national gas transmission

Re-wheel EJP – King's Lynn Cost Re-Opener

April 2025

Issue: 0.1

Version: Final

Version control

Version/revision number	Date of issue	Notes
0.1	Nov 2024	First draft
0.11	Feb 2025	NGT Internal Review
Final	Apr 2025	Ofgem Submission

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1 Executive Summary

1.1.1 This Engineering Justification Paper (EJP) explains the engineering justification, detailed scope, delivery plan, efficient costs and requested regulatory allowances for re-wheeling compressor Units C and D at King's Lynn. Our objective was to identify the safest and most cost-efficient method to complete the project to provide efficient and reliable service to consumers out to 2050.

1.1.2 Our proposed investment is the replacement of the following with larger capacity models: compressor rotor and impellor of both units along with their anti-surge valves (ASV). This is further detailed in Section 4.

1.1.3 King's Lynn compressor station has four compressor units. Units C and D are Siemens (formerly Rolls-Royce) SGT-400s which are compliant with MCPD emissions limits. Units A and B are Siemens SGT-A20 1533 (formerly Avon) and are not compliant with the MCPD Nox emissions limits. Units A and B can breach the Nitrogen Oxide (NOx) limits imposed and therefore are non-compliant. Figure 1 below shows the interior and exterior of Cab C at King's Lynn.

Figure 1: King's Lynn Unit C Exterior and Interior

1.1.4 [redacted]

1.1.5 This resulted in station flows above the flow limit on a single SGT400 compressor of 42 mscm/d. This led to over reliance on Unit B as the compressor wheels of Units C and D aren't appropriately mapped to those flow and head conditions. This has had a consequence of Unit B being operated above the future 500-hour Emergency Use Derogation (EUD) limit.

1.1.6 The increased usage necessitated in Unit B receiving significant support to keep it operational. Re-wheeling Units C and D would align their operational envelopes to the higher flow ranges. This enables them to take primary duty in single unit operation, reducing emissions by minimising the need to run the less efficient Unit B and ensuring it stays below the derogation hours limit as detailed in section 4.

1.1.7 This paper describes the costs to implement the compressor re-wheel options for Units C and D. The costs to implement the selected options for Units A and B are presented in separate EJP documents.

1.1.8 NGT are in the process of tendering for a Feasibility conceptual study to refine the scope and cost estimates. The recent engineering assessments of the installation and commissioning of the re-wheel scope also confirmed the need to replace the associated anti-surge valves (ASVs) for both Units C and D. This is due to the existing valves becoming incompatible with the units following completion of the re-wheel scope.

1.1.9 The preliminary cost to deliver the re-wheel of Units C and D is based on a combination of firm pricing for long lead items from the Original Equipment Manufacturer (OEM) Siemens Energy for the Compressor internal

[redacted]

[redacted]

[redacted]

[redacted]

1.1.12 The project is now at ND500 project stage 4.4 'Project Execution', having recently completed surveys to define scope and project boundaries to further support the needs case.

1.1.13 [redacted].

1.1.14 It is essential that we make an appropriate investment in our compressor fleet to continue being able to flow gas around the NTS in a safe and reliable way that is cost-effective for consumers. Out of the options considered i.e. no intervention, unit replacement or re-wheel, the last one offers the most cost-efficient solution ensuring that gas continues being delivered to our customers and consumers.

1.1.15 This EJP is intended to be reviewed in conjunction with the accompanying overarching document.

2 Introduction

2.1.1 The King's Lynn site ensures high EU import and export can be achieved by moving large volumes of gas towards or away from Bacton, as seen in 2022 and 2023, with very high King's Lynn utilisation to enable sustained high export. A key concern for King's Lynn compressors is the current need for parallel running of the SGT-400 units (Units C and D) to enable required import and export capability across the interconnectors can be met.

2.1.2 Global events which unfolded in the energy sector in 2022 demonstrated both the unpredictable nature of the global gas market and the importance of a resilient network to support energy security. The Russia / Ukraine war led to the GB market facilitating c20bcm of gas export in summer and autumn 2022. Unprecedented geopolitical changes might lead to further need for increased resilience to ensure security of supply in the future.

2.1.3 This paper provides a detailed view of the preferred option to re-wheel Units C and D. The Siemens SGT-400 compression Units C and D are critical to the operational flexibility of the site as they support and contribute to the resilience of the station's daily capacity requirement.

2.1.4 Figure 2 below shows a site overview. Units C and D are shaded for reference and are the lead units on site.

2.1.5 A Process Duty Specification (PDS) assessment was updated in July 2023 to cover the last 10 years of operation. It confirmed that Units C and D are not adequately mapped to manage the low head and high flow ranges and patterns. This has been detailed in Section 4.

2.1.6 Re-wheeling these units will give the station the resilience and flexibility needed to manage prevailing demands whilst complying with emissions limits. Funding to make the necessary interventions is now required to deliver the re-wheel of Units C and D in RIIO-GT3.

2.1.7 Unit B will be derogated to limit its usage to under 500 run hours on a five-year rolling average. Without the investment, the site would need to continue to rely on Unit B and be at risk of either breaching the running hours limit from 2030 or being unable to meet network needs, leading to constraint.

2.1.8 Dry Low Emissions (DLE) is a technology used in gas turbines to reduce nitrogen oxide (NOx) emissions during combustion. It is commonly employed to meet environmental regulations and improve the efficiency of gas turbine operations.

2.1.9 This EJP interacts with other documents to form the King's Lynn reopener submission pack as illustrated below in Figure 3.

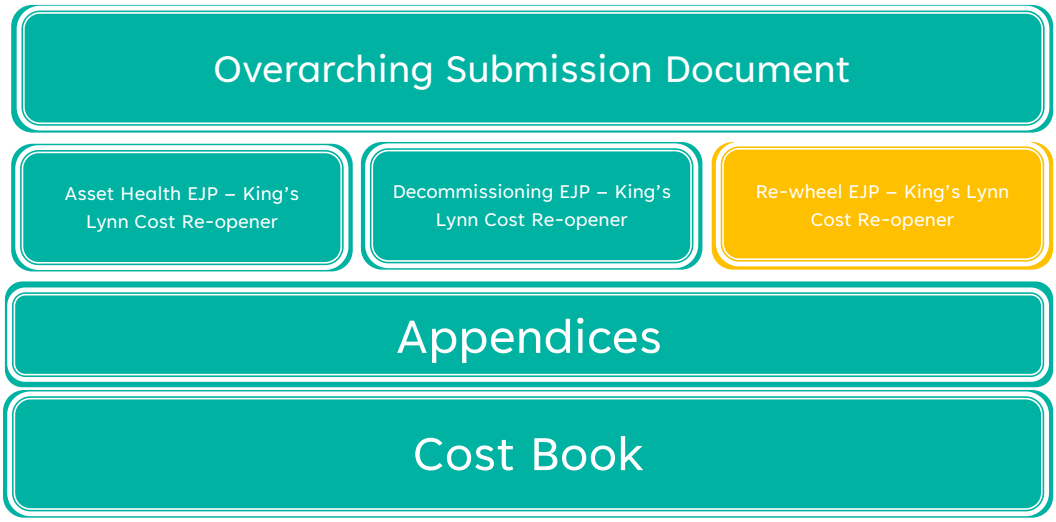

Figure 3: King's Lynn Reopener Submission Pack

Summary Table

2.1.10 Table 1 below sets out key information about the King's Lynn re-wheel investment project. This is further detailed in the Cost Book Appendix A and Section 3 of the Overarching Document.

Name of Project	King's Lynn Re-wheel (Units C and D)
Scheme Reference	PAC1203870
Primary Investment Driver	Compliance with MCPD legislation
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
Current Project Stage Gate	ND500 (4.4) Project Execution
Proposed UID	Ref - Table 7 of this EJP
Output PCDs	Ref - Table 5 of Overarching Document

Table 1: Summary table for King's Lynn Compressor Re-wheel

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

	RIIO-T2					RIIO-GT3				
(2018/19 Price base)	**FY22**	**FY23**	**FY24**	**FY25**	**FY26**	**FY27**	**FY28**	**FY29**	**FY30**	**Total**
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 2: King's Lynn Re-wheel Cost Summary

3 Equipment Summary

3.1.1 There are a total of three operational units at King's Lynn that can run in multiple configurations to move gas East or West. Unit C and D are the lead units on site, compliant with MCPD legislation. Unit C and D were commissioned in 2003 whilst Unit B was installed in 1971 and is now over 50 years old.

3.1.2 Units C and D are Siemens SGT-400, as shown in Figure 4, is a twin-shaft gas turbine designed for both power generation and mechanical drive applications. It is manufactured in the 10-15 MW power band, making it suitable for a variety of industrial applications. The SGT400 is equipped with Dry Low Emissions (DLE) technology which controls NOx and CO emissions within a specified load range.

Figure 4: Siemens SGT-400

3.1.3 The two SGT-400s Units C and D can operate in both single and parallel operation according to the flow levels required and have a capacity of up to 42 mscm/d.

3.1.4 The SGT-A20 Unit A was disconnected in 2017 after becoming life expired and no longer economical to continue maintaining. The SGT-A20 Unit B is still in service has a capacity of up to 56 mscm/d. Table 3 below is an overview of the compressors at King's Lynn Compression Station.

Unit	Engine	Fuel Type	Power Base (MW)	Installation Date	Minimum Operational Flow (mscm/d)	Nominal Capacity (mscm/d)
[redacted]						
*Disconnected in 2017 and partially decommissioned						

Table 3: King's Lynn Compressor Asset Overview

3.1.5 Due to high flows in 2022 and 2023, Unit B was oversubscribed as Units C and D compressor wheels aren't appropriately mapped to higher flow conditions. This resulted in Unit B being operated above the future 500-hour EUD limit and incurring high repair costs. An Asset Health programme to address the condition of Unit B is being submitted in a separate Asst Health EJP.

3.1.6 The current Anti-Surge Valves (ASV) are Mokveld 16" Class 600 RF, as shown in Figure 5. They are a key part of the safe operation and control of a compressor and are in scope of this project. They are a type of control valve used in gaseous and fluid systems to prevent surge that can damage equipment or cause system failure. It is typically used in systems that have variable flow rates, including centrifugal compressors and pumps. In centrifugal compressors, the valve is designed to open and return from the discharge to the suction of the compressor when the anti-surge control is activated, allowing the system to operate within a safe pressure range and preventing damage to the system.

Figure 5: Mokveld 16” Anti-Surge Valve

4 Problem Statement

4.1.1 As detailed below in the Process Duty Specification (PDS) Points section 4.1.12, the current Units C and D wheels are unable to meet a significant percentage of low head / high flow process duty with a single unit or in parallel configuration. Therefore, this duty is taken up by the Avon A20 driven compressor Unit B. Base case forecast hours in this duty area is about 1,000 hours per year.

4.1.2 Units C and D in parallel configuration are able to meet low head very high flow duty only when operating outside of Dry Low Emissions (DLE) due to DLE being limited to approximately 50% of rated power. This duty can also currently be met using non DLE Unit B.

4.1.3 As shown in section 4.1.25, Real Life Example, running either of the SGT400 compressor in its current configuration in single operation at demands higher than 42 mscm/d may lead to catastrophic damage to critical internal components such as the impeller.

4.1.4 National Gas's compressors need to comply with all emissions legislation within the Industrial Emissions Directive (IED) and Medium Combustion Plant Directive (MCPD). The deadline for our compressor compliance is 1 January 2030.

4.1.5 The completion of re-wheel on Units C and D, as stated before, supports the effort to bring Unit B into MCPD compliance via reduction in operational hours. From 2030, Unit B will be restricted to 500 hours (on a rolling 5-year average with a maximum 750 hours permitted in a single year).

4.1.6 The RIIO-GT3 Business Plan Need Case Report indicates that the Future Energy Falling Short Scenario 2023 anticipates a decline in flows in South East to levels below the historical average by the end of RIIO-GT3. However, there remains uncertainty regarding the magnitude and duration of these flows. There are limitations to the FES's data, with no consideration of sudden changes in market trends or geo-political events that result in significant global supply and demand pattern changes. It is therefore important that a full range of scenarios are considered and the appropriate level of capability and resilience for either high levels of entry or exports is maintained.

4.1.7 Running hours in FY2017/18, FY2018/19 and FY2021/22 were associated with higher UKCS supplies, leading to a need for higher compression to move gas away from Bacton. Isle of Grain supplies were low during these periods, if the supply from Isle of Grain had been higher, the running hours for King's Lynn would have been greater too.

4.1.8 In FY2019/20 and FY2020/21 the exports and entry levels at Bacton were mostly below the levels required for compression at King's Lynn. Running hours in FY2022/23 and FY2023/24 are due to the high levels of exports to Europe requiring compression to support the export pressures at the Bacton terminal. This led to greater reliance on Unit B as highlighted in Table 4.

King's Lynn Historical Running Hours (Hrs)								
Unit	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
[redacted]								

Table 4: King's Lynn Units B, C and D Historical Run Hours

4.1.9 As detailed in the approved Needs Case (Appendix O) the forecasted run hours of Unit B without re-wheeling Unit C and D are noticeably high due to the flow limitations on Unit C and D. Re-wheeling Unit C and D would improve the performance of these units, enabling their operation at higher flows, subsequently decreasing the reliance (and therefore running hours) on Unit B.

4.1.10 Therefore, to continue to meet flow demands beyond 2030, Ofgem as part of its preferred option for King's Lynn, has approved the re-wheel of Units C and D to enable single unit operations at higher flow demands whilst lessening the reliance on the non-compliant Unit B compressor. This is further detailed in Section 3 of the Needs Case.

[redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted] [redacted].

[redacted]

Figure 6: Historic Duty with PDS Points C1-C9 superimposed

4.1.15 The PDS spread and subsequent compressor design will cater for the full range of flows seen at King's Lynn over the last 10 years as shown on the chart. Figures 7, 8 and 9 are a breakdown of 3 years from 2014 to 2023 (July) to illustrate this.

Figure 7: 2014 - 2017 (New Envelope)

Figure 8: 2018 - 2020 (New Envelope)

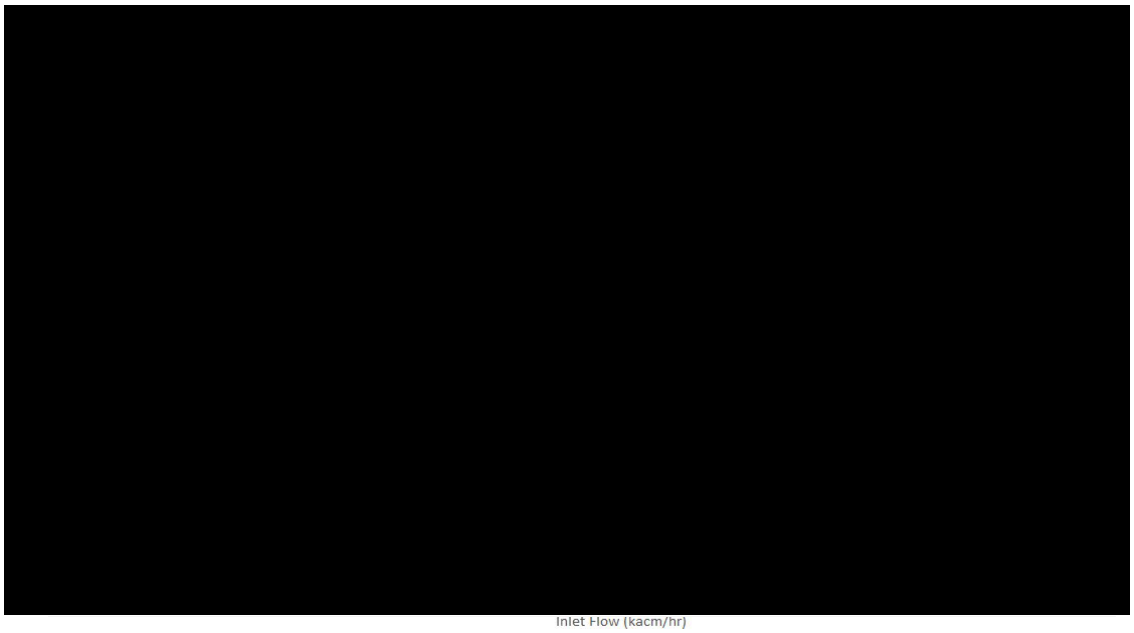

Figure 9: 2021 - July 2023 (New Envelope)

4.1.16 Details of the PDS inlet temperature, station flow, inlet and outlet pressure, process duty specification of the re-wheel are given in Table 5.

4.1.17 Over the approximately ten-year period covered by the process duty specification (2014 to July 2023), only circa 20% of all duty was below the current 42 mscm/d limit of a single SGT400 unit.

Duty	Date Stamp	Inlet Pressure (Barg)	Outlet Pressure (Barg)	Station Flow (MSCM/D)	Inlet Temp (Degrees C)
[redacted]					

Table 5: King's Lynn PDS points (updated July 2023)

As Built Compressor Envelope Mapping

4.1.18 The compressor envelope is the optimised operating region, where operating outside of the envelope is inefficient or unstable. These PDS maps show how the compressor is performing and can be used in conjunction with a performance map to demonstrate that a suitable re-wheel should be considered to meet the performance requirements of a unit in the most cost effective/efficient way.

4.1.19 Figure 10 shows the historic unit envelopes overlayed with the updated PDS points. The area shaded in red is outside of the compressor map for the current Units C and D. Only Unit B can currently cover operation in this area. If Unit C or D was used for this point it would lead to the compressor being heavily in choke (blue dotted line). Choke is an unstable operating condition that can damage the compressor affecting its operability. Units C or D operating on their own can only meet the operating points to the left of the blue choke line and below the maximum power line (blue dashed line).

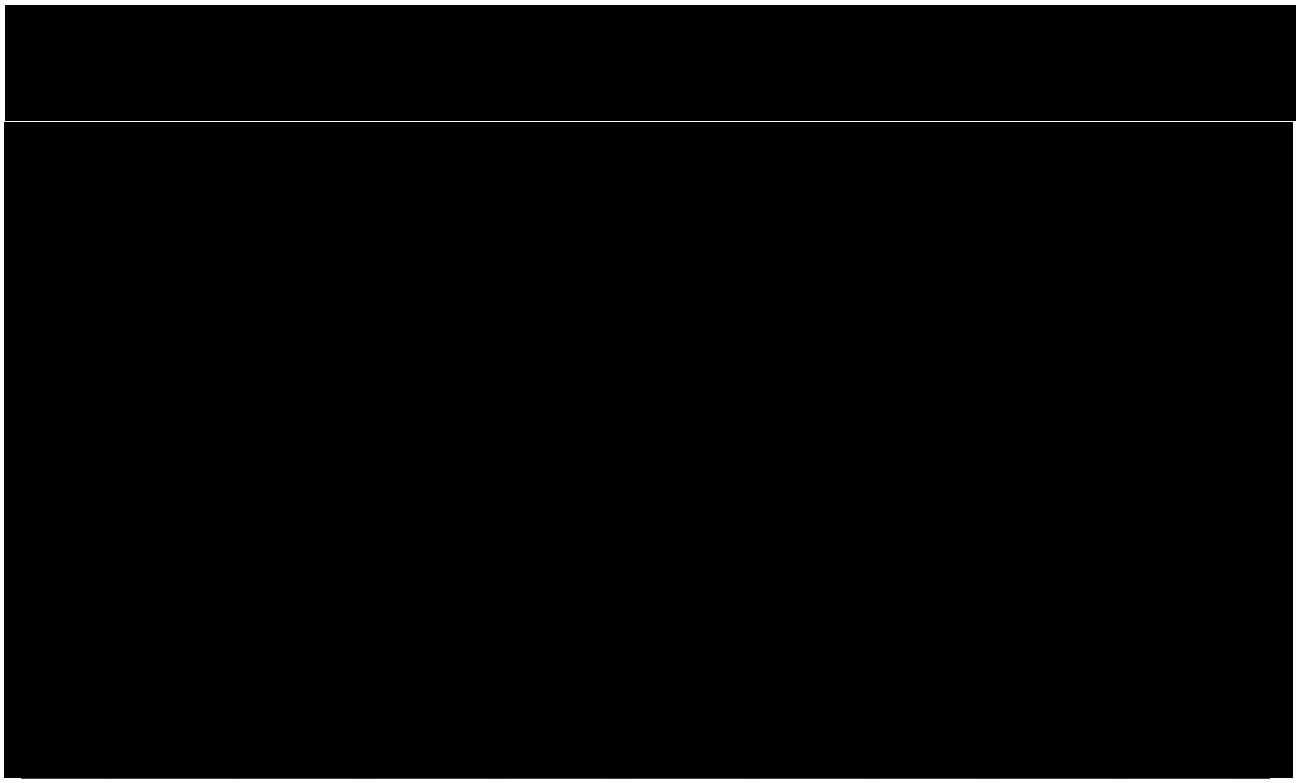

Figure 10: King's Lynn Units C and D Compressor single and parallel operating envelopes as well as backup Unit B against Process Duty Specification (PDS) Points

4.1.20 Table 6 provides a summary of why the units are required to operate in this area.

Duty	Date Stamp	Narrative	Feasibility to operate with single SGT400 today	Feasibility to operate with single SGT400 after re-wheel

Table 6: PDS Points Narrative

4.1.21 Table 6 shows that after the re-wheel PDS points C3 and C4 can be supported by a single SGT400. C2 can also be met with a single SGT400 on some occasions. This will depend on the available turbine power, which

is impacted by the inlet temperature. The higher the inlet temperature the lower the power capability.

4.1.22 From 2030, Unit B will be restricted to 500 hours (on a rolling 5-year average with a maximum 750 hours permitted in a single year) as such would not be available to take up high running hours low head / high flow duty in the C4 region representing about 1,000 hours. Units C and D SGT400 driven compressors are unavailable to meet C4 duty with their currently installed compressor wheels. Unit C and D operating in parallel are also unable to meet C3 duty unless they operate outside of DLE.

4.1.23 A re-wheel will result in more single unit running which is more efficient in terms of emissions. The re-wheel option also reduces overreliance on the back-up Unit B, when taking running hours into account. For duty point C4, if there is no re-wheel, there is diminished operational flexibility as only the back-up Unit B can currently operate at this point which may result in constraints on the network and associated costs.

Real Life Example – Nether Kellet SGT 400s Re-wheel completed in 2022

4.1.24 [redacted]

[redacted] e. .

4.1.26 Figure 11 below shows the nature of the damage to compressor components.

[redacted]

4.1.27 The process to deliver the re-wheel at Nether Kellet was as follows and gives a blueprint for the re-wheel works planned for King's Lynn.

4.1.28 The first step was for System Operator to conduct network modelling reviews to determine future expected site process (flow and head) conditions.

4.1.29 The compressor OEM then determined if the new compressor wheel can be driven by the existing gas turbine and power turbine. The OEM then proposed the new compressor envelopes and modification required.

4.1.30 [redacted]

4.1.31 [redacted]

4.1.32 [redacted]

How will we understand if the project has been successful?

4.1.33 Success will be measured by the project delivering the outcome of Ofgem's preferred option and approved Needs Case for "the re-wheel of the existing SGT-400 units".

4.1.34 Furthermore, success will be demonstrated by completing the full scope of re-wheel works on schedule and within budget, and in compliance with all relevant standards. This means the expected completion of re-wheel works on Units C and D in April 2028 will support the following outcomes:

- Reduction to station emissions and increased efficiency by shifting more of the site's running onto the cleaner units, ensuring we comply with derogated hour limits on Unit B from 2030 while continuing to meet network needs.
- Unit B will only be used for back-up with a significant reduction in run hours post completion of re-wheel works. This is supported by Future Energy Scenario (FES 2023).
- A 46% reduction in the need for parallel operation, post completion of re-wheel works as detailed in Section 4, Business Case of the Re-wheel Needs Case Appendix O.

5 Preferred Option Scope and Project Plan

5.1.1 The re-wheel process, sub-assets and associated works are summarised in the Project Scope below and supported in the approved King's Lynn Re-wheel Needs Case Appendix O.

5.1.2 Additionally, the associated anti-surge valves (ASVs) for both units are confirmed as being in scope following completion of preliminary engineering assessments for the proposed re-wheel scope. The existing anti-surge valves (Mokveld 16" Class 600 RF), will become incompatible with the minimum standards for compressors as established by the American Petroleum Institute Standard API617 and need to be replaced with a higher capacity version to support the re-wheeled units.

5.1.3 [redacted]

Project Scope

5.1.4 [redacted]

5.1.5 [redacted]

5.1.6 [redacted]

5.1.7 [redacted]

5.1.8 [redacted]

5.1.9 The provisional work scope includes:

- Design, specification, and procurement of long lead parts from the OEM Siemens.
- Specification and procurement of replacement ASVs and performance valve from our Valve Supply Partner Score.
- Feasibility study with a suitably competent Main Works Contractor / Principal Designer to confirm the full scope, cost and delivery programme for the investment.
- Detailed design, including Formal Process Safety Assessments, new ASVs, new performance valve, vibration monitoring system modifications / replacement, and control system modifications.
- Programming and coordination of works with coinciding site activities.
- Pre-works baseline Emissions, noise, and Compressor Performance testing.
- Temporary / enabling works including access and lifting equipment.
- Re-wheeling Units C and D (the replacement of the compressor rotor and impellor)
- Installation of replacement ASVs and new performance valve.
- Modification / replacement of Vibration Monitoring system
- Control system modifications associated with new ASVs control and changed compressors operation.

- Commissioning works, including post-modification emissions, noise, and performance testing.
- Records Update
- Collation and archiving of handover spares and records.

5.1.10 Following installation of the replacement parts, the compressor must undergo performance testing to demonstrate correct performance per the required process duty points (gas flows and pressures). To undertake performance testing, a 'performance valve' is used to throttle flow. The valve previously used for performance testing has sealing issues, therefore the preliminary scope includes provision of a new performance valve.

Re-wheel Works Output Summary

5.1.11 The re-wheeling of Units C and D is essential to meet the operational requirements of the network. Re-wheeling (the replacement of the compressor rotor and impellor) modifies the compressor performance (gas pressures and flow rates) enabling it to operate in wider demand range.

5.1.12 Below is a summary of works output being proposed to complete the re-wheel of Units C and D following completion of early engineering assessments by the OEM Siemens Energy.

5.1.13 **Material selection** - The original gas composition of the gas to be compressed contained hydrogen sulphide (H2S). However, the National Association of Corrosion Engineers (NACE) requirements were not applied because the partial pressure of H2S was below 0,0034bar, which was the limitation of NACE requirements according to the design standard API 617 6th edition valid at that time.

5.1.14 For the future operating conditions no hydrogen sulphide (H2S) is specified, and the partial pressure of carbon dioxide (CO2) is less than 0,0034bar. Therefore, no NACE requirements are considered for the compressor revamp selection.

5.1.15 **Thrust force** - The total thrust force is the sum of all forces in axial direction. Each axial force results from the specific pressure acting in the specific area.

5.1.16 The new impeller eye is larger than the current original. The differential pressure across the impeller is reduced. Therefore, the new process conditions combined with the new impeller will change the thrust force. It is expected that a combination of these two effects will result in a higher thrust force.

5.1.17 A preliminary check by the OEM in worst case scenario (high pressure difference over impeller) showed that the thrust force increases but stays within limits of the axial thrust bearings.

5.1.18 **Rotor dynamic** - A preliminary check of the rotor components has been conducted. According to this check, the weight of the impeller is expected to be reduced, whereas the centre of gravity is expected to be increased. It is assumed that the new resulting overhang moment is similar to the current original. Therefore, it is expected that the rotor dynamical behaviour is only impacted slightly. A detailed investigation of the rotodynamic will be conducted during the compressor OEM engineering phase.

5.1.19 Figure 13 below shows the cross section of the compressor. The bottom half shows the existing configuration, whereas the preliminary new configuration is shown in the top half.

5.1.20 The parts which are intended to be replaced are marked in different colours. The rotor, consisting of a new shaft and a new impeller, is marked in green. The new static parts are firstly a new end cover with a new volute marked in orange, and secondly a new inlet cone marked in red. Two additional plates, which are mounted to the existing casing (yellow) and to the end cover (blue), are required to adapt the position of the diffusor channel.

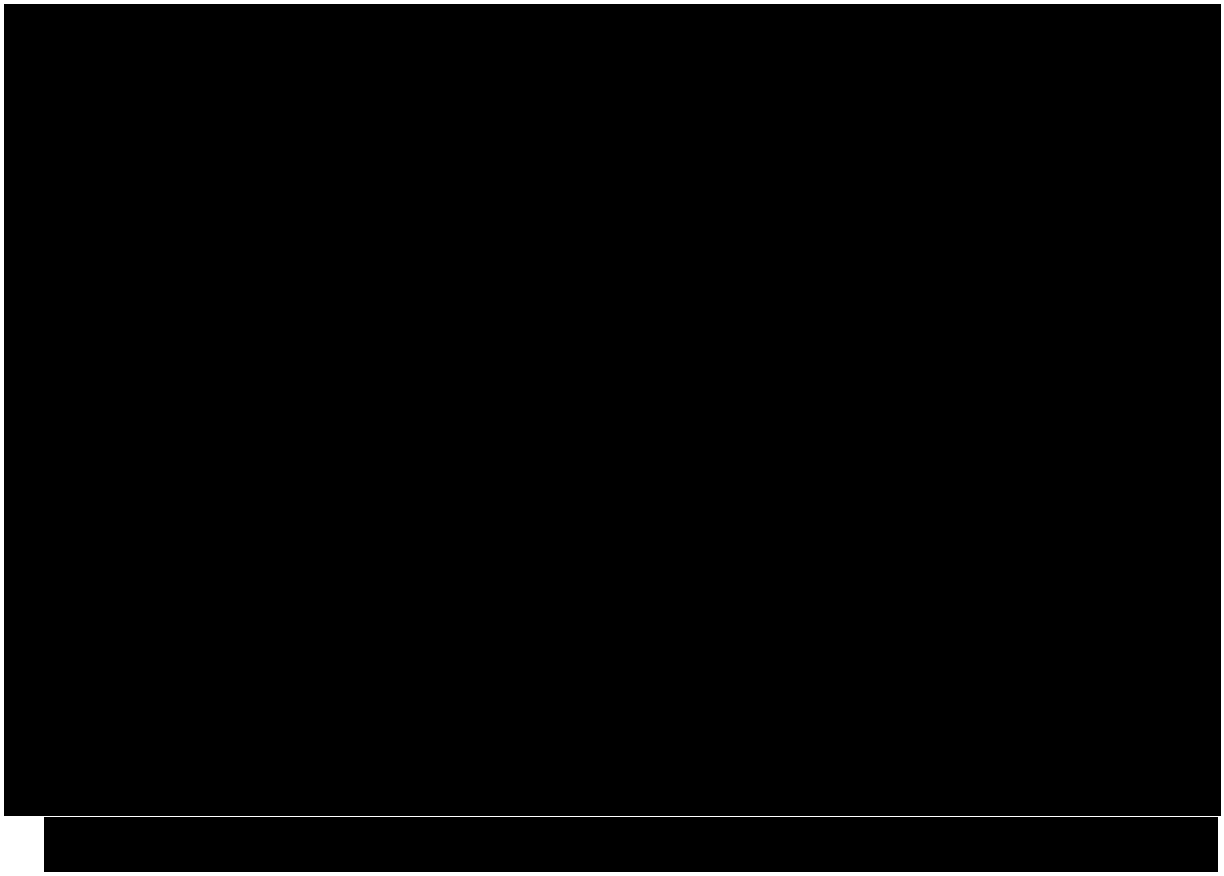

Figure 13: Cross-sectional drawing of SGT 400 unit

5.1.21 **Anti-surge valve (ASV)** – Through detailed engineering phase assessments for the re-wheeling of Units C and D, the OEM Siemens undertook assessment of the existing ASVs against the new operating parameters. This assessment concluded the existing ASVs are too small to manage a surge event where full re-cycle of gas through the compressor is necessary. To adequately protect the compressor train, the existing 16" ASVs will require replacement with 18" (provisional sizing, subject to more detailed assessment), along with minor Vibration Measurement, and Control System modifications.

5.1.22 Surge is a characteristic behaviour of an axial or centrifugal compressor that can occur when inlet flow is reduced such that the head developed by the compressor is insufficient to overcome the pressure at the discharge of the compressor. Once surge occurs, the flow through the compressor reverses, resulting in a drastic discharge pressure drop. This can be due to several factors, including:

- **Flow Limitations:** When the compressor is unable to maintain a stable flow due to excessive upstream demand or restrictions in the system, it can lead to a surge.
- **Control System Failures:** Malfunctions in the control systems that regulate the compressor's operation can cause it to operate outside its optimal range, triggering a surge.
- **System Imbalances:** Imbalances in the system, such as sudden changes in downstream pressure, for example inadvertent closure of a discharge valve can trigger surge.

5.1.23 The flow reversal from repeated surge cycles may result in compressor or system damage resulting from:

- Large dynamic forces on the impeller or blading within the compressor leading to fatigue damage.
- Overheat within the compressor leading to potential rubs created by differential expansion of components within the compressor as well as coating damage.
- Damage to piping components when subjected to flow reversal e.g. check valves.

5.1.24 Figure 14 below shows a diagram of the anti-surge valve.

[redacted]

Proposed Re-wheel Re-Opener UID

5.1.25 We propose to use the following new UID aligned with our re-opener request in Table 7 below.

New UID	Funding Type	Intervention Type	Option Name	Unit of Measure	Business Theme	Delivery Theme	Uncertainty Mechanism
B.2.2.5.21	UM	Replacement	King's Lynn Emissions UM - Re-wheel SGT400 Units C and D	Per unit	Emissions	Emissions	Yes

Table 7: New Units C and D Re-wheel UID

Project Timescales and Delivery Timeline

5.1.26 The project was sanctioned at NDP500 Stage 4.3 in June 2024, and a contract let with Siemens Energy to undertake detailed engineering and manufacture of replacement parts for both Units C and D. Delivery of the first set of parts is scheduled for May 2025, second set in June 2025.

5.1.27 The project was sanctioned at NDP500 Stage 4.4 in April 2025 for Feasibility Conceptual and delivery phases, based on provisional scope and cost estimates.

5.1.28 [redacted]

FY25				FY26				FY27				FY28			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
[redacted]															

Table 8: King's Lynn Re-wheel Indicative Project Timeline

5.1.29 Table 9 below gives the outline milestones for delivering the project across RIIO-T2 and RIIO-GT3. An indicative delivery programme in included in Appendix M.

	Activity Name	Indicative Completion Dates
[redacted]	[redacted]	[redacted]

	Activity Name	Indicative Completion Dates
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

Table 9: King's Lynn Re-wheel Indicative Milestones

Efficient Cost

5.1.30 [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

5.1.36 Table 10 provides a breakdown of the final costs for the project split by several categories.

	Cost Category	Cost (£m) 2024/25 Price Base	Costs (£m) 2018/19 Price Base
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]

	Cost Category	Cost (£m) 2024/25 Price Base	Costs (£m) 2018/19 Price Base
	[redacted]	[redacted]	[redacted]
	[redacted]		[redacted]
	[redacted]		[redacted]
	[redacted]		[redacted]

Table 10: Preferred Option Final Cost

5.1.37 We have incorporated lessons learnt and scrutinised the proposed programme to find efficiencies, working with the OEM and competitively established contractor prices to provide a cost that achieves value for the consumers. The investment and works will span across the RIIO-T2 and RIIO-GT3 period.

Key Project Delivery Risks

5.1.38 The risk management process adopted by NGT is described in Appendix F, NGT Cost and Risk Methodology, chapter 3: Risk Methodology. Full descriptions of these risks and their potential impact, including qualitative and quantitative assessments and mitigations, are detailed within the project Risk Register in Appendix A King's Lynn MCPD Costbook.

5.1.39 [redacted]

5.1.40 The risks have been identified through a rigorous risk assessment process involving multiple iterations and broad stakeholder engagements. The risks have been prioritised based on their potential impact on project which may cause costs and schedule overruns.

Risk ID	Scope	Title	Description	Probability Value (%)	P50 Value 2024/25 Price Base	P50 Value 2018/19 Price Base
T- [redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 11: Top 3 Key Delivery Risks

6 Conclusion

6.1.1 The King's Lynn Re-wheel Needs Case for compressor Units C and D was approved by Ofgem in June 2024. It was accepted that the intervention will enable the units to operate at higher flow ranges and therefore reduce the reliance on Unit B, without compromising our meeting of customer obligations/supply consumer's needs or 'without compromising security of supply'.

6.1.2 This EJP showcases the updated PSD study for the investment. The PSD study continues to indicate that a compressor re-wheel of Units C and D would move them from inefficient parallel operation to efficient single unit operation.

6.1.3 The solution proposed in this paper meets Ofgem's approved option and is necessary to ensure the continued security of supply to customers. Furthermore, this document summarises our approach to tender, delivery of the works and how we derived the estimated costs. And aims to minimise the impact to network operations that may contribute to the failure to supply gas to our customers and stakeholders.

6.1.4 Delivery of this investment will enable continuous efficient operation at the King's Lynn compressor station in compliance with the MCPD and provide cost-efficient value for consumers. Failure to invest would mean leaving the station unable to support flow towards Bacton or away from Isle of Grain terminals adequately, impacting security of supply for our customers and consumers.

6.1.5 [redacted]

7 Glossary

Glossary	
COMAH	Control of Major Accident Hazards (COMAH) Regulations 2015. Bacton Terminal is one of two designated NGT COMAH establishments. The other being St Fergus Terminal
DLE	Dry Low Emissions
EAC	**Estimated Cost At Completion:** A value expressed in money and/or hours to represent the projected final costs of work when completed.
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.
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**
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.
(G)NDP	**Network Development Process:** The process by which NGT identifies and implements physical investment on the NTS.
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**

Glossary	
Ofgem	**Office of Gas and Electricity Markets:** The regulatory agency responsible for regulating Great Britain's gas and electricity markets.
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.
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.
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