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Wormington Compressor Station

MCPD FEED Feasibility Project

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1 Executive Summary

1.1 Overview

[redacted] Limited were engaged by National Grid to undertake an engineering study to support the options selection process for MCPD compliance at Wormington. The outputs of the engineering study undertaken by [redacted] are summarised in their "FEED Report" (Ref. 20840-EN-RPT-000-0006 Rev 1). National Grid used the engineering output of the study by [redacted] alongside various inputs developed internally and with the support of other specialist contractors to inform the option selection process. This option selection process was supported by Cost Benefit Analysis (CBA) and Best Available Techniques (BAT) assessment.

This document highlights updates to the technical definition of options and associated cost and programme updates made following completion of the engineering study by [redacted]. The document has been structured to align with the "FEED Report" and the two documents should be read in parallel with this document taking precedence.

1.2 Long List Options

[redacted] identified seven technology solutions which either individually or in combination could provide enduring emissions compliant compression at Wormington compressor station to meet forecast future network capability requirements beyond 2030. These potential solutions are described in Table 1.

Table 1 - Long List Options Reviewed by [redacted]

Option No.	Description		Report Section	Shortlist
1	Restricted Avon (CSRP)	Restrict the operation of the Avon via control system modifications such that emissions are limited to within legislative limits (also referred to as control system restricted performance)	8.3	
2	500-hour EUD	Retain Avon driven compressor trains with 500 hour per year run-hour restriction; calculated as a rolling average over a period of five years, per the emergency use derogation allowed under the MCPD legislation	8.4	
3	SCR	Selective Catalytic Reduction system installed on the existing Avon driven compressor trains	8.5	*Note 1*
4	Retrofit DLE (Avon)	Upgrade combustion system on existing Avon's to a dry low emissions system	8.6	
5	New GT	Replacement of one or both Avon's with dry low emission gas turbine driven compressors which are compliant with MCPD new plant standards	8.7	
6	New Electric VSD	Replacement of one or both Avon's with electric VSD(s).	8.8	*Note 2*
7	Re-wheel	Options involving re-wheel of the existing compressors to better align with forecast capability requirements	8.9	

Note 1) *SCR options were reviewed by a specialist consultant ([redacted]) under a separate contract with National Grid. The outputs of the study by [redacted] fed directly into CBA and BAT assessments by National Grid and were not assessed by [redacted].*

Note 2) *Electric drive options were discounted in agreement with National Grid as this option would result in reliance on HV electrical supply for compression and any outage would result in complete loss of compression capability at Wormington*

When [redacted] commenced the engineering study a Planning and Reservation of Capacity Agreement (PARCA) for increased entry flow at Milford Haven Aggregated System Entry Point (ASEP) was under review by National Grid. To accommodate this additional flow, various network investment options were under consideration including pipeline and compressor modifications. These network investment options are considered as part of the Western Gas Network (WGN) Project which is subject to a separate funding allowance request. Wormington MCPD options have been reviewed against a range of potential future operational requirements including a range of potential investment outcomes for the WGN project.

1.3 Short List Options

National Grid developed a comprehensive option shortlist based on various combinations of the options assessed by [redacted] as described in Table 1. This shortlist is provided in Table 2. These shortlisted options were assessed in CBA and BAT assessments based on the outputs of the engineering study by [redacted] supported by the following additional inputs developed by National Grid supported by other specialist contractors:

- Network Capability assessment
- Availability assessment (supported by [redacted] and [redacted])
- Avon DLE prototype testing (by [redacted])
- CSRP Trials (supported by [redacted] and [redacted])
- TOTEX estimates by National Grid
- Risk assessment by National Grid

Table 2 – Refined Options Shortlist

Option	Description	Unit A	Unit B	Unit C	Unit D *(Future)*	Unit E *(Future)*
1	Counterfactual	500Hr EUD	500Hr EUD	No Change	-	-
2	2 x CSRP	CSRP Retrofit	CSRP Retrofit	No Change	-	-
3	2 x SCR	SCR Retrofit	SCR Retrofit	Compressor Re-wheel	-	-
4	DLE + 500	1533 DLE Retrofit	500Hr EUD	No Change	-	-
5	2 x 1533 DLE	1533 DLE Retrofit	1533 DLE Retrofit	No Change	-	-
6	2 x 1535 DLE	1535 DLE Retrofit	1535 DLE Retrofit	Compressor Re-wheel	-	-
7	New GT + 500	500Hr EUD	Decommission[1]	Compressor Re-wheel	New GT	-
8	New GT + CSRP	CSRP Retrofit	Decommission[1]	Compressor Re-wheel	New GT	-
9	New GT + DLE	1533 DLE Retrofit	Decommission[1]	Compressor Re-wheel	New GT	-
10[2]	2 x New GT	Decommission[1]	Decommission[1]	Compressor Re-wheel	New GT	New GT

Note 1) *Decision on decommissioning non-compliant units will be subject to an assessment of network capability after operational acceptance of the new units. Costs for decommissioning have been included in the CBA to ensure a consistent basis for all options*

Note 2 *Investment deferral has also been considered as a separate option (option 10+) which involves initially progressing with Option 7 before a decision on installation of a second new unit at a later date.*

2 Introduction

2.1 General

[redacted] were engaged by National Grid to support the options selection process for MCPD compliance at Wormington. The scope undertaken by [redacted] is summarised as follows.

- Identify a full suite of options to secure future emissions compliant operation of Wormington Compressor Station to meet current and forecast future capability requirements including the process duty specification for each scenario defined in Appendix A
- Carry out an initial options screening to identify a shortlist of feasible options for each scenario
- Provide a detailed justification for shortlisting of options supported by appropriate engineering documentation and credible data
- Develop the engineering design for each shortlisted option to a suitable level of definition and use this to develop ±30% cost estimates to be developed via an industry standard estimating methodology
- Estimate the CAPEX cost and associated delivery programme to an accuracy of ±30% for each shortlisted option
- Provide engineering inputs to support Client in developing whole life cost benefit analysis and Best Available Techniques (BAT) assessments for each option
- Identification of key risks and assumptions including quantification and provision of evidence that they are of sound and credible basis

The output of the scope undertaken by [redacted] including key engineering, cost estimating, and project planning deliverables is summarised in the "FEED Report" (20840-EN-RPT-000-0006 Rev 1). The "FEED Report" and associated appendices and references is included alongside this document in the Final Option Selection Report.

2.2 Document Purpose

The output of the scope of work executed by [redacted] was used to inform the Best Available Techniques (BAT) assessment and Cost Benefit Analysis (CBA) which were used by National Grid to select the preferred option as outlined in the Final Option Selection Report. Following formal issue of the "FEED Report" by [redacted] various changes and updates were made to the specified options due to the following:

- To allow the inclusion of potential options identified in preliminary CBA and BAT assessment (including investment deferral options)
- To ensure alignment with other MCPD Uncertainty Mechanism submissions and incorporate lessons learnt

- To select a preferred layout option for consideration in CBA and BAT assessment
- To incorporate direct feedback from Ofgem through regular engagement sessions

The purpose of this report is to highlight updates to the technical definition of options and associated cost and programme updates made after formal issue of [redacted] s deliverables. The document has been structured to align with the "FEED Report" and the two documents should be read in parallel with this document taking precedence.

3 References

3.1 Precedence

For the purposes of the Final Option Selection Report the order of precedence for technical documents is as follows:

- This document and other specific National Grid Documents Referenced herein
- "FEED Report" by [redacted] (20840-EN-RPT-000-0006 Rev 1)
- Other deliverables referenced within the "FEED Report"

3.2 Statutory Regulations

It is noted that the "FEED Report" (20840-EN-RPT-000-0006 Rev 1) refers to COMAH regulations which do not apply at Wormington Compressor Station.

3.3 CLIENT Design Guides

See "FEED Report" (20840-EN-RPT-000-0006 Rev 1).

3.4 Codes and Standards

See "FEED Report" (20840-EN-RPT-000-0006 Rev 1).

4 Definitions

It is noted that [redacted] refer to the work conducted as part of the option selection process as "FEED". However, it is noted that this is a somewhat ambiguous term and not appropriate for this phase of the project. Although FEED does not have a fixed definition and deliverables it typically refers to the phase of the project immediately prior to a final investment decision and subsequent detailed engineering. Therefore, within this document the scope undertaken to date is referred to as "Option Selection".

5 Abbreviations

Abbreviation	Definition
ALARP	As Low as Reasonably Practicable
BAT	Best Available Techniques
CBA	Cost Benefit Analysis
CDM	Construction, Design and Management Regulations
CSRP	Control System Restricted Performance - this is a compliance option whereby the performance of the Avon is restricted to ensure emissions are limited to within MCPD limits.
ERP3	Emissions Reduction Project Phase 3 (Recent project involving the installation of 2 off new Solar Titan 130 compressor trains at Huntingdon Compressor Station and 2 off at Peterborough Compressor station which are due for commissioning in 2022/23)
FEED	Front End Engineering Design
LCPD	Large Combustion Plant Directive
MCPD	Medium Combustion Plant Directive
NTS	National Transmission System
PARCA	Planning and Reservation of Capacity Agreement
PDS	Process Duty Specification
QRA	Quantitative Risk Assessment
RAM	Reliability, Availability and Maintenance
SIMOPS	Simultaneous Operations

6 Study Background

The option selection process consisted of the following key steps:

[redacted] led activities:

1. Identify options
2. Option Definition
3. Shortlisting of options
4. Refinement of option definition
5. Document recommendations

National Grid led activities:

6. Refine Options Definition
7. Assessment of shortlisted options

A brief overview of each of the above steps is described below.

6.1 Identify Options

Options were assessed against five process scenarios described by five sets of process duty specification points. A summary of these process scenarios is included in Table 3.

The Western Gas Project has been initiated by National Grid to define investment required to accommodate additional flow onto the NTS at the Milford Haven Aggregated System Entry Point (ASEP) which is subject to a Planning and Reservation of Capacity Application (PARCA) submitted by South Hook LNG.

During our technical assessment we considered five PDS cases to cover all potential operational requirements of the site. The detailed analysis of the PDS points has informed us on the capability of each of the compressor configurations and this work has been factored into our Network Capability assessments. As the CBA considers how options perform against all the potential supply/demand combinations identified as part of our probabilistic analysis of the Future Energy Scenarios the outcome of all PDS assessments, other than case 1 and case 5, factors into this analysis.

PDS Case 1 examined the technical performance if the network improvements identified as part of the WGN are not implemented. This has been assessed as a specific sensitivity. PDS Case 5 was an assessment to ensure that any of the options under assessment would be able to operate under any future expansion of the capability of the network based on an expansion of the reinforcements identified as part of the WGN.

Table 3 - Process Scenarios

PDS Case	Description
1	Sets of asset options focusing solely on MCPD PDS requirement
2	Sets of asset options combining both the MCPD and PARCA flows which include Western Gas reinforcements options #1 This PDS case includes the following WGNU network reinforcements: Pipeline from Wormington to Honeybourne (9km) and 2km at Churchover plus Feeder 28 pipe pressure uprating (Milford to Felindre – 99 barg and Felindre to 3 cocks – 102 barg)
3	Sets of asset options combining both the MCPD and PARCA flows which include reinforcements outlined in PDS Case 2 above, with the additional constraint that site lead compression capability cannot exceed 30 MW (i.e., compressor investment to replace the existing Avon gas turbines cannot exceed 15 MW shaft power per compressor train)
4	Sets of asset options combining both the MCPD and PARCA flows which include Western Gas reinforcements options #2 This PDS case includes the following WGNU network reinforcements: Pipeline from Wormington to Honeybourne (9km) and 2km at Churchover plus Feeder 28 pipe pressure uprating (Milford to Felindre – 99 barg and Felindre to 3 cocks – 102 barg) + additional 26km from pipe reinforcement along Feeder 28 from Tirley to Wormington.
5	This PDS case considers the incremental effect on Wormington, of compressor upgrades at Felindre compressor station to add an additional 3 MW to Felindre compression capability in addition to Western Gas reinforcements options #1 (see PDS Case 2 above)

During our technical assessment we considered five PDS cases to cover all of the potential operational requirements of the site. The detailed analysis of the PDS points has informed us on the capability of each of the compressor configurations and this work has been factored into our Network Capability assessments. As the CBA considers how options perform against all the potential supply/demand combinations identified as part of our probabilistic analysis of the Future Energy Scenarios the outcome of most of the PDS assessments factors into this analysis.

The main exceptions were case 1 - this examined the technical performance if the network improvements identified as part of the WGN are not implemented. This has been assessed as a specific sensitivity. The other is case 5 which was an assessment to ensure that any of the options under assessment would be able to operate under any future expansion of the capability of the network based on an expansion of the reinforcements identified as part of the WGN.

6.2 Definition of Options

To support initial assessment of options and shortlisting, initial engineering was undertaken including process modelling and layout development. Based on this initial engineering, order of magnitude estimates were developed and these inputs were used as part of the shortlisting process described below.

6.3 Shortlisting of Options

[redacted] assessed options against a mix of qualitative and quantitative criteria which were reviewed in a workshop environment as described in the "FEED Report". At this stage the electric drive option was discounted due to reliance on the high voltage electrical supply for compression which would expose Wormington to complete compression loss should electricity supply be lost. No other options were discounted following this initial assessment as it was agreed that all options should be progressed for detailed assessment supported by CBA and BAT processes.

6.4 Refinement of shortlisted options

Further detail on how the options were refined is described in the following subsections of this report and associated sections of the "FEED Report". This included technical and environmental assessment and development engineering and required inputs to CBA and BAT assessments.

6.5 Document Recommendations

[redacted] produced a suite of documents which are referenced in the "FEED Report" including engineering, cost and programme inputs that formed the basis of the subsequent development and assessment of options by National Grid.

6.6 Refine Options Definition

To support the CBA and BAT processes additional inputs were developed by National Grid to supplement the documentation and data provided by [redacted]. This included:

- Availability assessment based on a separate RAM study by a specialist contractor (see FOSR appendix L)
- Capability assessment against a single PDS scenario (case 2) with any shortfall in capability translated into a cost associated with the resultant exposure to potential constraint costs
- Verification of engineering inputs including selection of single preferred layout option and confirmation of material quantities
- Refinement of CAPEX and OPEX estimates including benchmarking of cost assumptions and inclusion of in-house cost data
- Semi-quantitative risk assessment for all options
- Assessment of investment timing and deferral

6.7 Assessment of shortlisted options

National Grid is legally bound under the IED to comply with the requirements of BAT in respect of its compressor installations operating gas turbine driven compressor plant. Beyond this, National Grid made a policy decision in 2013 that BAT would be the primary selection mechanism for all new and substantially modified compressor machinery trains. This approach is consistent with National Grid's corporate objective to demonstrate Whole Life Value for its internal and external stakeholders. We use a BAT assessment methodology which has been developed in house in discussion with the EA and SEPA.

In parallel to the BAT assessment process, National Grid has developed another Cost Benefit Analysis model (referred to as 'the CBA Tool'). This tool is used to support investment decisions internally and with Ofgem.

There is much in common between the BAT assessment and CBA process, and the two tools share many common inputs. The principles differences relate to:

- Monetising of externalities in CBA tool (such as emission of NOx), which are addressed as scores in the BAT tool.
- Qualitative scoring of operational factors in the BAT tool (such as emissions limits compliance); such factors are only included within the CBA Tool if they bring a monetised constraint cost risk.
- The CBA tool considers wider network interactions, such as the availability of other network stations, whereas the BAT tool is site specific.

All shortlisted options were assessed via CBA and BAT processes described above and the results used to support the selection of the final preferred option. This was an iterative process where additional option variations and sensitivities were identified following preliminary assessment. Final option selection is described in full in the Final Option Selection Report.

7 Engagement with Vendors

[redacted] contacted suppliers on National Grid's compressor OEM framework agreement to identify potential compressor machinery train options for new unit solutions. Various options were identified and budget prices provided by the suppliers as described in the "FEED Report". However, the budget prices were not utilised in the cost estimates and instead in-house National Grid cost data for Solar Titan 130 compressor trains from the ERP3 project were utilised. This was to ensure alignment with other MCPD project cost estimates for this key cost element.

A formal tender event will be initiated with compressor machinery train providers once the Wormington MCPD investment option has been confirmed.

8 Phase 2 Shortlist Options – Engineering

8.1 Overview

[redacted] reviewed the seven technology solutions as per Table 4 which are described in the referenced sections of the "FEED Report" and further described in respective sections of this report.

Table 4 - [redacted] Options

Option No.	Description	Report Section
1	Restricted Avon (CSRP)	8.3
2	500-hour EUD	8.4
3	SCR	8.5
4	Retrofit DLE (Avon)	8.6
5	New GT	8.7
6	New Electric VSD	8.8
7	Re-wheel	8.9

The technology solutions reviewed by [redacted] were used to generate an option shortlist to be assessed via CBA and BAT assessment by National Grid. The option shortlist is provided in Table 5. In the BAT assessment all options were assessed against a single process scenario (PDS case 3) rather than the five PDS cases initially identified. The CBA assessed the shortlisted options against all four Future Energy Scenarios (FES).

Table 5 - Options Shortlist

Option	Description	Unit A	Unit B	Unit C	Unit D *(Future)*	Unit E *(Future)*
1	Counterfactual	500Hr EUD	500Hr EUD	No Change	-	-
2	2 x CSRP	CSRP Retrofit	CSRP Retrofit	No Change	-	-
3	2 x SCR	SCR Retrofit	SCR Retrofit	Compressor Re-wheel	-	-
4	DLE + 500	1533 DLE Retrofit	500Hr EUD	No Change	-	-
5	2 x 1533 DLE	1533 DLE Retrofit	1533 DLE Retrofit	No Change	-	-
6	2 x 1535 DLE	1535 DLE Retrofit	1535 DLE Retrofit	Compressor Re-wheel	-	-
7	New GT + 500	500Hr EUD	Decommission	Compressor Re-wheel	New GT	-
8	New GT + CSRP	CSRP Retrofit	Decommission	Compressor Re-wheel	New GT	-
9	New GT + DLE	1533 DLE Retrofit	Decommission	Compressor Re-wheel	New GT	-
10	2 x New GT	Decommission	Decommission	Compressor Re-wheel	New GT	New GT

The SCR option which was referenced within [redacted]'s "FEED Report" as "on hold" has been developed under a separate study by a specialist contractor and is provide in appendix J of the Final Option Selection Report.

8.2 Asset Health

The existing Avon driven compressor trains were installed in 1990/91 and much of the equipment associated with these assets are original. Assets are maintained in accordance with National Grid policies, procedures, and specifications and OEM recommendations. However, many of the assets are not beyond their original design life and in many cases no longer supported by OEMs. This impacts on reliability and sourcing spares is becoming increasingly challenging in many cases which affects the cost of repairs and compression availability. More detail on the specific impacts on availability is described in the RAM study included in appendix L of the Final Option Selection Report.

Asset health scope is considered for each system associated with existing and new compressor assets considering the following factors:

- Replacement or refurbishment should be based on existing asset age, condition and remaining design life
- Investment decisions should be supported by cost benefit analysis where relevant
- Where Units A and/or B are targeted to be decommissioned prior to 1 January 2030 following operational acceptance of new units, minimal spend is required to ensure safe, secure and reliable operation until decommissioning.
- Certain scope is already included in RIIO-T2 investment plan under other investment themes so will not need to be included in the initial CAPEX investment for MCPD. (See Asset Health Report in appendix E of the Final Option Selection Report)
- Certain assets are in good condition with design life remaining and therefore will not be included in the initial MCPD CAPEX investment
- For assets not included in initial MCPD CAPEX investment then replacement or refurbishment should be included at some future date in the CBA based on current condition and assumed deterioration rate or remaining design life (e.g. For control system equipment a 15-year design life is assumed, beyond which replacement is required)

[redacted] reviewed existing asset information to recommend the asset health scope to be included in initial CAPEX spend for retrofit options.

In parallel to the option selection study by [redacted] a separate RAM study was undertaken by a specialist consultant and the output of this study is included in appendix E of the Final Option Selection Report. This report was used to support the CBA as well as scoping of asset health work for each option.

The technology options reviewed by [redacted] are listed in the following subsections. The sub-headings match those in the "FEED Report" by [redacted] and notes are added in each section to correlate [redacted] s technology options to the CBA/BAT options per Table 5.

8.3 Option 1 – Restricted Avon

Following process modelling [redacted] correctly note a capability shortfall for this option meaning that the required process conditions cannot be achieved unless combined with a new unit. This capability shortfall has been translated into a cost associated with exposure to potential constraint costs to allow full consideration of this option in the CBA and BAT assessment process.

A separate CSRP study has also been undertaken by National Grid with support of specialist consultants the outputs of which can be found in the Formal Option Selection Report appendix K.

The restricted Avon was considered in the CBA/BAT options shown in Table 6. The Avons cannot meet future capability requirements notably the increased flows from Milford Haven ASEP. Additionally, for CSRP options there will be a slight reduction in compression capability compared to a standard Avon due to the slight reduction in power associated with the control system restriction. This capability limitation of these options is translated into a constraint cost exposure in the CBA and BAT assessments allowing comparison against options which are fully compliant with capability requirements.

Table 6 - CBA/BAT Options Involving Restricted Avon

Option	Description	Unit A	Unit B	Unit C	Unit D (Future)	Unit E (Future)
2	2 x CSRP	CSRP Retrofit	CSRP Retrofit	No Change	-	-
8	New GT + CSRP	CSRP Retrofit	Decommission	No Change	New GT	-

8.4 Option 2 – 500-hour Emergency Use Derogation

Similar to the restricted Avon option described above this option results in a capability shortfall which has been used to calculate a cost associated with exposure to potential constraint costs which has been used in the CBA and BAT to allow this option to be fully assessed.

The 500-hour emergency use derogation has been considered in the options described in Table 7 which include the counterfactual.

The Avons cannot meet future capability requirements notably the increased flows from Milford Haven ASEP. The 500-hour running restriction of the Avons further restricts compression capability at Wormington. These capability limitations have been translated into a constraint cost exposure for these options allowing them to be compared against options which are fully compliant with capability requirements.

Table 7 - CBA/BAT Options Involving 500 Hour EUD

Option	Description	Unit A	Unit B	Unit C	Unit D (Future)	Unit E (Future)
1	Counterfactual	500Hr EUD	500Hr EUD	No Change	/	/
4	DLE + 500	1533 DLE Retrofit	500Hr EUD	No Change	/	/
7	New GT + 500	500Hr EUD	Decommission	No Change	New GT	/

8.5 Option 3 – SCR

An SCR report by [redacted] can be found in appendix J of the Final Option Selection Report. This option was assessed as part of the CBA and BAT assessment based on the outputs of the study by [redacted].

SCR options assessed in the CBA and BAT tools include an engine upgrade to increase the available shaft power at the compressor hence maximising the capability of this option without replacement of the compressor machinery train. The net thermal input per compressor has been limited to 50 MW to avoid the application of LCPD requirements which include energy efficiency requirements that cannot be achieved by the Avon. Even with the gas turbine upgrade there will be a capability shortfall and this will be translated to a constraint cost exposure in the CBA and BAT assessments.

SCR has been considered in CBA/BAT Option 3 only as described in Table 8. This option could also be applied in combination with single new GT however it was apparent from the CBA and BAT assessment that other retrofit options were preferable due to additional cost and constructability issues associated with the SCR option.

Table 8 – CBA/BAT Options Involving SCR

Option	Description	Unit A	Unit B	Unit C	Unit D (Future)	Unit E (Future)
3	2 x SCR	SCR Retrofit	SCR Retrofit	No Change	/	/

8.6 Option 4 – Retrofit DLE

Separate options including the Avon 1535 and 1533 engine derivatives have been included in the options assessment. It should be noted that the power of the 1535 derivative will need to be restricted by control system modification to ensure the net thermal input does not exceed 50 MW which would result in the LCPD requirements being applicable.

Further details of this option, including results of ongoing testing are included in appendix I of the Final Option Selection Report.

Avon DLE retrofit has been considered in the CBA and BAT assessments in the options described in Table 9. There is a shortfall in capability for these options which has been translated into a constraint cost exposure in the CBA and BAT assessments to allow comparison with options which provide the full capability required.

Table 9 - CBA/BAT Options Involving Avon DLE Retrofit

Option	Description	Unit A	Unit B	Unit C	Unit D (Future)	Unit E (Future)
4	DLE + 500	1533 DLE Retrofit	500Hr EUD	No Change	-	-
5	2 x 1533 DLE	1533 DLE Retrofit	1533 DLE Retrofit	No Change	-	-
6	2 x 1535 DLE	1535 DLE Retrofit	1535 DLE Retrofit	Compressor Re-wheel	-	-
9	New GT + DLE	1533 DLE Retrofit	Decommission	Compressor Re-wheel	New GT	-

8.7 Option 5 – New GT

New units options are based on the installation of dry low emission (DLE) gas turbine driven compressor which meet the MCPD emissions limits for new plant. New units will be specified to operate as a single unit or with one other compressor in parallel and will be sized appropriately for the required duty. Appropriately sized new units will be selected via competitive tender.

For options which feature a single new appropriately sized GT, the new GT would be used to meet the range of high-power process duties when operating in parallel with the existing electric VSD or the Avon GT. When the new GT is unavailable, the electric VSD would need to operate in parallel with the Avon GT which could be either an EUD Avon on 500 hours, a

DLE Avon 1533, or a CSRP Avon power limited. The total capability at the site when the new GT is not available would be limited by the Avon GT investment option in place: the EUD Avon GT combined with electric drive (c. 27MW; limited to 500 hours); DLE Avon combined with electric drive (c. 27 MW); CSRP Avon combined with electric drive (less than 27 MW).

All options involving installation of new units are based on Layout 2 (greenfield area to the south of Feeder 23). Section 11.2 of this document describes the layout review process used to select this layout and other greenfield and brownfield layout options considered.

Figure 1 - New Unit Layout

No allowance for future expansion is included in the layout design but a conservative approach has been taken including compliance with the requirements of T/SP/G/37. A more detailed layout review will be conducted during FEED and potential optimisations investigated.

Options which consider the installation of new units are summarised in Table 10.

Table 10 - CBA/BAT Options Involving New Units

Option	Description	Unit A	Unit B	Unit C	Unit D (Future)	Unit E (Future)
7	New GT + 500	500Hr EUD	Decommission	Compressor Re-Wheel	New GT	/
8	New GT + CSRP	CSRP Retrofit	Decommission	Compressor Re-Wheel	New GT	/
9	New GT + DLE	1533 DLE Retrofit	Decommission	Compressor Re-Wheel	New GT	/
10	2 x New GT	Decommission	Decommission	Compressor Re-Wheel	New GT	New GT

8.7.1 Deferral Option – Option 7 & 10+

In the CBA investment deferral has been considered through an option where we initially progress with option 7 (1 off new unit + 1 off Avon 500 hr) with a subsequent investment decision on a potential second unit in 2030 with operational acceptance in 2034. This option attempts to address immediate capability requirements and MPCD compliance whilst leaving an option for increasing site resilience through the installation of a second new unit at a later date depending on forecast capability requirements at the time.

Given the uncertainty around future energy supply and demand patterns, notably resulting from updates to government energy policy aligning to net zero targets, there may be benefits to delaying investment decisions regarding the required compression resilience at Wormington. More detail on the wider considerations of investment deferral is included in the Final Option Selection Report. In terms of engineering and delivery strategy it is assumed that the initial investment for option 7 would progress immediately following confirmation of the preferred option in Feb 2023. The only pre-investment included for in the cost estimates is the allocation of adequate space for a second unit which ensures maximum benefit of discounting is accounted for. However, this approach would result in delivery inefficiencies which have not been fully allowed for in cost estimates and a detailed review would be required through the development of a pre-investment philosophy alongside a development of the delivery strategy. For example, pre-investment in piling and civil works would most likely be required to avoid excessive outage periods for these works when the first new unit is operational.

8.8 Option 6 - New Electric VSD

The lead unit at Wormington is an electric VSD (Unit C). Options involving the installation of new Electric VSDs were discounted at the shortlisting stage due to resulting complete reliance on high voltage electrical supply for compression which would result in complete loss of compression capability should electrical supply be lost.

8.9 Option 7 – Re-wheel

Options where the gas turbine driven compression capability is modified result in a requirement for the electrically driven compressor to be re-wheeled to accommodate higher flow. This will ensure efficient load share between compressors. A re-wheel of Unit C's compressor has been included for all options involving the installation of one or two new units and where an engine upgrade is specified for Unit A and/or B as summarised in Table 11.

The "FEED Report" by [redacted] indicates that a re-wheel of one of the Avon driven compressors would allow the high flow and high head process duty point including future flow increases (PDS Case 2 Point P11) with no engine modifications. However, the power required to achieve this process duty would exceed the max power provided by any two of the three compressors running in parallel. A small power increase is available by upgrading the Avon gas turbine to the more powerful 1535 variant, but the efficiency of the Avon cannot meet LCPD requirements and therefore the power would need to be limited to 50 MW net thermal input. Modifying the compressor alongside this power upgrade would not provide significant benefit and this has therefore not been considered.

Table 11 - CBA/BAT Options Involving Compressor Re-wheel

Option	Description	Unit A	Unit B	Unit C	Unit D (Future)	Unit E (Future)
3	2 x SCR	SCR Retrofit	SCR Retrofit	Compressor Re-wheel	/	/
6	2 x 1535 DLE	1535 DLE Retrofit	1535 DLE Retrofit	Compressor Re-wheel	/	/
7	New GT + 500	500Hr EUD	Decommission	Compressor Re-wheel	New GT	/
8	New GT + CSRP	CSRP Retrofit	Decommission	Compressor Re-wheel	New GT	/
9	New GT + DLE	1533 DLE Retrofit	Decommission	Compressor Re-wheel	New GT	/
10	2 x New GT	Decommission	Decommission	Compressor Re-wheel	New GT	New GT

9 Cost Estimate

CAPEX estimates to support the CBA and BAT assessment were produced by National Grid for the ten shortlisted options and sensitivity cases based on material quantities and other outputs of the engineering study by [redacted]. To allow lessons learnt from previous compressor projects on the NTS and to ensure consistency across estimates for MCPD investments and for consistency with other RIIO-T2 submissions National Grid cost data was applied. This cost data includes: unit costs for asset health scope as agreed in RIIO-T2 final

determinations; compressor equipment cost; material prices; labour rates; productivity factors and estimating factors which is detailed in the Cost Estimate section of the Final Option Selection Report.

A ±50% estimate was produced by [redacted] for retrofit and new build options prior to shortlisting. These costs were originally developed to support option shortlisting but it was agreed that no option could be shortlisted based on CAPEX only. These estimates were therefore discounted.

Following refinement of engineering and cost estimating, ±30% cost estimates were produced. However, these estimates were not aligned to the final option shortlist and were superceded by National Grid produced estimates described above.

10 Schedule for Options

[redacted] developed programmes for Avon DLE, Restricted Avon (CSRP) and new gas turbine driven compressors which are included in their "FEED Report". Although potentially achievable with an aggressive delivery strategy the level of risk associated with the programmes presented by [redacted] is not considered acceptable at this stage.

A summary of the milestones associated with the schedules provided by [redacted] is provided in Table 12 along with notes and key risks. The schedules developed by [redacted] also did not align with the final option shortlist and they were therefore not referenced as part of the option selection process.

Table 12 - Milestones per [redacted] Schedules

Milestone	Restricted Avon	Avon DLE	New GT	Notes / Risks
FEED Contract Award	Feb 23	Feb 23	Feb 23	Aligns to confirmation of selected option from Ofgem. Tendering and scope development would need to take place during re-opener period prior to Feb 2023
EPC Contract Award	Jul 23	Aug 23	Aug 23	Insufficient time allowed for EPC tender following FEED
Construction Start	Jul 24	Oct 23	Jul 24	Retrofit option schedule will be driven in large part by asset health scope, notably the unit control system replacement. It is therefore anticipated that the construction start date and overall delivery will be similar for retrofit options contrary to the programme presented by [redacted].

Milestone	Restricted Avon	Avon DLE	New GT	Notes / Risks
Operational Acceptance	May 25	Jul 25	Nov 25	Given the scope and based on previous experience c.12 months construction and commissioning is insufficient for new build options. For retrofit options given the extent of brownfield scope the construction will need to be delivered over multiple outage windows
Project Completion	Jun 25	Jul 25	Dec 25	Insufficient time allowed for production of as built documentation and project closure.

The schedules produced by [redacted] were discounted and superceded by level 2 programmes produced by National Grid for each shortlisted option as summarised in section 8.4 of the Final Option Selection Report. These schedules were developed based on an assumed standard EPC delivery strategy and incorporate lessons learnt from previous compressor projects.

The purpose of the schedules produced at this stage is to demonstrate the feasibility of the assumed delivery approach for each option in advance of the 2030 MCPD deadline and to highlight any significant schedule related risks which are captured in the Project Risk Register in appendix G of the Final Option Selection Report. The schedules have also been used to develop spend profiles for each option which are used in the CBA. There are no other elements of the cost estimates that rely on schedule input at this stage.

During FEED a Level 3 schedule for the selected option will be developed alongside the development of an appropriate delivery strategy. The schedule development will include an optimisation process to identify efficiencies across the whole MCPD programme as well as opportunities to bundle scope with other investments being delivered in the same timeframe.

11 Formal Process Safety Assessment

11.1 General

HAZID and Layout Reviews have been carried out as noted in the “FEED Report”. Were appropriate the output of these studies has been used in the option selection process. Actions and specific areas of concern have been highlighted for further review following confirmation of a single selected option.

11.2 Site Location and Layout Review

National Grid undertook a GIS based site location review in February 2020 to identify suitable areas for new units. This study showed that installation of new units within the existing site footprint would not be possible without deviation from required safety separation distances

specified in T/SP/G/37 and/or relocation of existing equipment. Greenfield locations were also reviewed and an area of land within the current land ownership boundary to the south of the site was identified as a suitable location.

After this initial screening exercise, [redacted] developed six layout options for further review consisting of options within the existing site boundary and utilising the area identified to the south of the site. Plant Layout drawings (20840-PI-XKY-000-0001-Sheets 1-6) and Piping layout drawings (20840-PEN-WO-00-DR-P-0000-S3-PO1-Sheets 1-6) for each option were developed by [redacted]. The layout options developed by [redacted] are summarised in Table 14.

The six layout options were reviewed in a workshop lead by [redacted] and supported by National Grid with the aim of identifying non-compliances, risks and opportunities associated with each option. The carbon impact and biodiversity net gain assessment for each layout were also reviewed by [redacted] as outlined in the Environmental and Sustainability report (20840-EN-RPT-000-0005).

Table 13 - Layout Options

	A	B	C	D1	D2	
Ref.[1]	**Existing Berth A/B**	**Aftercooler area**	**Existing Control Building Area**	**"Greenfield" North of Feeder 23**	**"Greenfield" South of Feeder 23**	**Comment**
1	-	-	-	New Unit(s)		
2A	-	-	-	-	New Unit(s)	North/south compressor orientation Discounted
2B						East/west compressor orientation *(ref. layout sheet no.2)*
3	One Existing Retained	-	New Unit	New control Building		Applicable for new single unit options (7,8,9) only. Other layouts relevant to all options
4	-	New Unit(s)	New Unit(s)	New control Building		
5	New Unit(s)	-	-	-		
6	New Unit(s)	-	-	Control building relocated		

Note 1) Drawing reference is sheet number for the following drawings:
Plant Layout Drawing - 20840-PI-XKY-000-0001-Sheets 1-6
Piping Layout Drawing – 20840-PEN-WO-00-DR-P-0000-S3-PO1-Sheets 1-6

As indicated in Table 14, the six options developed by [redacted] involve the use of five potential locations for new compressor machinery trains. National Grid undertook a comparative assessment of these five locations using a traffic-light based system based on the outputs of the engineering study by [redacted]. A summary of this assessment is shown in Table 15.

Based on this assessment the greenfield area to the south of feeder 23 (option D2) was selected as the preferred layout for new build compressors. CAPEX estimates, CBA and BAT assessments were based on this selected layout.

The selected layout option allows most of the construction to be carried out in a separate CDM area away from operational plant thus reducing SIMOPS risk and limiting the impact on site operations. The new compressors will be a safe distance from occupied buildings, other plant and the rerouted fenceline therefore from a safety perspective this option is also preferred.

The cost is likely to be higher than other options due to additional tie-in length and cost associated with plot extension. However, some of this additional cost will be offset by the likely requirement for additional safety mitigations required due to non-compliance with T/SP/G/37 for other options, particularly options A and B.

This option requires the removal of habitat within the grass area and wooded area further south. However, there are no significant environmental concerns which cannot be managed by normal policies, procedures and specifications and overall biodiversity net gain of 10% is considered achievable. The nearest receptors are to the south of the site so locating plant in this area will require review during the next stage of the project to ensure suitable mitigations are implemented.

The layout will be further developed following confirmation/approval of the preferred investment option and opportunities for optimisation will be reviewed. At this stage a conservative approach has been applied to determining the layout and an opportunity is noted in the risk register (see Final Option Selection Report appendix G).

More detail on layout selection can be found in the Layout Review report attached to this document [ref. PAC1050295-01-7260-NGG-0039].

Table 14 - New Unit Location Assessment

Assessment Criteria	A Existing Berth A/B	B Aftercooler Area	C Existing Control Building Area	D1 "Greenfield" North of Feeder 23	D2 "Greenfield" South of Feeder 23
Project Development Cost					
Project Development Schedule					
Impact on Existing Operations					
Safety Assessment					
Environmental Impact					
Constructability					

Note 1) Refer to Table 14 for description of each location and correlation to [redacted] layout options considered in the G37 review and drawing references

11.3 HAZID

HAZID was undertaken in accordance with National Grid procedures. Relevant risks were captured on the project risk register and actions documented for follow up in the next phase of the project. As part of the lessons learnt process it was agreed that formal HAZID at this early stage was of limited value and alternative approaches should be considered for other similar projects in future.

Information included in section 12 of the [redacted] "FEED Summary Report" are superseded by the Environmental and Sustainability report (20840-EN-RPT-000-0005_rev0) produced by [redacted] which should be referenced alongside the notes below.

11.4 Carbon impact

Potential carbon impacts and opportunities associated with the investment and operational phases of the project are summarised below.

11.4.1 Investment phase

National Grid has set a target to achieve carbon neutral construction for all major projects by 2025/26, in accordance with the principles of PAS2080 - Carbon Management in Infrastructure. The option selection study used the Client's Carbon Interface Tool (CIT) and study-generated material take-offs (tonnes; m^3) to estimate the carbon impact associated with materials (defined in PAS2080 as Stages A1 – 3: material extraction, transport, manufacture) that would be used during the construction of the new GT options for the six originally identified layouts. The results of the assessment are presented in the [redacted] Environment and Sustainability Report and were used to inform the Option Location Assessment (PAC1050295-01-7260-NGG-0039). The following table provides a summary the results of the carbon impact assessment for materials.

Table 15 - Investment Carbon Impact

Layout Number	Description	No. of new GTs	Embodied Carbon (TCO_2e)	**Ranking** (low to high impact)	Comments
1	Greenfield North of feeder 23	1	1,371	3	Single GT reduces carbon contribution from all activities
		2	2,238	7	Increased civils and mechanical contributions from two GTs
2	Greenfield South of feeder 23	1	1,194	2	Single GT reduces carbon contribution from all activities
		2	1,924	5	Increased civils and mechanical contributions from two GTs
3	Brownfield in current control room location New control room in greenfield	1	2,044	6	New control room is the largest carbon contributor
4	Brownfield in current control room location and aftercooler location	2	2,600	8	New control room and mechanical (pipework) are largest carbon contributors
5	Existing Avon Berths	2	1,139	1	Assumed no impact from civils and reduced mechanical (pipework) contribution
6	Existing Avon Berths New control room in greenfield location south of feeder 23	2	1,919	4	Assumed no impact from GT civils, but impact increased as a result of new control room

The site location layout review (Section 11.2) selected Layout 2 as the preferred option. This was assessed to have the second highest potential investment carbon impact.

In broad terms, the higher the capital investment, the higher the carbon impact incurred through the material supply chain. During the ongoing design and procurement phases, there will be opportunities to reduce the carbon impact through:

- Local sourcing of generic materials/equipment to reduce impact from transportation.
- Design and selection of equipment to reduce process losses/fugitive emissions.
- Design/maintenance of equipment to prolong lifespan and avoid replacement.
- Selection of energy-efficient equipment.

The option selection study has provided an early indication of the embedded carbon impact of investing in two new GTs. This estimate will be refined as more data on the actual design becomes available and materials/equipment is selected. A lower construction carbon impact will reduce the level of carbon offset required to achieve carbon neutrality in construction.

11.4.2 Operational phase

During the operational phase, activities contributing to carbon impact will include:

- Direct on-site production through the consumption of fuel gas by the GTs.
- In-direct production through the generation of electricity used to power the VSD and ancillary equipment.
- Process gas released through venting.
- Seal gas leakage from compressors.
- Fugitive releases from pipework.
- Maintenance of equipment.

There are opportunities to reduce carbon impact through the use of equipment, its maintenance, repair, replacement and refurbishment. These opportunities can be realised through equipment selection/procurement, good site practices and energy sourcing.

The BAT assessment estimates carbon emissions associated with the direct fuel gas consumption and indirect electricity generation of different gas compression techniques. The embedded carbon impact is not determined in the BAT assessment. During the next phase (FEED), the contribution of carbon from seal gas losses will be included.

The BAT assessment (see Final Option Selection Report appendix H) determined that options that include new GTs have a lower operational carbon impact as they are more fuel efficient than the existing Avons. This operational carbon is also included as a carbon cost within the CBA.

11.5 Biodiversity Net Gain

The RIIO2 Environmental Action Plan contains a target to achieve 10% biodiversity net gain (BNG) on new construction projects. This is consistent with the provisions in the Environment Act 2021 which will require new developments permitted under the Town and Country Planning Act and Nationally Significant Infrastructure Projects in England to demonstrate a 10% increase in biodiversity. The losses and gains associated with a development must be measured in 'biodiversity units' (i.e., a measure of the value of habitats) using a recognised metric. The Natural England Biodiversity Metric 3.0 is currently considered the most likely tool that will be used to underpin the net gain requirement in large projects.

[redacted] undertook a BNG assessment on the proposed six initial layout options, estimating likely landtake and habitat types in each area, informed by a Preliminary Ecological Assessment (October 2021) undertaken for the Wormington project. BNG calculations were made using the Natural England Biodiversity Metric 3.0. Key assumptions used in the assessment were:

- With the exception of layout 5 (brownfield within existing operational fenceline), a temporary construction laydown compound would be located south of the current operational fenceline in a greenfield area (1.062 ha). Although a temporary land use, it is included in the calculations because the habitat will be damaged.
- The greenfield area south of the current operation fenceline used for the construction laydown area and for new GTs is assumed to be neutral grassland in poor condition.
- There would be no damage to streams or hedgerows.
- It does not cover all ecological impacts of the development, e.g., it does not adequately cover protected species impacts, which requires further study at the next stage.

The following table presents the BNG inputs and results. This is conditional until more detailed design is available.

Table 16 - Biodiversity Net Gain Summary

Habitat Types		Layout					
** All units in hectares (ha) unless indicated*		1	2	3	4	5	6
Grassland Habitat	Area of Grassland Habitat Unit	1.062	1.062	1.062	1.062	N/A	1.062
	Area of Habitat Removed	1.062	1.062	1.062	1.062		1.062
	Area of Permanent Hardstanding - GTC	-0.118	-0.253	-0.156	-0.156		-0.140
	Area of Permanent Hardstanding Fence	-0.054	-0.362	-0.054	-0.054		-0.045
	Resultant Habitat Created after construction (Good Condition Other Neutral Grassland)	0.890	0.777	0.852	0.852		0.903
Woodland Habitat	Area of Woodland Habitat Unit	N/A	3.430	N/A	N/A		N/A
	Area of Habitat Removed		-0.660				
	Area of Permanent Hardstanding - Road		-0.110				
	Area of Permanent Hardstanding - Fence		-0.348				
	Resultant Habitat Created after construction (Good Condition Other Neutral Grassland)		0.514				
BNG Total On-Site Net % Change		17.59%	2.47%	12.57%	12.57%		19.31%
BNG Enhancement	Enhancement Woodland Area Enhanced, 2.77ha	N/A	20.49%	N/A	N/A		N/A
BNG Off-site Creation	Off-site Replacement of cropland with Broadleaved Woodland 2ha	N/A	13.26%	N/A	N/A		N/A

The results show that:

- With the exception of Layout 5, all layouts will cause loss of habitat as a result of the temporary construction area and creation of permanent hardstanding.
- Due to the poor condition of the greenfield neutral grassland, at least 10% BNG can be achieved for Layouts 1, 3, 4 and 6 through improving the condition of this grassland alone.
- The loss of woodland habitat caused by Layout 2 will require further improvement of habitats.
- Two options are presented to compensate for Layout 2 biodiversity loss and to provide 10% net gain:
    - enhance existing woodland in addition to improving the quality of existing grassland within the area under National Grid ownership at Wormington
    - undertake off-site mitigation of the net gain requirement, through the purchase of adjacent agricultural land and replace with broadleaf woodland.

The conclusions of the BNG assessment were summarised against the National Grid Net Gain Assessment Matrix, as follows.

Table 17 - Net Gain Assessment Matrix

Layout	Impact Score	Delivery Score	BNG Score	Summary
1	Med (3)	NG Land available (1)	3	Small area of permanent hardstanding created. Reinstatement of remaining land taken for construction works by higher value habitat would fulfil BNG.
2	Med (3)	Some NG / small offsite requirement (2)	6	Area taken for permanent hardstanding small, but area taken for separation distances requires removal of mature broadleaved woodland. Worst case is off-site replacement, but likely that on-site BNG can be delivered within NG land boundary.
3	Med (3)	NG Land available (1)	3	Small area of permanent hardstanding created. Reinstatement of remaining land taken for construction works by higher value habitat would fulfil BNG.
4	Med (3)	NG Land available (1)	3	Small area of permanent hardstanding created. Reinstatement of remaining land taken for construction works by higher value habitat would fulfil BNG.
5	Low (1)	NG Land available (1)	1	No BNG required. Works within boundary and do not require planning permission.
6	Med (3)	NG Land available (1)	3	Small area of permanent hardstanding created. Reinstatement of remaining land taken for construction works by higher value habitat would fulfil BNG.

Whilst these are project constraints, they are not insurmountable. The Environment and Sustainability Report sets out recommendations for the next stage of the project, to better define the impact and mitigation options.

The Western Gas Project will include a temporary construction area to the north of Wormington Compressor station. There may be an opportunity to use the same temporary construction laydown area as the Wormington MCPD Project which would reduce the overall biodiversity impact of the two projects. This will be investigated further during FEED.

11.6 Local planning considerations

Under Part 15, Power Related Development of the Town and Country Planning (General Permitted Development) (England) Order 2015, development is not considered permitted development if it concerns buildings/plant that:

- Exceed 15 metres in height.
- The design/external appearance would be materially affected.

Depending on their scope, brownfield options may be considered permitted development, for example CSRP or Avon DLE techniques, since they will take place within the existing permitted boundary and would not materially change the external appearance of the existing GTs. The Avon SCR technique most likely will require an increased stack height, for which planning permission will be required.

All the layout options that extend beyond the current permitted boundary (i.e., the current operational fenceline) will require planning permission. This will include layouts that involve locating either new GTs or relocated control building outside the current permitted boundary. The local planning authority will require environmental assessments to accompany the planning application documentation, in order to consider the impact of the development on the local environment and sensitive receptors. The preferred Layout 2 would result in a GT being closer in proximity to dwellings, therefore it will be important to understand and to mitigate any concerns associated with noise and visual impact.

12 CDM

Requirements of the CDM regulations will be reviewed once an option has been selected and appropriate project specific management processes put in place based on appropriate National Grid policies, procedures and specifications.

13 Risk Registers

Technical and CDM risks registers were used during the engineering study undertaken by [redacted] to capture specific risks identified during the formal process safety assessments including HAZID and layout review. These detailed registers will be developed further following option selection.

Following completion of the engineering study and to support the option selection process National Grid developed a Project Risk Register which captures the full range of risks associated with each option. This risk register can be found in appendix G of the Final Option Selection Report. A semi-quantitative methodology was applied with the following objectives:

- Coherently identify and address key uncertainties present in the current design/project plan across the scope of the proposed modifications and project boundaries;
- Assess and quantify the risk for each option;
- Ascertain a view on key project risks that require active onwards risk management;
- Identify the spread of risk across different project parameters (e.g., CAPEX, OPEX, schedule, availability) and where significant degrees of risk manifest;
- Identify key risks which may justify modification of the options/design to mitigate.

To structure the risk assessment process the 10 compliance options were split into six option blocks. A summary of the total risk magnitude per option block is shown in Figure 2. These results are used as an indicative comparison of the options only as they are based on indicative risk impact ranges and probabilities.

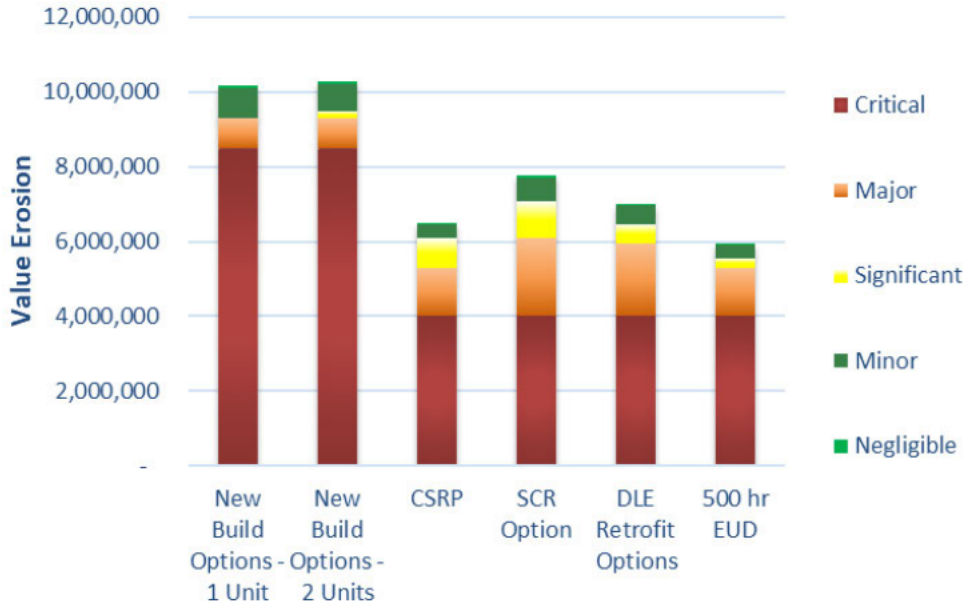

Figure 2 - Risk Magnitude by Option Block

New unit options carry the highest risk magnitude largely due to the larger scope and cost of these options. Much of the potential value erosion are associated with risk of CAPEX increase or schedule delay with lower risk associated with OPEX, outage and availability loss. Therefore, onward risk management should focus on cost and schedule factors.

14 Conclusions and Recommendations

14.1 Conclusions

The Engineering Study by [redacted] provided engineering basis to allow CAPEX estimates to be developed and option selection to be confirmed by National Grid supported by CBA and BAT assessment. This assessment was conducted on the options summarised in Table 19 (below) which includes options identified by [redacted] as well as a limited number of additional options identified following preliminary CBA.

[redacted] correctly note that some options cannot achieve the required duty in some cases. However, rather than discount these options they have been included in the CBA and BAT assessment with any shortfall in capability translated into a cost associated with the potential exposure to constraint costs.

To simplify option selection a single layout option (greenfield area to the south of feeder 23) has been assumed for all new unit options and this decision is captured in PAC1050295-01-7260-NGG-0039.

Table 18 - Shortlist Options

Option	Description	Unit A	Unit B	Unit C	Unit D *(Future)*	Unit E *(Future)*
1	Counterfactual	500Hr EUD	500Hr EUD	No Change	-	-
2	2 x CSRP	CSRP Retrofit	CSRP Retrofit	No Change	-	-
3	2 x SCR	SCR Retrofit	SCR Retrofit	Compressor Re-wheel	-	-
4	DLE + 500	1533 DLE Retrofit	500Hr EUD	No Change	-	-
5	2 x 1533 DLE	1533 DLE Retrofit	1533 DLE Retrofit	No Change	-	-
6	2 x 1535 DLE	1535 DLE Retrofit	1535 DLE Retrofit	Compressor Re-wheel	-	-
7	New GT + 500	500Hr EUD	Decommission[1]	Compressor Re-wheel	New GT	-
8	New GT + CSRP	CSRP Retrofit	Decommission[1]	Compressor Re-wheel	New GT	-
9	New GT + DLE	1533 DLE Retrofit	Decommission[1]	Compressor Re-wheel	New GT	-
10[2]	2 x New GT	Decommission[1]	Decommission[1]	Compressor Re-wheel	New GT	New GT

Note 1) Decision on decommissioning will be subject to an assessment on network capability after operational acceptance of the new units. Costs for decommissioning have been included in the CBA to ensure a consistent basis for all options

14.2 Recommendations

[redacted] recommended in the conclusion of the "FEED Report" that full consideration be given to asset health costs and associated risks due to the age of much of the equipment. [redacted] also suggest that planned asset health investment in RIIO-T2 may be avoidable for options that do not require existing Avon's to be retained. Detail of how initial and ongoing asset health investment has been accounted for is detailed in appendix E of the Final Option Selection Report.

[redacted] recommend that a holistic study of the gas transmission network is undertaken with a focus on options such as line-packing and supply-demand balancing as a route for reducing compression capability requirements at Wormington. These options are considered alongside other commercial "rules and tools" considering exposure to potential constraint costs as part of the Cost Benefit Analysis (CBA).

15 References

Document Ref.	Document Title	Author
20840-EN-RPT-000-0006	FEED Report	[redacted]
PAC1050295-01-7260-NGG-0039	Option Location Assessment	National Grid
PAC1050295-01-7260-NGG-0036	Execution Programmes	National Grid
PAC1050295-01-7260-NGG-0042	Cost Estimate Report	National Grid
PAC1050295-01-7260-NGG-0043	Risk Report	National Grid
PAC1050295-01-7260-NGG-024	Project Risk Register	National Grid