probability of failure is high and the failure oof one column may affect others on the same circuit	Medium since the probability of failure lower than Option 1	Low
	Emergency responses failures	High as lighting is critical particularly during the night	Medium	Low - addresses all luminance challenges
Overall viability		Not viable	Not Viable	Viable

Table 15: External lighting option selection

7.1.2 The chosen option for all LV assets in this EJP is replacement as it resolves all asset life and asset health issues as confirmed by the defects lists in Appendix E. This also brings the assets into compliance with safety legislation and allows safe operation of the terminal up to 2050.

7.1.3 For all the new electrical installations, it is recommended as best practice to install the assets with new power and instrumentation cables. This is mainly of paramount importance because:

- Old cables can be a source of recurring failures resulting in outages which compromises the availability and reliability of new assets.
- It avoids breach of warranty agreements with suppliers when old cables are used on new installations.
- This will be an opportunity for all the non-compliant cables to be phased out.

7.1.4 Old cables may result in major failures of high cost newly procured assets. Already, the site is experiencing an increased number of DSEAR defects which will be significantly addressed by the installation of new cables. As of August 2024, Bacton had a total of 602 electrical defects.

8 Preferred Options Scope and Project Plan

8.1.1 The assessments outlined in this paper and the associated discounting and costing of options demonstrates that the most viable, cost effective and logical options to take forward in this reopener is complete replacement of all defective Transformers, DBs, UPS and Battery systems, External lighting, Kiosks. This is in line with the approved FOSR option to address all asset health issues to enable the safe operation of Bacton Terminal with high availability and reliability.

8.1.2 NGT recognises the significant CAPEX investment required to achieve this scope through the preferred option. However, considering the reliability and safety improvements, the need to comply with current legislative and engineering standards, the opportunity to rationalise and modernise various assets, we believe this represents the best investment options to continue to meet customer needs, maintain security of supply and achieve lowest Whole Life Cost.

8.1.3 Focus is therefore on ensuring assets of the best available technology and standards are procured and the investment is delivered at the lowest overall cost.

Project Scope

Asset Type	Recommendations
Transformers	• Given the paper degradation in both transformers, it is recommended that they be replaced to ensure maintenance requirements can be met and the asset remains operational and serviceable until 2050. • The cage will be removed and reinstated once the transformers have been replaced. • Both transformers are to be replaced. • New HV cable installed back to the UKPN HV switchgear. • New LV cable back to the LV panel. • New oil bund alarm.
Generator	• To meet the project's objective of extending the terminal's lifespan to 2025, it is recommended that the asset be replaced. • The generator and all associated cabling are to be removed from the pump house. • A new 600KVA generator set is to be installed in a self-contained container adjacent to the new LV room. The generator will come with appropriate features to ensure it performs correctly in the coastal location. • A new manual transfer switch is to be installed to switch between the generator and temporary hook-up.
DBs	• The existing panels now considered obsolete with some containing asbestos material. New Form 4 Type 7 panel board is to be installed with a single incoming supply fed from LV2A. • New submains to panels and local distribution boards to be installed. • All redundant cabling is to be completely removed back to source. • Appendix H demonstrates how the volume of the DBs was determined. Circa 45 boards were surveyed by the Main Works Contractor. NGT internally assessed the DBs and 31 DBs were confirmed for replacement. The volume further reduced to 28 (requested in this EJP) as boards such as DB W and DB Z will be rationalised into one.
UPSs	• Existing outgoing circuits to be retained and tested. • General power and lighting to be completely rewired. • All redundant cabling is to be completely removed back to source.
Kiosks	• The existing panels are now considered obsolete. With the decommissioning of ENI 1 & 2, we propose combining kiosks C and D into a single kiosk (C/D). • A new elevated GRP kiosk with a Form 4 Type 7 panel board will be installed with a single incoming supply from LV2A.

	• All valve actuators will be rewired. • The GRP kiosk will be fully equipped with building services. • All redundant cabling will be completely removed back to the source.
External Lighting	• All existing columns and cabling will be removed back to the source. • Non-ATEX Thorlux LED emergency floodlights will be installed, mounted on Abacus heavy-duty base-hinge, flange-mounted columns. • A new external lighting control panel (DB P) will be installed in the existing LV room, which will supply several feeder pillars. Sub-circuits will be installed from the feeder pillars to the lighting columns. • All cabling will be rewired and installed in below-ground ducting. • Emergency fittings will be self-contained and controlled via Thorlux SmartScan technology. • Switching of all fittings will be controlled via a time clock and photocell arrangement, with an override switch installed in the control room and security hut. • Roads and access lighting: 10 lux • Site corners for security routine inspection: 15 lux • Emergency lighting (roads/walkways): 1 lux • Emergency exits: 5 lux • All lighting will comply with 'Dark Skies' lighting standards. • Six 110V socket outlets will be provided adjacent to the pits to supply task lighting, fed from local kiosks.
C & I	• Several visibly obsolete systems at the Bacton Terminal site have yet to be upgraded such as the FGS in the control room. • The existing marshalling rack panels although still operational the original panel doors have been removed thus creating a Hazard and exposing the entire operations to risk.

Table 16: Outline Project Scope

	Activity Name	Indicative Completion Dates
001	Anticipated Contract Award	August 25
002	Detailed Design Complete	August 26
003	Anticipated Construction Start date	September 26
004	Completion of Works including demobilisation	January 2034
005	Completion Handover Documents	March 2034
006	Project Closure	September 2034

Table 17: Outline Project Milestones

Final costs

8.1.4 To ensure robustness of the FOSR costs, NGT employed the use of a Designer / Main Works Contractor (MWC) to validate scope, understand some of the engineering challenges associated and to help refine details as well as building up an externally priced estimate showing how the market would cost works of this nature. NGT Utilised [redacted] to undertake this work as they were already in contract with NGT for the first stage of work undertaken to supplement the FOSR submission in February 2024. Further details are highlighted in Section 4 of the Overarching document.

8.1.5 Table 18 provides a breakdown of the final costs for the project split by several categories.

[redacted]

Table 18: Preferred Option Final Costs

Asset Health spend Profile

Table 19 shows the spend profile for our preferred options in 2018/19 pricing.

	RIIO-T2		RIIO-GT3					RIIO-GT4					
£m 18/19	FY25	FY26	FY27	FY28	FY29	FY30	FY31	FY32	FY33	FY34	FY35	Total	Total plus Escalator
Direct Cost Phasing (£m)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 19: Spend profile of preferred option

8.1.6 The cost accuracy at this stage of the project is estimated at +15%/-10% in accordance with the Infrastructure and Projects Authority (IPA) cost estimating guidance.

8.1.7 This report has explained the safety and operational risk concerns NGT has regarding the defected assets and the implications of these on terminal operations. The interventions are necessary to ensure the safety of site personnel and ongoing 24/7/365 operation of the terminal facility.

8.1.8 Removal and the subsequent replacement of LV Assets at Bacton Terminal totals [redacted] **(2018/19) Prices.**

9 Conclusions

9.1.1 This report has explained the approach that NGT takes with managing Bacton Terminal's Electrical Systems and the implications of not continuing to invest in its LV Assets. As detailed in this paper, it is of paramount importance to secure the necessary investment to maintain compliance with legislation.

9.1.2 The need to preserve the performance of LV Assets to protect electrical systems is well understood within the industry and the chosen option presented in this paper meet with current industry guidance and international standards.

9.1.3 Failure to obtain funding will put the LV assets at unreasonable risk, leaving Bacton terminal vulnerable to integrity incidents caused by obsolescence among other issues and would ultimately result in an abdication of NGTs statutory duties.

10 Appendices

10.1 Appendix A: FEED Study Report

File: [redacted]

10.2 Appendix B: Bacton RAM Study

File: [redacted]

10.3 Appendix C: Bacton JMS Electrical Report

File: [redacted]

10.4 Appendix D: Transformer Oil Diagnostics Reports

File 1: [redacted]
File 2: [redacted]

10.5 Appendix E: Bacton Defects List

File: [redacted]

10.6 Appendix F – Distribution Boards Maintenance Records

File: [redacted]

10.7 Appendix G – CIBSE Indicative Life Expectancy Guide

File: [redacted]

10.8 Appendix H – Summary of Surveyed Distribution Boards

File: [redacted]

11 Glossary

Glossary	
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
DSEAR	Dangerous Substances and Explosive Atmospheres Regulations 2002
ECI	Early Contractor Involvement
EJP	Engineering Justification Paper
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
EPC	Engineering Procurement and Construction
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
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
HSE	**Health and Safety Executive**
IPA	**Infrastructure and Projects Authority**

Glossary	
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.
LAV	Locally Actuated Valves
MWC	Main Works Contractor
(G)NDP	**Network Development Process:** The process by which NGT identifies and implements physical investment on the NTS.
NEA	Network Entry Agreement
NEC	New Engineering Contract
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 94 barg. NTS pipelines transport gas from Terminals to NTS offtakes.
OEM	**Original Equipment Manufacturer**
Ofgem	**Office of Gas and Electricity Markets:** The regulatory agency responsible for regulating Great Britain's gas and electricity markets.
PFD	**Process Flow Diagram**
PV	**Process Valves**
PSSR	**Pressure Systems Safety Regulations**
RAM	**Reliability Availability Maintainability**
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.
ROV	**Remotely Operated Valves**
SOL	**Safe Operating Limit**
Uncertainty Mechanism	Uncertainty mechanisms exist to allow price control arrangements to respond to change. They protect both end consumers and licensees 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

Contact:

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