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Wormington Compressor Station
MCPD FEED Feasibility Project

Document Title: Risk Report

Document Number: PAC1050295-01-7260-NGG-0043

Revision: 02

Date: 15/08/2022

DOCUMENT HISTORY

Rev	Date	Description	Author	Checked	Approved
01	21/07/2022	First Issue	HR	AR	
02	15/08/2022	Issued for FOSR	HR	AR	ND

HOLDS

Hold	Date	Description

CONTENTS

1 Executive Summary

Table 1 describes the specific shortlist of options assessed by National Grid in the final option selection process supported by CBA and BAT assessment. More detail on the option shortlist and option selection process undertaken by National Grid can be found in the Formal Option Selection Report.

Table 1 - Shortlist Options

Option	Description	Unit A	Unit B	Unit C	Unit D	Unit E
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 (Greenfield)	/
8	New GT + CSRP	CSRP Retrofit	Decommission	Compressor Re-wheel	New GT (Greenfield)	/
9	New GT + DLE	1535 DLE Retrofit	Decommission	Compressor Re-wheel	New GT (Greenfield)	/
10	2 x New GT	Decommission	Decommission	Compressor Re-wheel	New GT (Greenfield)	New GT (Greenfield)

To allow efficient assessment of risks options have been categorised into the following option blocks:

Table 2 - Option Blocks

New Build Options - 1 Unit	New units to be installed on area of National Grid owned land to the south of the existing plot and south of feeder 23
New Build Options - 2 Units	
CSRP	Control System Restricted Performance
SCR Option	Vertical SCR arrangement to be installed on existing Avon(s)
DLE Retrofit Options	Upgrade of existing Avon to replace combustion system with Dry Low Emissions system
500 hr EUD	Emergency Use Derogation of Avon restricting operation to 500 hours per year

Risks have been identified and assessed using a semi-quantitative method 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.

A summary of the total risk magnitude per option block is shown in Figure 1. These results should be used as an indicative comparison of the options only as they are based on indicative risk impact ranges and probabilities.

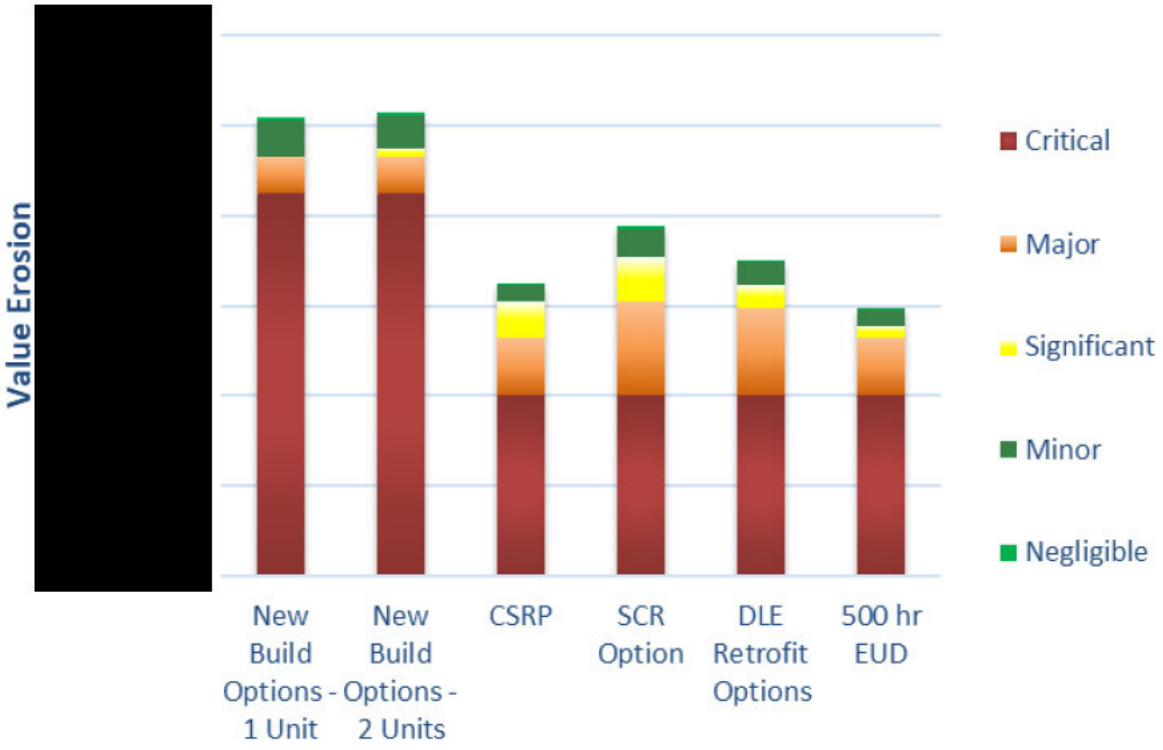

Figure 1 - Risk Magnitude

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.

2 Abbreviations

Abbreviation	Definition
ALARP	As Low as Reasonably Practicable
BAT	Best Available Techniques
CAPEX	Capital Expenditure
CBA	Cost Benefit Analysis
CDM	Construction, Design and Management Regulations
CSRP	Control System Restricted Performance (also referred to as derated Avon, this is a compliance option whereby the performance of the Avon is restricted to ensure emissions are limited to within MCPD limits.
DLE	Dry Low Emissions
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
OPEX	Operating Expenditure
PDS	Process Duty Specification
QRA	Quantitative Risk Assessment
RAM	Reliability, Availability and Maintenance
SCR	Selective Catalytic Reduction

3 Introduction

3.1 General

3.2 Document Purpose

The objective of this document is to describe the risk assessment methodology applied to the Wormington MCPD options selection process and to provide an overview of the resulting risks including a comparison of the relative risk exposure of each option. The complete risk register is included for reference.

4 Risk Assessment Methodology

4.1 Objectives

Each shortlisted investment option identified as part of the option selection process is defined by a set of deterministic estimates covering: CAPEX; OPEX; schedule and availability. These estimates have been developed using a set of base data and assumptions and they are therefore affected by a number of uncertainties. These uncertainties include: data, project execution, commercial, political, operational and organisational uncertainty which may have a negative impact on project value (i.e. risk) or a positive impact (i.e. opportunity).

During the option selection phase a semi-quantitative risk assessment methodology is applied in order to:

- 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 risk for each option
- Identify the spread of risk across project parameters (eg. CAPEX, OPEX, schedule, availability) and where significant levels of risk manifest
- Identify unacceptable risks which may require either: discounting of an option; adjustment of the underlying deterministic estimates for an option including CAPEX; OPEX; schedule, availability estimates used in the cost benefit analysis and BAT assessment
- Identify key project risks that require immediate active onward management

4.2 Risk Identification

Risks have be identified for the following option blocks allowing efficient assessment of risks against the full range of shortlisted options.

Table 3 - Option Blocks

New Build Options - 1 Unit	New units to be installed on area of National Grid owned land to the south of the existing plot and south of feeder 23
New Build Options - 2 Units	
CSRP	Control System Restricted Performance
SCR Option	Vertical SCR arrangement to be installed on existing Avon(s)
DLE Retrofit Options	Upgrade of existing Avon to replace combustion system with Dry Low Emissions system
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To provide a structure to the risk identification process risks were assessed for the following categories:

- Compressors and compressor modifications
- Supporting utilities and modifications
- Other offsites

4.3 Risk Quantification

Uncertainties have been identified on a risk register through a systematic review in a workshop environment focussing on the following categories:

- compressors;
- supporting utilities;
- other offsites, and
- commercial, political and organisational uncertainty.

The probability of occurrence was estimated from a range as shown in Table 2.

Table 4 - Probability Range

Very Low	Low	Medium	High	Very High
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

The potential impact was then categorised as one of the following:

- CAPEX
- OPEX
- Schedule
- Availability
- On off Outage

Based on the above categorisation the estimated impact was selected from Table 4. To allow comparison of risk across various categories an associated loss of revenue has been assigned to each category.

Table 5 - Impact Range

	Very Low	Low	Medium	High	Very High
CAPEX	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
OPEX	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Schedule	<0.5 months	0.5-1.5 months	1.5 to 5 months	5-15 months	>15 months
Availability	<1 day per year	1-3 days per year	4-12 days per year	13-36 days per year	>36 days per year
One off Outage	<1 week	1-5 weeks	5 weeks to 4 months	4-11 months	>11 months
Loss of Revenue	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Each risk was then quantified as an expected value erosion based on the product of the probability and impact as shown in Table 6. The application of this value erosion figure allows direct comparison of risk across options. However, as noted in section 4.7 it should be used for comparative purposes only.

Table 6 - Value Erosion (£k)

Probability \ Impact	Very Low	Low	Medium	High	Very High
Very Low	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Low	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Medium	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
High	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Very High	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Based on the value erosion each risk was then categorised as either: negligible; minor; significant; major, or critical as shown in Table 7.

Table 7 - Risk Classification

	Very Low	Low	Medium	High	Very High
Very Low	*Negligible*	*Negligible*	*Negligible*	*Minor*	*Significant*
Low	*Negligible*	*Minor*	*Minor*	*Significant*	*Major*
Medium	*Negligible*	*Minor*	*Significant*	*Major*	*Critical*
High	*Minor*	*Significant*	*Major*	*Critical*	*Critical*
Very High	*Minor*	*Significant*	*Major*	*Critical*	*Critical*

4.4 Populating The Risk Register

The risk register was initially populated by the Project Manager including risks identified in previous project phases and consideration of relevant risks from other similar compressor projects. This pre-populated risk register was then reviewed in a risk workshop with other relevant stakeholders within National Grid including representatives from the following teams:

- Construction
- Engineering
- Operations
- HSSE
- Investment Management
- Asset Strategy
- Project Controls (including Risk Management)
- System Operator

As noted in section 4.6, opportunities were identified and captured on the risk register for onward management, but they were not quantified.

All risks were captured on the risk register but retired risks or those that were considered as outside of the scope of the project were "greyed out" on the register and not quantified or included in the presentation of results.

4.5 Consideration of HSE Risks

HSE considerations may also be present as inherent uncertainties in the concept design and deterministic assessments, which would represent a significant impact on the expected project economics if they materialised.

An example is delay to environmental approvals creating an overall project schedule delay. The risk assessment process therefore considers such high-level HSE considerations, and their associated impact on the expected deterministic estimates, as appropriate and relevant to the project specific development options and uncertainties. However, the business risk assessment will not consider HSE risks in detail, consider HSE specific impacts such as loss of life, reputational damage etc., and is not in any way intended to replace or combine essential HSE assessments (safety QRA/HAZID/ENVID/HAZOP etc.).

4.6 Opportunities

Many uncertainties may have an 'upside', which results in a positive impact on the project as opposed to a negative impact. There may also be various opportunities that the project team may choose to implement as the project progresses.

Theoretically, all upsides and opportunities identified can be quantified based on probability and impact, as per risks. For opportunities and upsides, this will lead to a positive impact on overall project value rather than a negative erosion. However, during a risk assessment process, the natural psychological bias is towards a more extensive/thorough consideration of risk (negative impacts and threats) than upside and opportunity (positive outcomes). Consequently, unless exhaustive efforts are undertaken to ensure that upsides and opportunities are afforded equal consideration alongside risk, the final results will potentially be skewed. Realising opportunities may also introduce new (unidentified) risks, which have not been fully explored under the concept development stage risk assessment.

It is therefore recommended that potential upsides and opportunities are documented as they arise during the risk assessment process and considered during subsequent concept definition on a qualitative basis. However, upsides and opportunities will not be quantitatively assessed in combination with the risks. Post-workshop, all opportunities captured during the risk assessment process can be reviewed and moved to a dedicated value engineering register as appropriate for further study and management.

4.7 Relationship to Absolute Economics

Risk assessment at the Concept Design Stage has a number of known limitations:

- A high level, expected value methodology has been utilised - probability distributions and interdependent relationships between risks are not taken into account, as would be considered under detailed Monte Carlo assessment;
- Indicative, pre-tax economic factors have been employed (aligned with open book economics) as opposed to absolute economic parameters.

As a consequence, the absolute value of the risks presented will not be fully aligned with absolute project economic values, and therefore have limited meaning from a pure economic value assessment perspective. However, the process undertaken enables the following:

- An equitable and appropriately scaled quantification of risk resulting from different uncertainties;
- An appropriate indication of the magnitude of risk resulting from each uncertainty;
- Identification of key risks and potential issues for further focus under onwards project stages.

5 Risk Register and Results

5.1 Risk Register

The full risk register upon which this report is based can be found in document reference PAC1050295-01-7260-NGG-0024_Revision 5.

5.2 Results Summary

Much of the 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.

The following summarises the **critical** risks that have been identified during the risk assessment process:

Coordination and Alignment with External Stakeholders – As part of the project milestones, coordination with external stakeholders is required (Ofgem etc.,). For the new Build options, there may be a potential delay in gaining alignment on a preferred option and as a result, schedule delay.

Coordination and Alignment with Internal Stakeholders – As part of the project milestones, coordination with internal stakeholders is required. For the Retrofit Options, there may be a potential delay in gaining alignment on a preferred option and as a result, schedule delay.

Network Outage Scheduling and Coordination – The planned network outage period for construction/ commissioning activities (e.g., tie-ins) on the project is assumed to be 6 months (April – September). For the New Build Options, there is a greater risk of potential schedule delay (based on longer outage duration requirements for tie-ins) due to the allowed outage period being shorter than anticipated or at less optimum time for construction.

Geopolitical Issues – For all Options, there are country specific and worldwide geopolitical issues affecting equipment supply and workforce. However, for the New Build Options in particular, there is a greater (critical) risk identified with cost escalation based on potential scope growth of unknown additional brownfield modifications.

The following summarises the **major** risks that have been identified during the risk assessment process:

Refurbishment Scope for Avon Unit – For the Retrofit Options, a major risk was identified around the Avon Unit refurbishment scope. As this is a conceptual phase project, no in-depth condition assessment surveys have been carried out for the existing Avon Unit B. Therefore, there is uncertainty in the 're-life' scope modifications currently identified and whether all areas of concern have been captured. There is potential for 're-life' component scope growth and as a result, CAPEX increase. This risk can be mitigated by undertaking detailed condition assessments and facilities surveys prior to project execution.

New Technology Reliability – For the DLE Retrofit Option, the technology being implemented is considered new for National Grid. As a result, there are potential unknown operability issues (e.g., wider system dynamic issues) which may arise. If these operability issues / teething troubles are discovered during the initial operating period, this may result in poor availability. However, field trials are currently ongoing which may help to mitigate / alleviate these concerns.

Land Use / Extension – New build options are all greenfield and will involve extension of the site boundary. To facilitate this, permitting and consent is required, alongside environmental and commercial negotiations. This could result in potential scheduling delays with managing multiple stakeholders and gaining consent. The additional land ownership is within the National Grid land ownership boundary. If further detailed studies indicate a greater site boundary extension is required, then additional land acquisition will be required which has not been accounted for.

Planning and Permitting – SCR options involve significant modification to the exhaust stack including significant increase in stack height and notable visual impact. Permitting and consent is required. This could result in potential scheduling delays with managing multiple stakeholders and gaining consent.

Geopolitical Issues – For all Options, there are country specific and worldwide geopolitical issues affecting equipment supply and workforce. For the Retrofit Options in particular, a major risk has been identified (lower risk than for the New Build Options discussed above) regarding potential cost escalation.

All other risks are classified as either significant, minor or negligible. Significant risks are described in further detail under the following sections. All minor and negligible risks and identified opportunities are detailed in the risk register provided under Appendix A.

5.3 CAPEX Risks

The critical and major CAPEX risks identified are discussed above under Section 5.2. The following summarises the **significant** CAPEX risks that have been identified during the risk assessment process:

DLE Technology Cost – For the DLE Retrofit Options, the CAPEX estimate is based on quotation provided by Alba Technology for the 1533 option and budget price from Siemens for the 1535 option. No other technologies have been considered at this stage of the project. Therefore, in future phases, there is a potential to select an alternative supplier with an associated cost increase.

Capacity of Existing Instrument Air System – For the two-unit New Build Options and with no capacity assessment to date, there is a concern regarding sufficient capacity for additional compressors. The current project basis is to tie-in to the existing system, as a result, there is a potential for additional instrument air package requirements, resulting in increased CAPEX.

SCR Layout – Due to space constraints the SCR option is based on a vertical arrangement. The existing layout is not compliant with T/SP/G/37 separation distances for which there is a deviation in place following QRA. There is potential that additional SCR equipment will impact the QRA resulting in the feasibility of SCR being rejected and a requirement to revert to new units.

Failure To Meet Emissions Requirements – For the Retrofit Options in particular, any future changes to the pollution requirements or stricter requirements applied at the permitting stage could have a significant CAPEX implication. As a result, there may be a requirement for additional modifications/ replacement of units to meet these limits, resulting in increased CAPEX.

All other risks are classified as either minor and negligible and are detailed under the risk register provided in Appendix A along with any CAPEX improvement opportunities.

Environmental Permit Refusal – Potential that CSRP is not considered BAT by the EA resulting in rejection of permit request for this option and a requirement to revert to new unit option. National Grid is engaging with the EA on this option and will review this risk following feedback.

5.4 OPEX Risks

There weren't any primarily OPEX related risks identified under the scope of the assessment. Some risks may impact OPEX but in all cases this is not the primary impact. Generally risks which were identified to impact OPEX also impacted outage/availability resulting in potential network constraints which have a significantly larger impact than OPEX.

5.5 Schedule Risks

The critical and major schedule risks identified are discussed above under Section 5.2. No significant schedule related risks have been identified.

5.6 Outage / Availability Risk

There was a major risk associated with availability for DLE options which is discussed in section 5.2. One significant risk associated with one off outage is described below.

Compressor outage window for Avon unit refurbishment – For retrofit options asset health scope is required on the existing Avons in addition to the emissions reduction scope. For SCR options there is a significant risk that this work cannot be completed in the planned outage as well as the SCR scope which would result in the unit not being returned to service following outage. For other retrofit options the risk is lower as the emissions reduction related scope is much less than for SCR options.

6 References

Doc Ref	Title	Revision
PAC1050295-01-7260-NGG-0024	Project Risk Register	Rev 5