NGT_AH2_05 St Fergus HV Switchgear

Engineering Justification Paper

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1. Executive summary

1. National Gas Transmission, (hereafter referred to as 'NGT'), are submitting the needs case and funding request in accordance with the RIIO-T2 Engineering Justification Paper Guidance v2 document. The purpose of this stage of the process is to justify the project need, set out the different options considered along with the preferred strategic options, and request funding for the preferred option justified within this paper.
2. This Engineering Justification Paper (EJP) details the investment for the replacement of non-compliant High Voltage (HV) switchgear and associated civil assets at the St Fergus Gas Terminal.
3. This is part of a suite of documents, shown in Figure 1, and should particularly be read in conjunction with the St Fergus Site Strategy and HV transformers EJP. The St Fergus Site Strategy describes the gas terminal's function, its criticality to the network and the proposed investments. The HV transformers EJP provides the needs case for the replacement of non-compliant and defected transformers with new, safe, and fit for purpose units.

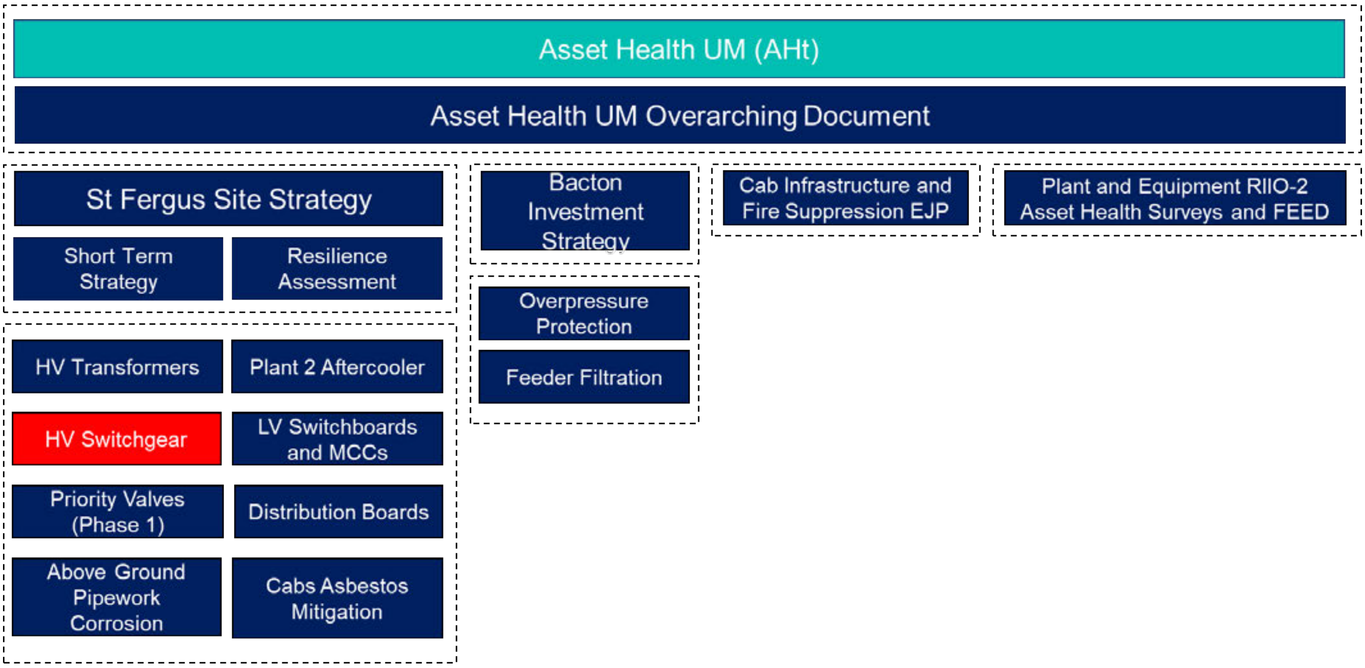

Figure 1: St Fergus Submission Documents Structure

4. The St Fergus Gas Terminal handles between 25% and 50% of the UK's gas supplies, dependent on supply and demand patterns. The site has been in continuous operation for over 45 years and is now moving beyond the design life of the critical original assets. The site is one of two upper tier COMAH sites on our network and as such is a major accident hazard site, subject to regular HSE and SEPA inspections and significant health, safety, and environmental legislation.
5. The 11kV switchgear, which consists of Oil filled Circuit Breakers (OCBs) and Vacuum Circuit Breakers (VCB), has been in use for more than 45 years. As with most equipment at this age it does not conform to current industrial standards and regulations on electrical equipment, current specifications bear little resemblance to those in place when the equipment was designed and installed.

6. Publications by the Health and Safety Executive (HSE) have highlighted various challenges and safety risks of operating oil filled switchgear, many of which are currently being experienced on site.

7. The St. Fergus long-term strategy confirms the requirement for investing in the replacement of the switchgear due to the need for compressor availability and delivering the most value to consumers. The need for timely intervention on these assets is further supported by asset condition surveys carried out by the [redacted]

8. Failure to intervene increases the risk on impact on the reliability of the terminal as the Variable speed drive (VSD) compressors rely on uninterrupted supply of HV power to compress gas. This in turn presents a risk to Security of Supply into the wider network. There are also significant safety risks, as a failure of oil filled switch gear can be catastrophic with the expulsion of burning oil and gases which can be fatal whilst also causing significant damage to plant and buildings.

9. The RIIO-T2 business plan included all work associated with Plant 1 and Plant 2 under the Emissions Uncertainty Mechanism as the uncertainty about the future solution affected all those assets.

10. NGT is submitting this investment proposal in the June asset health submission window as funding is required to ensure compression availability of the site and efficient delivery of asset health works, through bundling of works in planned outage windows, within this regulatory period.

11. The options considered for the HV switchgear are:

    - Do nothing
    - Minor refurbishment
    - Major refurbishment
    - Replacement

12. The above options were assessed against a wide range of criteria, and the replacement of the HV switchgear has been deemed to be effective solution when considered in conjunction with replacement of other electrical assets in the terminal.

13. If the replacement of the HV switchgear was to be delayed to the next regulatory period, the legacy assets would require design and modifications to integrate with the HV transformers, also identified for replacement, to utilise their full design capability.

14. This would not present the best value to consumers as the HV switchgear will then have to be replaced in the next regulatory period and would present ongoing risk to operating the terminal as the switchgear does not comply with the latest standards and specifications.

15. The indicative cost of this investment is [redacted] (18/19 price base). The estimated RIIO-T2 cost profile is shown in the **Table 1**. This project is at stage 4.2 in the ND500 process: Option Selection. Therefore, the cost accuracy is estimated at +30/-15% in accordance with the Infrastructure and Projects Authority (IPA) cost estimating guidance

Table 1 Current estimated RIIO-T2 spend profile

£m 18/19	FY2023	FY2024	FY2025	FY2026	Total	Comments
HV switchgear (£m)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	

16. NGT are making this funding application for the transformer replacement Programme RIIO-T2 investment costs through the Asset Health Re-opener, in line with Special Condition 3.14, requesting an adjustment to the value of the NARMAHOt term for costs incurred in RIIO-T2.

17. This is summarised, along with other investments, within the Asset Health Overarching Document provided as NGT_AH2_05 of the June 2023 Asset Health Re-opener Submission.

2. Introduction

18. This paper provides the justification for the replacement of the High Voltage (HV) switchgear at the St Fergus Gas Terminal.

19. In developing our investment programmes at the St Fergus Gas Terminal since the RIIO-T2 Final determinations, we have adopted a two-phase strategy to ensure clarity between short-term and long-term site operating strategy.

20. Our St Fergus Short-Term Strategy provides certainty on the terminal operation requirements, including minimum compression across Plant 1 and 2, for operation out to 2030. The long-term strategy will deliver the enduring terminal solution, including compression, required for operation beyond 2030.

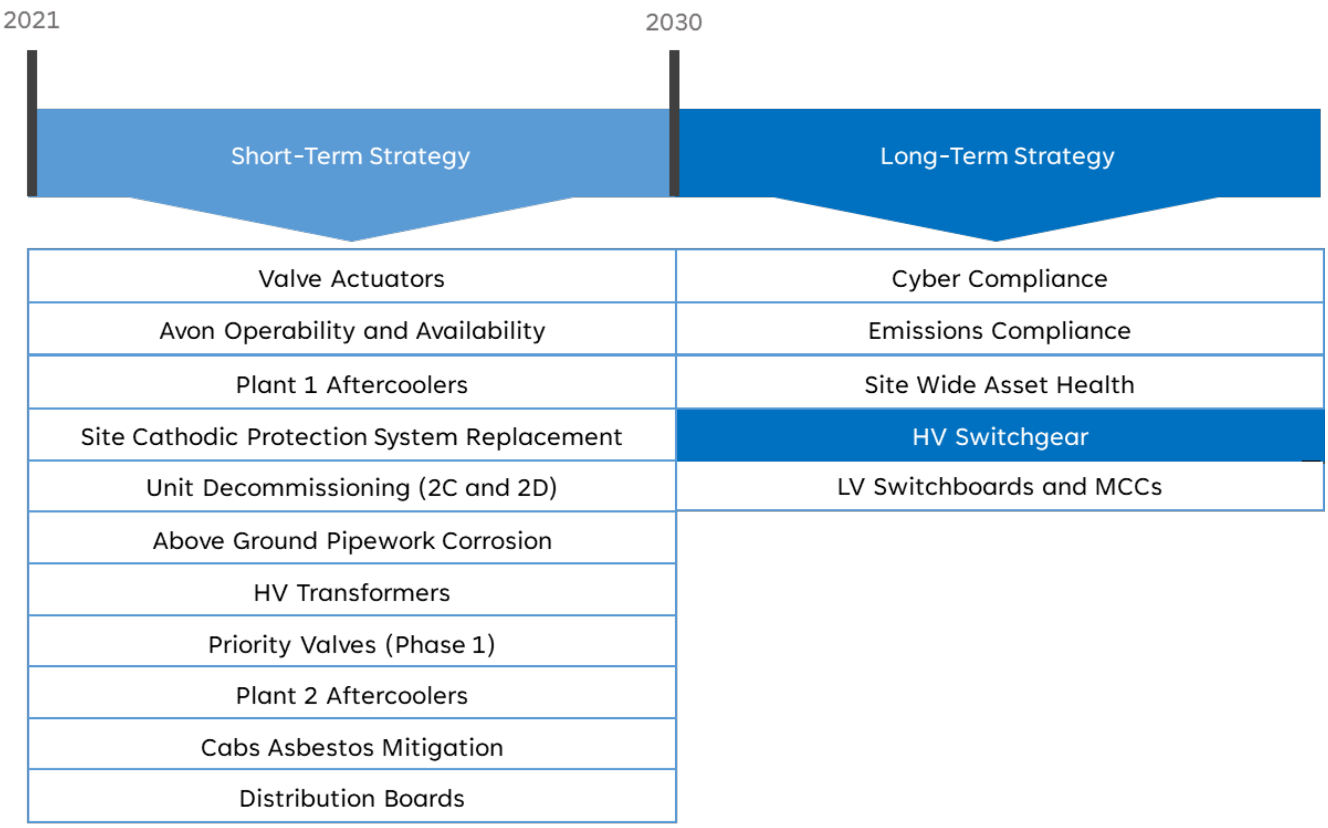

Figure 2 St Fergus Site Strategies Summary

21. The St Fergus short-term strategy supports the decision to rationalise the compression units across Plant 1 and 2 to four Avon units (1A, 1B, 1D and 2B) and maintain these in operation to at least 2030. That recommendation is fundamental to the proposals in this paper; therefore, it is important that these two documents are considered in parallel.

22. The HV switchgear at the terminal is used to connect high voltage power from the Scottish and Southern Electricity Network (SSEN) Substation to the step-down transformers for Low Voltage (LV) supply used by various equipment on the terminal and the Variable Speed Drive (VSD) compressors. The equipment is essential for the protection and safe operation, without interruption, of the terminal's high voltage power system.

23. The 11kV switchgear, which consists of Oil filled Circuit Breakers (OCBs), has been in use for more than 45 years. As with most equipment at this age, current specifications bear little resemblance to those in place when the equipment was installed.

24. In 2015, the Health and Safety Executive (HSE) published a guidance aimed at owners and operators of electrical switchgear in industrial and commercial organisations. This document particularly highlighted the high risk of operating switchgear that does not meet current safety standards and the resulting catastrophic consequences that would arise in the event of a failure. Many of these highlighted risks and challenges apply to the switchgear at St. Fergus where:

    - The equipment is over 45 years old and as a result faces obsolescence challenges with the unavailability of spare parts.
    - Lack of support from the Original Equipment Manufacturer (OEM), who is no longer available, to provide technical design support. This results in a reliance upon contractors who may or may not have the required knowledge or commitment on managing the specific asset.
    - The equipment is not fitted with anti-reflex type operating handles which are designed to prevent serious injury to operators during manual operations.

25. The failure of oil filled switchgear has a significant impact on the reliability of the terminal as the VSD compressors rely on uninterrupted supply of HV power to compress gas. This in turn presents a risk to Security of Supply into the wider network.

26. There are also significant safety risks, as a failure of oil filled switch gear can be catastrophic with the expulsion of burning oil and gases which can be fatal whilst also causing significant damage to plant and buildings.

27. Non-conformance to current British and European (BS EN) standards further supports the need for immediate intervention on the High Voltage switch gear St Fergus.

28. This paper highlights the applicable challenges and risks associated with the HV switchgear and discusses potential options towards addressing them with the aim of developing an optimal solution that is in line with the terminal's long-term strategy.

3. Equipment Summary

29. The main power supplies for the National Gas St Fergus Gas Terminal originate from the Scottish and Southern Electricity Network (SSEN) Substation located within the NGT's terminal perimeter fence line.

30. The SSEN Substation is supplied by two 132kV/11kV transformers connected to the overhead lines and contains 11kV switchgear. This interfaces with NGT's 11kV electrical switchgear with Oil Circuit Breakers (OCBs) and Vacuum Circuit Breakers (VCBs).

31. Future developments by SSEN, for the relocation of their Substation, are in progress and the new SSEN Substation will be located to the west of the St Fergus site outside the site perimeter. SSEN will install a modern Substation and switchgear to meet with the latest switchgear standards and HSE Regulations. The present SSEN GEC OCB switchgear is obsolete and does not meet with modern switchgear standards and HSE requirements.

HV Switchgear

32. The 11kV, 3 phase, 3 wire, 50Hz switchgear is of type BVP17 manufactured by GEC Switchgear Ltd. It is rated at 350MVA for 3 seconds, with the busbars rated at 800A.

[redacted]

Figure 3 Single line diagram switchboard A BGC 11kV substation main HV switchboard see Appendix C.1 - Single Line Diagrams

33. The switchgear consists of 15 panels arranged with 7 panels either side of a central bus-section panel. The switchboard is separated into three sections, whereby A8 (bus-section) is separated by two blast walls adjacent to A7 and A9. This is shown in Figure 4.

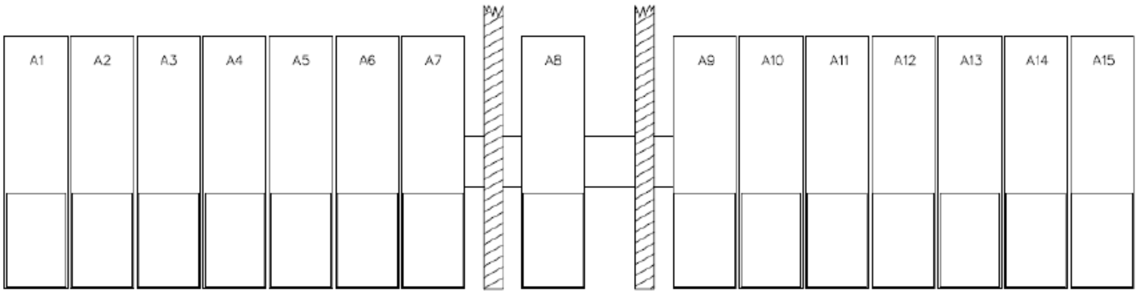

Figure 4 Switchboard General Arrangement

34. Switchgear is of air insulated, indoor metal clad, vertically isolated, horizontal draw-out, OCBs rated at 11kV, 3 phase, 350MVA. The spring-operated mechanisms are hand charged and the OCBs are single shot reclose without further charging of the mechanism.

Figure 5 Legacy switchgear (LHS) section at St Fergus

35. Each OCB and VCB panel are fitted with a Remote/Local Selector switch enabling control from a remote-control panel (best practice during normal operations) or locally at the panel. Local closing of the OCB is done by a mechanical pull handle which can be padlocked when the remote-control mode is selected. This current handle design does not meet current safety standards as it can be a danger if ever manual switching operations were required (**see** Appendix E - Anti-reflex handles).

36. Trip /Close power supplies for the operation of the circuit breakers are derived from a 110V battery charger and distribution board located within the NGC Substation 415v Switch room.

Distribution

37. From the 11kV switchgear, the outgoing power is directed via feeder OCBs and VCBs to 11kV/415V transformers for onward Low Voltage (LV) distribution at 415V.

38. There are LV switchboards and motor control centres (MCCs) in the NGT Main Terminal Building (MTB) area, Plant 1 Substation, Plant 2 Substation and Plant 3 Substation (VSD supply).

39. MTB, Plant 1 and Plant 2 LV switchboards are fed by 2 of 11kV/415V transformers for security of supply, Unit 3A and 3B VSD's auxiliaries are each fed by their own dedicated transformer.

40. All transformers are designed to remain energised at the High Voltage (11kV) side with the ACB's on the LV side being electrically and mechanically interlocked to prevent both circuit breakers being closed simultaneously (**see** Appendix C.2 - Single Line Diagrams).

4. Problem Statement

41. Switchgear of all types and ratings have been manufactured in accordance with British and international standards. As with most equipment, however, current specifications bear little resemblance to those of earlier years in that the previous specifications have been shown, by subsequent experience and by technical developments, to be deficient.

42. At St. Fergus, the HV switchboards are over 45 years old and have exceeded their expected useful life period (usually 25 years). They no longer meet the latest standards and regulations as shown below:

- BS EN 62271- 2022 High Voltage switchgear and control gear
- Gas transmission electrical specifications (T/SP/EL/50)
- IEEE guide for performing Arc Flash hazard calculations (IEEE 1584)

43. The legacy equipment presents multiple challenges to site operations such as:

- Lack of knowledge on the equipment: As the 11kV switchgear at St Fergus terminal is over 45 years old, it is reliant on contractors to maintain it to meet with the relevant Safety Codes of Practice. Much of the maintenance and Original Equipment Manufacturers (OEMs) information is available but there is a lack of expertise on the maintenance of the legacy asset industry wide including within the OEM.
- Equipment not being modified as per OEM requirements: The original OEM is now no longer available to provide detailed technical design support therefore the only support is from contractors who may or may not have the required knowledge or commitment.
- Equipment does not meet current safety design measures:
- Equipment fitted with operating handles that are not anti-reflex type. Although the switching is carried out remotely there are still the old design handles fitted which can be a danger to the operator if ever manual switching operations were required (**see** Appendix E - Anti-reflex handles**)**.
- St. Fergus HV switchgear was not designed to meet the latest Arc flash standards.
- Obsolescence: components are subject to increasing obsolescence, the impact of which, will be magnified as existing spares stocks are used. Current spare parts on site that were acquired during the installation of the HV switchgear are also aged (over 45 years).

44. This investment aims to:

- Maintain compressor availability by ensuring that the newly installed HV switchgear is safe, fit for purpose, secure by design, reliable and maintainable by complying to the latest standards and regulations

Spend Boundaries

45. The basic outline scope of work includes the Main HV switchboard A (GEC 11KV board) consisting of the following compartments:

- 13 x 400A BVRP17 Oil Circuit Breaker (OCB) compartments
- 2 x 400A BVRP17 Vacuum Circuit Breaker (VCB) Compartments
- 15 panels
- Electrical protection relays
- Remote control panel (located in the room adjacent to the switchboard)

46. This does **not** include electrical distribution from the HV switchboard to the transformers. This is covered under the HV transformer EJP.

[redacted]

Figure 6 Spend boundaries (see Appendix C.2 - Single Line Diagrams for full drawing)

47. Please note: The SSE substation is already in construction and will be in service next year. They have included re-cabling from the new substation to our existing one and changing out the distance protection relays as part of their works (and costs).

48. NGT will be able to re-use the incoming cables from them as the proposed location of the new NGT substation (discussed later in the paper) is closer to them than the current one. Any relay changes required later would have to be at NGT cost, this will not be known till detail design.

5. Probability of Failure

49. In general, oil-filled HV switchgear has a proven record of reliability and performance. Failures are rare but, where they occur, the results may be catastrophic. Tanks may rupture, resulting in the ejection of burning oil and gas clouds, causing death or serious injury to persons and major damage to plant and buildings in the vicinity of the failed equipment.

50. The HV switchgear consist of various electrical components. However, the oil filled circuit breakers present the highest risk of failure as indicated by HSE guidance (see Appendix D - HSE guidance) and are focused on in this document. The main failure modes for oil switchgear according to guidance document are:

- faults within oil compartments.
- failure of oil circuit-breaker to trip (which may result in an extended disconnection time due to fault clearance by upstream equipment); and
- solid insulation faults (external to oil compartments).
- Faults within the oil compartment can result from:
- contaminated insulating oil
- poor maintenance of the arc interruption system (contacts and arc control devices)
- breakdown of solid insulation
- making or breaking fault current above the rated capability (in the case of a circuit-breaker) or internal component failure

51. Accidents experienced within industry (see Appendix D.2 - HSE guidance) has shown that failure usually occurs at, or shortly after, operation of the equipment. Thus, the way HV switchgear is operated, its condition and the circumstances existing in the system at the time of operation, to a large extent, determines whether the equipment will safely perform its duty.

52. Industrial data from IEEE (see Appendix F - IEEE Gold book) on the failure modes of circuit breakers is shown in Table 2. It should be noted that "opening when it should not" is the highest contributor to failure and the current HV switchgear on site has been flagged for not meeting current safety design measures.

Table 2 **mode of circuit breakers during failure**

Metal-clad draw out (under 15kV)	**Failure characteristic**
49%	Opened when it should not
24%	Failed while in service (not while opening or closing)
21%	Failed while opening
4%	Damaged while successfully opening
2%	Failed to close when it should

Table 3 Equipment reliability data from the Gold book standard network configuration

Item description	Mean time to repair (h)	Failure rate (failures per year)
Circuit breaker, 600 V draw out, normally closed, < 600 A	6	0.000210

53. Very little other published data is available on failure modes of power circuit breakers and on the probability of a circuit breaker not operating when called upon to do so. The data shown in Table 3 is based on 1 sample (see, Appendix F - IEEE Gold book, Table 10, chapter 4)

Probability of Failure Data Assurance

54. The data is taken from IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems which is the only standard dedicated solely to the reliability analysis of industrial and commercial power systems.

Consequence of Failure

55. Failure of the HV switchgear through the aforementioned failure modes can lead to impacts on safety, security of supply, financial and the environment. "Failed while opening" results in the highest impact on consequence of failure due to the fault condition remaining for an extended period before upstream devices can clear the fault.

Safety impact:

- Where the equipment requires manual operation, a major failure e.g., from an arc flash could cause severe burns or death.
- Also burning gas clouds and oil mist can envelop anyone near the failed oil HV switchgear and have resulted in death or serious burn injuries.
- Fire risks can arise from faulty oil filled HV switchgear or switchgear which fails to clear a transformer/cable fault

Security of supply impact:

- Due to the current state of the HV transformers there is no redundancy in the HV equipment. A major failure will necessitate reliance on standby generation for continued operation of the terminal. Example of failure scenarios and their consequences are shown below:
    - Failure on LHS of the HV switchboard: This would only lead to a trip of unit 3A gas compressor as the BG sub, Plant 1 and Plant 2 transformers are already isolated due to their condition (Please see the HV transformer EJP for more information)
    - Failure on RHS of the HV switchboard: This would trip unit 3B gas compressor and all BG sub, Plant 1 and Plant 2 transformers, resulting in an outage of Plant 1,2 and the main terminal building. This would mean loss of all flow through North Sea Midstream Partners (NSMP) as this has no flow path without going through NGT compression. This is normally 50% of the gas flow through St Fergus which is a significant impact on the UK security of supply.

Financial:

- In the event of an outage, the site will be at risk of not meeting its flow obligations to NSMP, their shippers and consumers which is disruptive as well as potentially affecting the offshore oil platform with the additional consequences/costs of this. NGT would also be liable for expensive constraint costs which we want to avoid by having reliable/resilient equipment.

Environmental impact:

- Environmental damage from uncontrolled oil leaks from catastrophic failure of HV switchgear
- Resulting outage at the terminal will result in flaring of the gas which NSMP are unable to flow into St Fergus.

6. Options Considered

56. In total, four options are considered here for management of the condition issues and associated risks as outlined in the **Consequence of Failure** section. Of these four options, three are discounted they are not viable for compliance and safety reasons, the reasoning being outlined below. Options 2, 3 and 4 are then expanded upon to outline the benefits to support the final option selection.

Options discounted

Option 1: Continue to operate without intervening on the asset (**Do nothing**)

- This option is not viable as it does not meet HSE and latest standards
- The HV switchgear is also obsolete and will continue to present multiple challenges to site operations
- This presents the lowest value to consumers as the risks associated with continued operation of this asset have major consequences on UK security of supply as well as site staff operating equipment
- Not intervening is not a viable option as modification on the legacy asset will be required to integrate with the new transformers on site.

Option 2: Replacement of the Oil circuit breakers (Minor refurbishment)

57. This involves the replacement of the beyond design life OCBs with VCBs only.

Advantages:

- Complies with HSE requirements
- This eliminates the risk of an oil fire
- Low expenditure and no major change in current infrastructure

Disadvantages:

- The original HV switchgear does not meet with Arc Flash requirements and BS EN standards. Various components of the HV switchgear such as the protection relays are obsolete.
- Therefore, components other than OCBs would have to be replaced at a later time which would be inefficient and would disrupt operations due to the increased number of outages required to facilitate the works. This is due to the current condition of the HV transformers, only three of which are in service as described in **Consequence of Failure** section.
- This solution would not be deliverable in this regulatory period

Option 3: Upgrade critical components and other systems (Major refurbishment)

58. This involves replacement of all OCBs with VCBs together with all HV switchgear components. The protection system would be upgraded and control system replaced with smart technology digital solutions.

Advantages:

- This eliminates the risk of an oil fire
- Reduces the risk of equipment failure and safety issues associated with the equipment operation as installed components are modern and reliable
- Removes obsolete and beyond design life equipment

Disadvantages:

- This is a high CAPEX option and would not deliver the best value to consumers as the HV switchgear will have to be replaced in the next regulatory period.
- The original HV switchgear would have to be isolated prior to any modifications being carried out which would extend the time period required to carry out the work. Additionally, only half the switchboard could be isolated at one time in order to maintain supply to the Terminal, each Plant being on single circuit risk for this entire time period.
- Refurbishment would be a complicated scope of work to install due to the bespoke requirement of matching new components with the legacy design as the OEM does not exist anymore.
- The original HV switchgear does not meet with Arc Flash requirements, the solution is a retrofit of installed equipment and has no modifications to the design affecting the arc flash compliance.
- Multiple legacy items including the existing building, switchboard, busbars and remote control remain as part of the final solution.
- Difficulty in obtaining quotations and costs: Obtaining accurate quotations and costs for refurbishing outdated HV switchgear can be a complex task. The availability of specialized contractors or service providers experienced in refurbishing such legacy equipment may be limited, resulting in fewer options for obtaining competitive quotations. Additionally, due to the age and unique requirements of the HV switchgear, it can be challenging to accurately assess the extent of refurbishment required, leading to potential cost uncertainties and discrepancies.

Do nothing, minor and major refurbishment options were deemed not viable and therefore not costed. This is because they present significant limitations that do not address the major investment drivers and would also not guarantee long term reliability of the assets to 2050.

<u>**Options progressed**</u>

Option 4: Replace the entire switchboard (Replace):

59. This option involves replacing the existing switchboard with a new intelligent digital switchboard in a pre-assembled Unit (PAU) type Prefab Substation

Advantages:

- The new switchboard can be installed with minimum disruption to the plant operations by installing it in a Pre-assembled Unit type Prefab Substation.

- This solution can be installed and commissioned in the current regulatory period
- This option complies with all HSE and electrical regulations.
- This option integrates seamlessly with newer technology/upgrades being done on other electrical assets on the terminal (See St Fergus site strategy chapter 4: Electrical assets)
- This solution is equipped with automatic transfer system which reduces the impact of failure on the SSE HV network
- This eliminates the risk of an oil fire
- Reduces the risk of equipment failure and safety issues associated with the equipment operation as installed components are modern and reliable
- Removes obsolete and beyond design life equipment
- Replacing the legacy HV switchgear present the best value to the consumer as the new HV switchgear will be designed to incorporate all the extra alarms and trips from the new transformers.

Disadvantages

60. High CAPEX

- Civil works will be required to protect existing HV cables which pass under the new substation location.

Options Cost Details

Options	Programme element	Unit costs (22/23 prices)	Cost evidence	Volume	Price base conversion	Investment value
Option 1	Do nothing					
Option 2	Minor refurbishment					
Option 3	Major refurbishment					
Option 4	Replacement	[redacted]		[redacted]		[redacted]

7. Option analysis and selection

The following table provides a summary of the options considered.

Solution considerations		Option 1 Do Nothing	Option 2 Minor refurbishment	Option 3 Major refurbishment	Option 4 Replace HV switchgear
Meeting HSE Requirements (eliminates oil and fire explosion risk)		Non-comp iant Risk prohibition notice	Comp iant	Comp iant	Comp iant
Operational Resilience	Security of supply	High risk- Current y 3 transformers are iso ated. Fai ure wou d ead to a oss in compression from tripping the VSDs	Current y 3 off transformers are iso ated. Fai ure wou d ead to a oss in compression from tripping the VSDs During de ivery one ha f of the switchboard is iso ated for ~3 months during this time no back up system is avai ab e.	Current y 3 off transformers are iso ated. Fai ure wou d ead to a oss in compression from tripping the VSDs During de ivery one ha f of the switchboard is iso ated for ~3 months during this time no back up system is avai ab e.	None Modu ar substation with new HV switchgear this wi be insta ed simu taneous y with the current HV switchgear thus minimizing downtime
Compliance	BS EN 62271 -2022	Non-comp iant	Non-comp iant	Partia Comp iance Unknown condition of other components. In depth survey is required	Comp iant
	T/SP/EL/50	Non-comp iant	Non-comp iant	Partia Comp iance Unknown condition of other components. In depth survey is required	Comp iant
	Arc flash (IEEE 1584)	Non-comp iant	Non-comp iant	Partia Comp iance Unknown condition of other components. In depth survey is required	Comp iant
Maintenance	Ongoing OPEX	High - continuous OPEX cha enge to maintain. Requires contractors to maintain o d components	High - continuous OPEX cha enge to maintain. Requires contractors to maintain o d components	Medium - continuous cha enge to maintain o d asset. However not a high OPEX as site personne wi be equipped to hand e the maintenance of asset as opposed to contractors	Low
	Risk	High- unsafe for personne to work in vicinity due to risk of arc f ashes, mechanica inter ocks not suitab e fau ty or ack of which puts technicians at a high risk	High- unsafe for personne to work in vicinity due to risk of arc f ashes,	High- unsafe for personne to work in vicinity due to risk of arc f ashes,	Low
Cost		None	Not costed as is not a viab e option	Not costed as is not a viab e option	High
Overall viability		Not Viab e	Not Viab e	Not Viab e	Viab e

61. Based on the above recommendation, replacing of the legacy HV switchgear with a new intelligent digital switchboard in a pre-assembled Unit (PAU) type Prefab Substation. There are multiple technology options available.

62. A Best Available Techniques (BAT) assessment (see Appendix B - [redacted] report) was commissioned and delivered by [redacted] as part of the HV switchgear survey. It assessed the range of technologies available for the HV switch gear at St Fergus.

63. This assessment supports the decision to install vacuum type HV switchgear over oil and SF6 types.

Table 4 High level BAT study carried out by [redacted]

Description	Technology	Remarks	Environmental impact	Ranking
Vacuum	Vacuum interrupters are used for making and breaking load and fault currents.	Any arc is rapidly extinguished and the dielectric strength in the breaker builds up rapidly Higher rated short circuit current than SF6 and oil No interrupter servicing during its lifetime only operating mechanism Complies with T/SP/EL/50	No environmental issues	1
SF6	Sulphur hexafluoride (SF6) Insulated	The current continues to flow after the contacts are opened causing an arc and ionised gas. No interrupter servicing during its lifetime only Operating mechanism Complies with T/SP/EL/50	Requires controlled disposal. Requires continual monitoring of leakages Sulphur hexafluoride (SF_6) is a greenhouse gas and has a very high radiative forcing effect and a GWP of 22,800 compared with carbon dioxide	2
Oil	Oil insulated Interrupters	High maintenance Old oil breakers do not pass the fault clearance tests of modern switchgear BS specifications	Requires controlled disposal	3

8. Preferred Option Scope, cost, and Project Plan

64. The assessments outlined in this paper and the associated discounting and costing of options demonstrates there is only one effective and logical option to take forwards: Option 4 - replacing of the legacy HV switchgear with a new intelligent digital switchboard in a pre-assembled Unit (PAU) type Prefab Substation to meet NGT specifications (T/SP/EL/50) and current standards and regulations.

Project scope

65. It is expected that the project is delivered in two distinct phases:

66. Phase 1 – Survey and Conceptual Front End Engineering Design (FEED).

- Surveying the existing and relevant systems and equipment to inform Conceptual Design and future project phases
- Perform a conceptual FEED design phase that recognises the current HV system status, makes recommendations, and sets out the detailed design and build scope of work

67. This phase is currently complete with the recommendation being the replacement of the asset with a new intelligent digital switchboard in a pre-assembled Unit (PAU) type Prefab Substation.

68. Phase 2 – Detailed Design and Build

- Including detailed design, procurement, off-site switchgear, manufacture, and testing following by on site installation, commissioning of the pre-assembled Unit (PAU) type Prefab Substation.

The following is a summary of the phase 2 project scope deliverables:

- Provide safe, fit for purpose, secure by design, reliable and maintainable HV switchgear and associated equipment, suitable for present and future operations, while sustaining operational capability of the St Fergus Terminal, in line with T/SP/EL/50 and specification for control and instrumentation systems on compressor installations (T/SP/COMP/30).
- The replaced switchgear and associated equipment should have a minimum 25-year design life with sufficient availability of spares and OEM lifecycle support to maintain acceptable reliability and availability for this period. The Supplier or OEM shall provide, if possible, a premature obsolescence management plan, detailing the future availability of spares, repairs, and technical support.
- The replacement Assets shall be bundled with other asset Health projects, allowing flexibility for operational constraints, outage dates / requirements, and providing commissioning stage fallbacks to ensure no significant impact on operations and planned gas flow through the site.
- The replacement Assets will integrate with retained systems and provide capacity for foreseeable future modifications. Where possible to assist with the integration of new switchgear related assets with existing site installed infrastructure, the use of marshalling panels, shall be considered to act as a termination point, including capacity for future

proofing and additional redundancy for existing or new network interfacing systems, in line with T/SP/EL/50 and T/SP/COMP/30.

- Meet the COMAH Competent Authority (Health & Safety Executive) expectations and Critical National Infrastructure security requirements.

Final cost and programme

69. The table below, Table 6 provides a breakdown of the final costs for the project split by several categories.

Table 5 Project cost breakdown

	Cost Category	Outturn Costs (£m)	Costs (£m) 2018/19 Price Base
	OEM costs	[redacted]	
Direct	EPC Estimate		
Indirect	EPC PM		
Direct	EPC Site Establishment		
Direct	NGGT Direct Company Costs		
Indirect	NGGT Indirect Company Costs		
	Contractor Risk		
Direct	NG Project Risk		
	FEED		
	Development / Optioneering		
	Land / Easements		
	TOTAL		
	Direct		
	Indirect		

Table 6 shows the spend profile for our preferred option in 2018/19 pricing.

Table 6 spend profile of preferred option

£m 18/19	FY2023	FY2024	FY2025	FY2026	Total	Comments
HV switchgear replacement	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	

RIIO-T2 Volume UIDs

70. Costs associated with this project have been assigned against the RIIO-T2 Unique Identifier **(UID) - ST FERGUS TERMINAL – HV Switchgear Replacement.**

national gas transmission

71. The table below provides a summary of the UIDs and associated funding for the scope of works proposed in this paper.

UID	Baseline volume of Intervention (By PP) (by unit of measure)	Baseline total funding available (£ 18/19)	Current volume of intervention (by unit of measure)	ECC total funding required (£m 18/19)	Output Year	UID funding requested through UM (£m)
[redacted] ST FERGUS TERMINAL – HV Switchgear Replacement	[redacted]	[redacted]	[redacted]	[redacted]	2026	[redacted]

Table 7: UID Details

72. The cost accuracy at this stage of the project is estimated at +/-30% in accordance with the Infrastructure and Projects Authority (IPA) cost estimating guidance.

NARMs Benefit

73. Following discussions with Ofgem in the NARM Development Monthly Meetings, it is proposed that for simplicity all the investments that arise from the UMs are collated and one NARMs update is provided after the Plant & Equipment submission.

74. For further details and a summary of UIDs please see the Asset Health UM overarching document.

Conclusion

75. This report has explained the asset health and compliance shortcomings of the HV Switchgear at St Fergus and their implications to the safe and reliable operation of the terminal.

76. The intervention is necessary to ensure the safety of site personnel and ongoing 24/7/365 operation of the terminal facility.

77. Removal and the subsequent replacement of HV switchgear at the St Fergus gas terminal totals [redacted] (18/19 Prices).

9. Appendices

Appendix A – Project Summary

Table 8 Project summary table

Name of project	T2_St Fergus_2021_St Fergus RIIO-2 Asset Health Programme		
Scheme reference	[redacted]		
Primary investment driver	Asset Deterioration/Obsolescence		
Project initiation year	2023		
Project close out year	2026		
Total installed cost estimate 18/19	[redacted]		
Cost Estimate accuracy (%)	+30/-15		
Project spend to date Outturn	[redacted] (all St Fergus T2 AH UM development)		
Current project stage gate	F2		
Reporting table ref	RRP Table 6.3 (Asset Health) and Table 6.4 (Asset Health Projects)		
Outputs included in RIIO-T1 business plan	No		
Spend apportionment 18/19	T1	T2	T3
	[redacted]	[redacted]	[redacted]

Appendix B - [redacted] report

1. File: 5210385-001-EL-REP-020, 20 - HV switchgear, [redacted] Rev 03, 2023

Appendix C - Single Line Diagrams

1. File: Single line diagram switchboard A BGC 11kV substation main HV switchboard - 6011/03/01/03/0033
2. File: Overall Single line diagram 6011/03/01/03/0032

Appendix D - HSE guidance

1. File: HSG230, Keeping electrical switchgear safe, HSE, 2nd edition, 2015
2. Oil -filled electrical distribution and other switchgear – HSE operational circulars- 483/27

Appendix E - Anti-reflex handles

Oil switches, such as those incorporated within ring main units, may be rated to close onto a fault but not to interrupt fault current (sometimes referred to as fault make, load break switches). Where switchgear using oil switches is also fitted with integral earthing, incidents have resulted when a failure to check the position of the selector mechanism has led to operators switching from OFF to EARTH instead of from OFF to ON. This action has the potential to put an earth fault onto the HV system. This is not necessarily a dangerous situation as oil switches are designed to close onto a fault, but danger arises if the operator, realising that a mistake has been made, instinctively reacts and attempts to open the switch. Oil switches are not rated to interrupt fault current, and where this has occurred, switches have failed, causing serious injury to the operator.

To address this problem, manufacturers supply 'anti-reflex' handles. These are handles that have to be removed and re-inserted before they can be used to reverse the operation of an oil switch. They are provided to ensure that if a mistake is made, it is not possible to immediately reverse a switching action. This may allow sufficient time for circuit protection to operate, clearing a fault by operating a circuit breaker or other device designed to break fault current, or it will provide thinking time for an operator before making the conscious decision to reverse a switching action. A review of oil switches and oil switch fuses present on a system should be undertaken to determine if anti-reflex handles have been provided. If not, it is advisable to replace standard handles with anti-reflex handles.

Appendix F - IEEE Gold book

File: IEEE Gold book Std-493-2007, IEEE Recommended Practice for the Design of Reliable Industrial Commercial Power Systems, IEEE ,2007