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REPORT

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Peterborough Compressor Station Risk Workshop Report

Prepared for: **National Grid PLC**

Prepared by: [redacted]

Project Title: **King's Lynn & Peterborough Compressor Station MCPD FEED Project**
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[redacted]

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ABBREVIATIONS

CAPEX	Capital Expenditure
C&I	Control and Instrumentation
CSRP	Control System Restricted Performance
DLE	Dry Low Emissions
HV	High Voltage
GT	Gas Turbine
MCPD	Medium Combustion Plant Directive
MM	Million
NTS	National Transmission System
OPEX	Operating Expenditure
RIIO	Revenue=Incentives+Innovation+Outputs
RR	Rolls-Royce
SCR	Selective Catalytic Reduction
UKPN	UK Power Networks
VSD	Variable Speed Drive

HOLDS LIST

HOLD	SECTION	DESCRIPTION

1.0 EXECUTIVE SUMMARY

The Peterborough Compressor Station Risk Workshop was held on Thursday 7th July 2022 via Teams. The purpose of this report is to document the details, methodology, results and outcome of the Peterborough Compressor Station Risk Workshop.

At the concept design stage, a semi-quantitative method was employed, which provides a risk-adjusted expected value of the project and the key uncertainties associated with the development options. The process aims to achieve the following:

- 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 of the options;
- 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 any key risks which may justify modification of the options or immediate design changes to mitigate.

The technical options considered during the Risk Workshop were as follows:

<u>New Build (Replacement of RR Avon) Options:</u>

a) New Gas Turbine (GT) Driven Compressor (single and or dual units). *Note, the Electric Driven VSD Compressor New Build Option was discarded during the Phase 1 Option Review Workshop [Ref. 3].*

<u>RR Avon Retrofit Options:</u>

a) Upgrade the combustion system on the existing RR Avon to a dry low emissions (DLE) system;

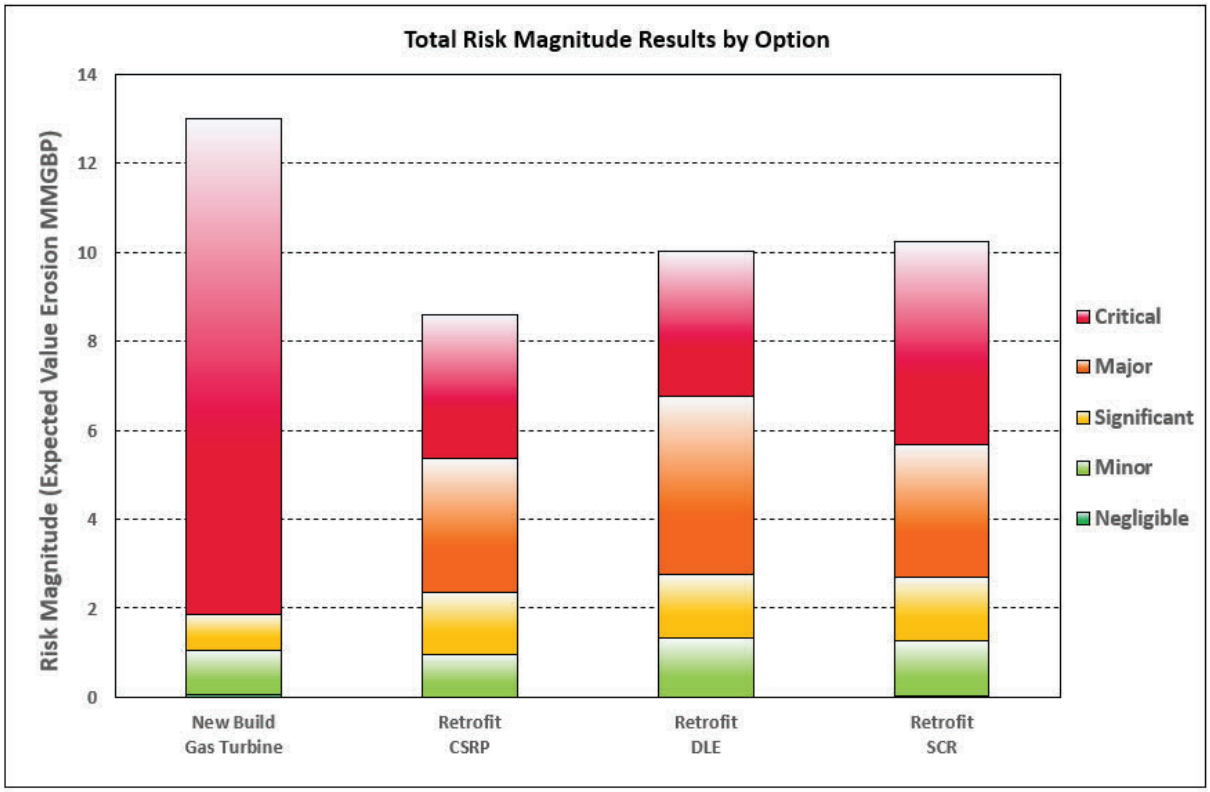
b) Use of Control System Restricted Performance (CSRP);

c) Installation of a Selective Catalytic Reduction (SCR) unit.

Figure 1-1 provides a summary of the total risk magnitude by option, as calculated from the sum of the individual risks identified in the risk register (provided in Appendix A). 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 1-1 shows that the new build option carries the highest risk profile. This is attributed to the risks concerning; planning permission, country specific and worldwide geopolitical issues affecting equipment and workforce and coordination and alignment with external stakeholders. For the Retrofit options, the Selective Catalytic Reduction (SCR) option carries the highest risk magnitude (although only marginally) due to the location of SCR facilities and potential equipment clash with ERP3 project installed drawpits. Note, if the SCR option is selected by the MCPD Project, the location of the SCR facilities needs to be confirmed following detailed site surveys including assessment of all existing underground pipework / channels etc. This is followed closely by the DLE Option which is considered a new technology for National Grid. Test bed trials are currently ongoing, which may help to mitigate future operability concerns with the DLE technology.

Figure 1-1 Total Risk Magnitude and Risk Breakdown of the Options



The majority of the risks identified concern CAPEX increase or schedule delay, with a smaller number of risks concerning production outage and availability issues. Therefore, it can be surmised at this stage of the project that cost and schedule increase is one of the primary areas of concern and onwards risk management focus.

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 phase gate milestones, coordination with external stakeholders is required (Ofgem etc.,). For the New Build Option, there may be a potential delay in gaining alignment on a preferred option and as a result, a schedule delay (initial engagement between Ofgem and National Grid indicate a strong preference from Ofgem for Retrofit Options).
- **Coordination and Alignment with Internal Stakeholders** – As part of the project phase gate 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, a schedule delay (currently the New Build Options are the preferred option for internal stakeholders).
- **Geopolitical Issues** – For all Options, there are country specific and worldwide geopolitical issues affecting equipment supply and workforce. However, for the New Build Option in particular, a critical risk has been identified regarding potential cost escalation.
- **Planning Applications** – For the New Build Option and SCR Retrofit Option, planning permission is required. A critical risk has been identified regarding extension to

schedule due to planning consent taking longer than anticipated. This was an issue experienced on the ERP3 Project.

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 A. 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.
- **Re-Use of Existing Underground Production Piping** – For the Retrofit Options, a major risk was identified around the condition of the existing underground production piping. As this is a conceptual phase project, no in-depth underground piping survey has been carried out. Therefore, there is potential for more extensive damage/ lower integrity of pipework than currently expected (more of a concern for the Retrofit Options). There could be requirement to replace large sections of underground piping and as a result, CAPEX increase.
- **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, test bed trials are currently ongoing which may help to mitigate / alleviate these concerns.
- **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 regarding cost escalation based on potential scope growth of unknown additional brownfield modifications.

All other risks are classified as either **significant**, **minor** or **negligible** and are detailed in full (including identified opportunities) within the risk register provided under Appendix A.

The purpose of the risk register is to highlight differential risks between the options and thus allow the information to be used as part of selecting the preferred MCPD compliance option for Peterborough Compressor Station. Therefore, no further updates to the Risk Register will be made during this phase of the project.

It is recommended that at the beginning of the next phase, the risk register is filtered to show just the identified potential risks for the selected MCPD compliance option. Then, all relevant risks identified as critical, major or significant are subject to onwards risk management and development of risk action plans and appropriate mitigations under future phases of the project.

2.0 INTRODUCTION

2.1 General Background

The Medium Combustion Plant Directive (MCPD) requires that existing plant between 1 MW and 50 MW net thermal input must not exceed specified operational emission limit values or be taken out of service before 1 January 2030. This legislation impacts the Rolls Royce Avon driven compressor units on the gas National Transmission System (NTS) including units at King's Lynn and Peterborough Compressor Stations. Investment is required to ensure the capability, that the network requires, can be maintained beyond 1 January 2030. Investment may include various combinations of the following options and the investment must be assessed against network capability requirements predicted under various future energy scenarios to ensure the most cost-effective solution for end consumers, for operation till and beyond 2050.

- Upgrading non-compliant units to bring emissions within acceptable legislative limits;
- Replacement of non-compliant units with new low emissions compressor sets or compression drivers;
- Taking non-compliant units out of service;
- Restrict the performance of non-compliant units through control system restriction such that operational emissions are limited to within legislative limits;
- Limit the use of non-compliant units to a maximum of 500 hours per year under an emergency use derogation as defined in the MCPD legislation;
- Upgrading units to ensure available asset life is in compliance with National Grid requirements.

National Grid submitted a compressor emissions compliance strategy paper to Ofgem in 2019 within which compliance options for each site impacted by the incoming MCPD legislation were presented. Due to the uncertainty around the optimum solution for the Peterborough Compressor Station it was agreed that further review of options would be conducted with the optimum solution presented to Ofgem in a Final Options Selection Report. Agreement on the optimum solution would then allow the project to progress to the next phase of development prior to final funding allowances being agreed via an uncertainty mechanism under the RIIO regulatory framework.

2.2 Site Background

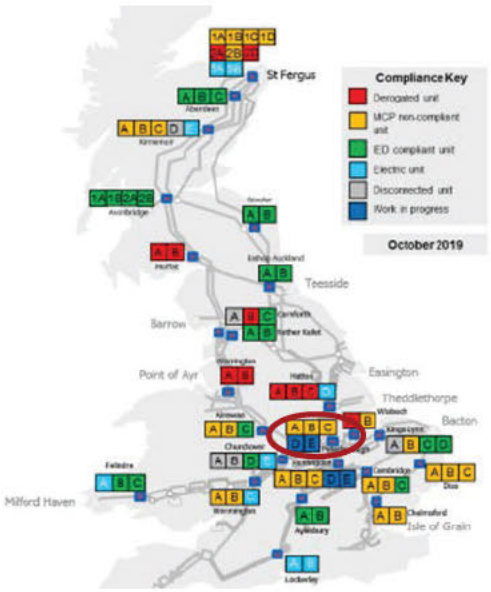
The Peterborough Compressor Station is located in the East of England and its location on the NTS is shown on the schematic below. A brief outline of the site is provided in the section below to put the project scope into context.

Figure 2-1 Peterborough Compressor Station

Peterborough

Unit A, B, C – RR Avon

Unit D, E – Solar Titan 130



2.3 Peterborough Compressor Station

The Peterborough Compression Station is used primarily for bulk transmission of gas to support demand and currently has:

- 3 off Rolls-Royce Avon gas driven compressors (A, B, C) existing that do not meet emissions limits;
- 2 off Solar Titan gas driven compressors (D, E) in process of being installed to become lead units;
- Part of ERP3 project due for commissioning Q4 2022. Other modifications also being undertaken;
- Installation of 3rd Solar Titan was originally planned: Limited Construction has been done.

A, B and C compressors do not comply with MCPD (Medium Combustion Plant Directive). They will be used to provide resilience after commissioning of Units D, and E but need to be replaced/modified by 2030.

2.4 MCPD Legislation Compliance Project Options

The technical options being considered to meet MCPD legislation at the existing Peterborough Compression Station are as follows:

RR Avon Retrofit Options:

a) Change out of engine of an existing Avon Unit to a Dry Low Emissions (DLE) unit;

b) Use of Control System Restricted Performance (CSRP);

c) Installation of a Selective Catalytic Reduction (SCR) unit.

New Build (Replacement of RR Avon) Options:

a) New Gas Turbine (GT) Driven Compressor;

b) New Electric Variable Speed Drive (VSD) Compressor.

Note, the Electric Driven VSD Compressor Option was discarded during the Phase 1 Option Review Workshop [Ref. 3].

2.5 Document Objectives

A Risk Workshop was held with the aim of identifying and assessing uncertainty and risk associated with each of the potential options for the Peterborough Compressor Station MCPD Project. The risk assessment results serve as input to onwards mitigation discussions and wider project risk management activities.

The objective of this report is to document the details, methodology, results and outcome of the Peterborough Compressor Station Technical Risk Workshop.

2.6 Document Structure

This document is structured as follows:

Section 1.0 Executive Summary.

Section 2.0 Introduction.

Section 3.0 Workshop Details.

Section 4.0 Workshop Objectives and Methodology.

Section 5.0 Risk Register and Results.

3.0 WORKSHOP DETAILS

3.1 Workshop Date and Location

The Peterborough Compressor Station Risk Workshop was held on Thursday 7th July 2022 via Teams.

3.2 Workshop Agenda and Presentation

The agenda observed during the workshop is as follows:

13:00	Kick Off, Take 5 and Introductions	[redacted]
13.10	Workshop Objectives and Methodology	[redacted]
13.30	Options Descriptions / Scope	[redacted]
13:45	Risk Identification – Compressors and Modifications	All
14.30	***BREAK***	
14.45	Risk Identification – Compressors and Modifications	All
15.00	Risk Identification – Supporting Utilities and Modifications	All
15.20	Risk Identification – Other Offsites Modifications	All
15.40	Risk Identification – HSSE, Commercial, Political, Organisational, Other	All
16:00	***WRAP UP AND CLOSE***	

The workshop presentation is provided in Appendix B.

3.3 Workshop Attendees

The workshop attendees are provided under Table 3-1.

Table 3-1 Workshop Attendees

Name	Company	Project Role
[redacted]	National Grid	Project Director
		Project Manager
		Design Coordinator
		Senior Network Analyst
		Technical Safety Lead
		Rotating Equipment Lead
		Economics Officer
		Environmental Lead
		Operations Team Lead
		Operations Supervisor (Peterborough)
		Construction Manager (Peterborough)
	[redacted]	Project Manager
		Design Manager
		Piping and Layouts Lead

4.0 WORKSHOP OBJECTIVES AND METHODOLOGY

The approach and methodology employed for the Peterborough Compressor Station MCPD Project Risk Assessment is summarised under the following sections.

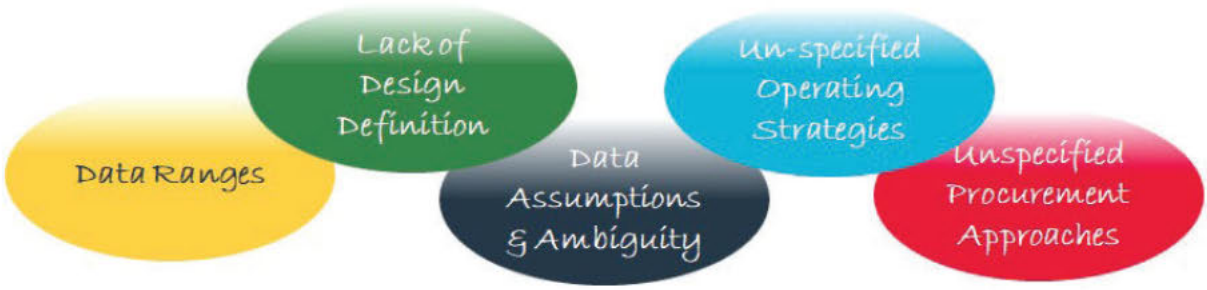
4.1 Methodology Overview and Objectives

Deterministic estimates generated during the Concept Design Stage typically form the initial basis for assessing the value and economic viability of the development options and determining an overview of project costs.

Figure 4-1 Example Deterministic Estimates

However, deterministic estimates and financial metrics are not the only data that should be used to assess project value. At any point in the asset life cycle, there will be a significant number of uncertainties, including data uncertainties, project execution uncertainties (e.g., installation issues, procurement approach) as well as other uncertainties, such as commercial, operational, political and organisational aspects.

Figure 4-2 Typical Project Uncertainties



These uncertainties result in a possibility that the deterministic project value is impacted:

- A potentially negative impact is described as a **risk** or **threat**;
- A potentially positive impact is described as an **upside** or **opportunity**.

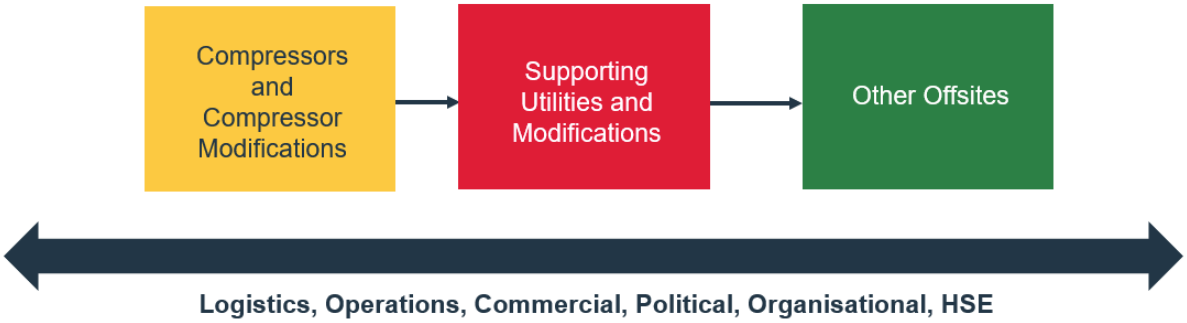
At the Concept Design Stage, it is recommended that a semi-quantitative method is employed, which provides a risk-adjusted expected value of the project and the key uncertainties associated with each development option. The process aims to achieve the following:

- 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 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 any key risks which may justify modification of the options or immediate design changes to mitigate.

4.2 Risk Assessment Structure

The Concept Design Stage risk assessment methodology utilises a structured brainstorming approach. Under this methodology, the development options are broken down into a logical progression of blocks, from start to finish, to enable a structured brainstorming of risks. Each block is then discussed systematically, to ensure that no key uncertainties or risks are missed and all potentially differentiating uncertainties between options are identified. The flow of system blocks used for the risk assessment is shown in Figure 4-3.

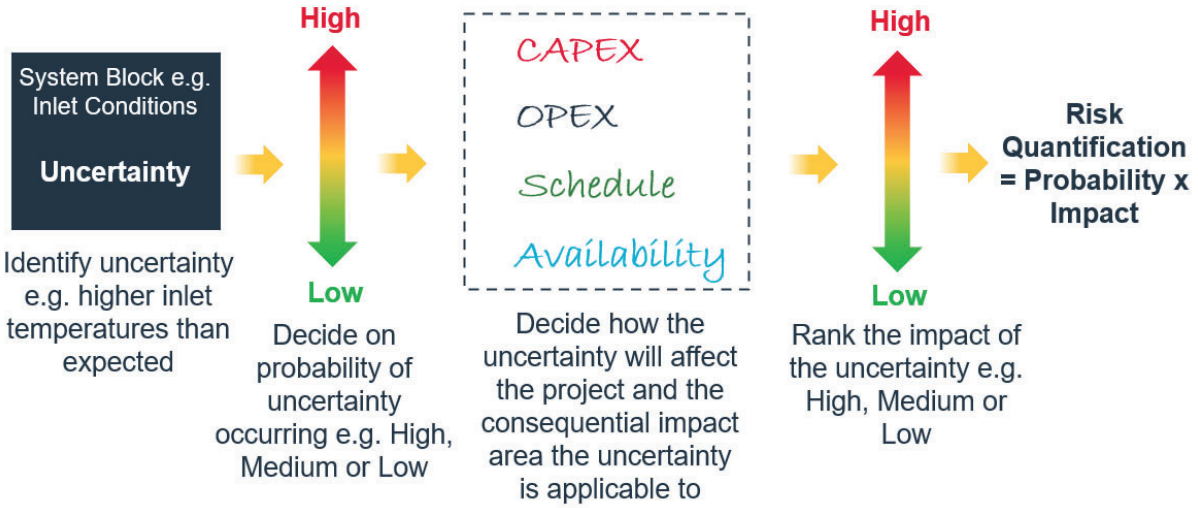
Figure 4-3 System Block Breakdown



4.3 Risk Quantification

Within each system block, a wide range of uncertainties will be identified which are relevant to that part of the system/development options. For each of the uncertainties identified, the risk presented to the project will be described and quantified using the methodology shown under Figure 4-4.

Figure 4-4 Risk Quantification Process



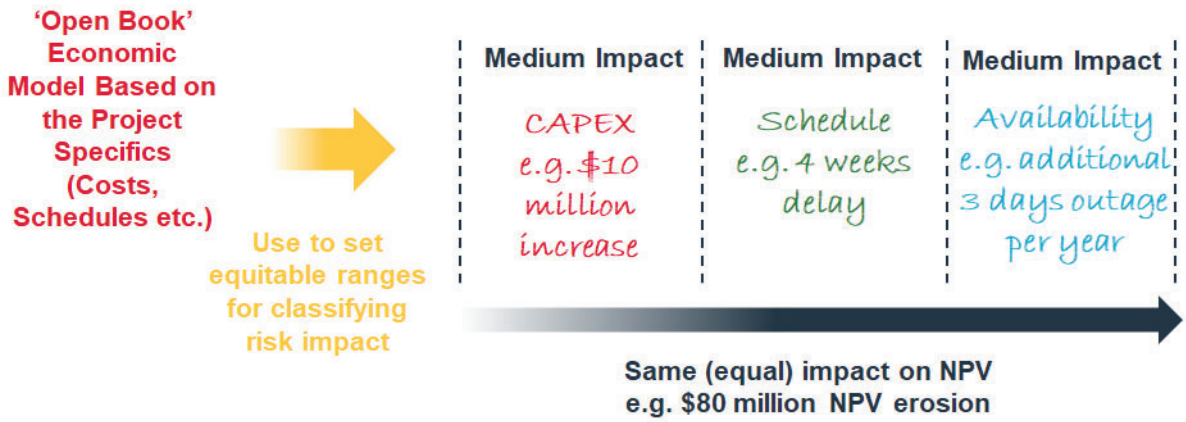
This process identifies a wide variety of risks, spread across the various impact areas (CAPEX, OPEX, availability, schedule etc.). This consequently presents the challenge of ranking the different types of risk on an equitable basis e.g., ensuring that a medium schedule impact provides the same overall (total) risk contribution as a medium CAPEX impact when summing risks and comparing options. To address this issue, NPV is used as a common denominator, as illustrated under Figure 4-5.

Figure 4-5 NPV as a Common Denominator

NPV is common denominator between variables

To set equitable ranges for impact variables (CAPEX, OPEX, schedule, availability etc.), an 'open book' pre-tax economic model is employed to determine the degree of variation in CAPEX, OPEX, schedule and availability which result in an equal impact on NPV, as illustrated under Figure 4-6.

Figure 4-6 Setting Equitable Impact Ranges



The risk ranges developed specifically for this project are given under Figure 4-7 and Figure 4-8.

Figure 4-7 Probability Risk Ranges

Probability				
V. Low	Low	Med	High	V.High
<2%	2% - 10%	10% - 30%	30% -70%	>70%

Figure 4-8 Impact Risk Ranges

	Impact				
	V. Low	Low	Med	High	V.High
CAPEX	<£250k	£250k - £1 MM	£1MM - £3 MM	£3MM - £10 MM	>£10MM
OPEX	<$30k/yr	30 - 130 £k/yr	130 - 450 £k/yr	0.45 - 1.3 £MM/yr	>$1.3MM/yr
Execution Schedule	<2 weeks	2 - 6 weeks	6weeks - 5 months	5 - 15 months	>15months
Availability Loss	<1 day/yr	1-3 days/yr	3-12 days/yr	12-36 days/yr	>36 days/yr
One-Off Production Outage	<1 weeks	1 - 5 weeks	5weeks - 4 months	4 - 11 months	>11months
Loss of Revenue	<£150k	£150k - £0.6 MM	£0.6MM - £2 MM	£2MM - £6 MM	>£6MM

Figure 4-9 shows the final risk quantification, which results from combining the probability with the impact to provide the expected value erosion. Note that the mid-point of each range bracket is used to calculate the expected value erosion, except for the high bracket, where 1.5 times the upper limit is employed. If a risk is identified which lies significantly outside of the impact ranges i.e., is very high, this will be quantified separately offline after the workshop as an exceptional case.

Figure 4-9 Expected Value Erosion Risk Quantification

			Composite Risk Index (P x I) in £k				
			V. Low	Low	Med	High	V.High
			<£150k	£150k - £0.6 MM	£0.6MM - £2 MM	£2MM - £6 MM	>£6MM
Probability	V. Low	<2%	1	4	13	40	120
	Low	2% - 10%	5	25	80	240	720
	Med	10% - 30%	15	80	260	800	2400
	High	30% -70%	40	190	650	2000	6000
	V.High	>70%	65	320	1110	3400	10000

To aid the workshop discussions and visualisation of the risk quantification during the workshop, the risk quantification values do not have to be shown on the workshop register, and instead a risk classification will be shown instead when the expected value quantifications are calculated e.g., **Medium Probability** x **High Impact** = **Major Risk**. The risk classification system is shown under Figure 4-10. Further calculation of the expected value erosion for each risk is then managed post-workshop.

Figure 4-10 Risk Quantification Signifiers

			Composite Risk Index (P x I) in £k				
			V. Low	Low	Med	High	V.High
			<£150k	£150k - £0.6 MM	£0.6MM - £2 MM	£2MM - £6 MM	>£6MM
Probability	V. Low	<2%	Negligible	Negligible	Negligible	Minor	Significant
	Low	2% - 10%	Negligible	Minor	Minor	Significant	Major
	Med	10% - 30%	Negligible	Minor	Significant	Major	Critical
	High	30% -70%	Minor	Significant	Major	Critical	Critical
	V.High	>70%	Minor	Significant	Major	Critical	Critical

4.4 Populating the Risk Register

The risk register is developed by working through the system blocks and identifying uncertainties that are applicable to each part of the development options. An example of the Risk Register is shown in Figure 4-11.

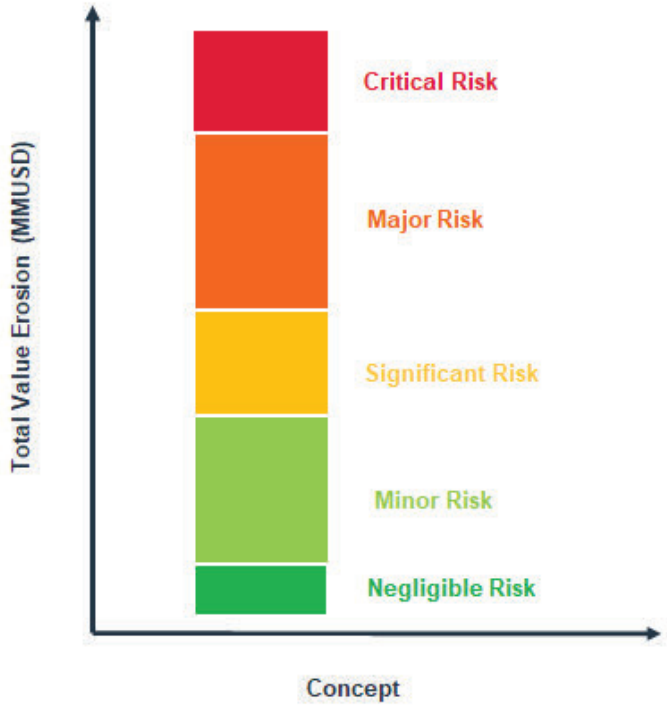
Figure 4-11 Example Risk Register

Type	No.	Uncertainty Area	Description & Possible Outcome	Key Impact Area	Opportunity (Y/N)	Risk Block	Risk Block Ranking			Comments/Mitigations
							Probability	Impact	Value Erosion	
Centralised Processing Facilities and Product Export										
CPF	1	Retrofit Riser Installation - SIMOPS	Production shutdown is required anytime an installation vessel is in close proximity to the facility. Risk that increased production shutdown will be required when vessels are in close proximity with facility.	Production Outage	N	1 - 2 New Risers at Existing Facility	H	L	Significant	
						3 New Risers at Existing Facility	H	M	Major	
CPF	2	Temporary Winch Installation	Require temporary winch installation to enable retrofit riser and umbilical operations. Locations for winch installation not currently specified. Location appears to be obstructed. Risk that temporary winch installation may be more complex than currently anticipated.	CAPEX	N	Risers at Existing Facility	M	L	Minor	
CPF	3	Installation of New Production Pipework	Tie-in point provisions and routings have been made and modelled. However, no site survey work has been completed to date, and installation of pipework from the riser slots to the existing production system may be more complex than currently expected, resulting in an extended construction schedule. Construction activities involve the lifting and installation of numerous sections of large bore pipework and hot work	Production Outage	N	Risers at Existing Facility	H	M	Major	Current design is based on yard fabrication and needs more revision for onsite construction. This risk is recommended for review following site survey activities.
CPF	4	Post Weld Heat Treatment	Post weld heat treatment required for large diameter spools. Potential schedule extension to accommodate. Risk for all options.	Schedule	N	All Options	M	L	Minor	
CPF	5	MEG System Installation	Base option is to install MEG system via deck extension. Complex work. Risk of increased schedule and production outage to install MEG system. Small risk of CAPEX increase for new MEG system installed at new facility.	Production Outage	N	MEG System at Existing Facility	H	L	Significant	Installation vessel required in close proximity with platform. High probability of production outage to allow this.
				CAPEX		MEG System at New Facility	L	L	Negligible	

4.5 Results Presentation

The risk results breakdown is presented in chart format, showing the contributing degree of different types of risk. Separate charts are produced for overall risk, CAPEX, OPEX, schedule and availability risk, if identified.

Figure 4-12 Example Results Breakdown



4.6 Consideration of HSE Risks

A number of HSE considerations may also be present as inherent uncertainties in the concept design and deterministic cost assessments, which would represent a significant impact on the expected project economics if they came to light.

An example is delay to environmental approvals creating an overall project schedule delay. The risk assessment process therefore takes into account 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.).

4.7 Consideration of Opportunities and Upsides

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 be a management decision that is not ultimately pursued, or may 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.

4.8 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.

4.9 Pre-Workshop, Workshop and Post-Workshop Activities

4.9.1 Pre-Workshop Activities

Prior to the risk workshop, a starter risk register was initiated and prepared by a risk specialist with input from the project team.

4.9.2 Workshop Activities

The workshop activities focused on the review of the draft risk register produced during the preliminary risk work. During the workshop, each risk identified on the draft register was reviewed in detail, the quantification assigned to the risk discussed and modified as appropriate. Any new risks identified during the workshop were also added to the risk register and further discussed and quantified.

Once the risks had been reviewed, the opportunities identified were also reviewed, thereby completing the risk register.

4.9.3 Post-Workshop Activities

Post-workshop, the following activities have been undertaken:

- The total expected value erosion for the development options has been calculated via summation of the individual risks. Results are ultimately presented on a chart;
- The finalised risk register has been developed post-workshop for review and comment;
- The workshop methodology, workshop discussions, results charts, risk analysis and finalised risk register have been fully documented under this dedicated workshop report.

5.0 RISK REGISTER AND RESULTS

5.1 Risk Register

The full risk register is provided under Appendix A.

5.2 Risk Results Summary

Figure 5-1 provides a summary of the total risk magnitude and breakdown of risks identified by Option, as calculated from the sum of the individual risks identified in the risk register (provided in Appendix A).

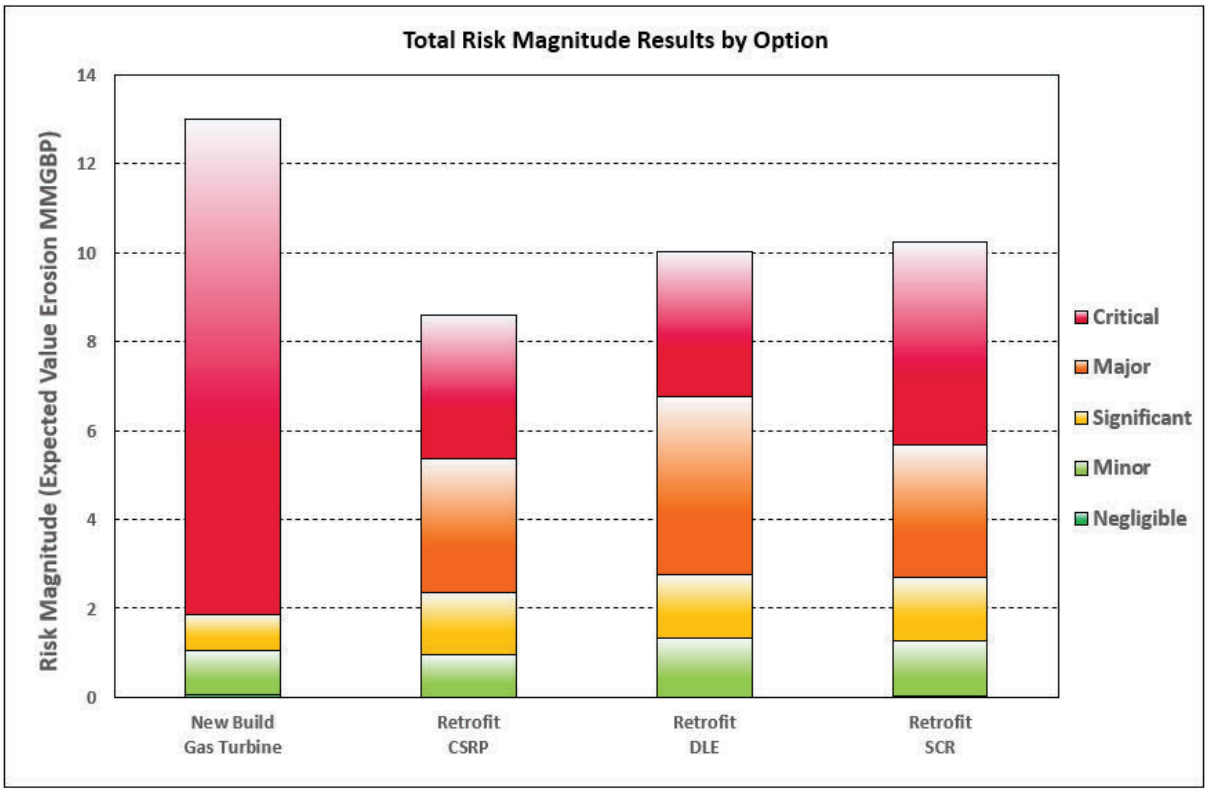


Figure 5-1 Total Risk Magnitude and Risk Breakdown Results by Option

The majority of the risks identified concern CAPEX increase or schedule delay, with a smaller number of risks concerning production outage and availability issues. Therefore, it can be surmised at this stage of the project that cost and schedule increase is one of the primary areas of concern and onwards risk management focus.

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 option, there may be a potential delay in gaining alignment on a preferred

option and as a result, schedule delay (initial engagement between Ofgem and National Grid indicate a strong preference from Ofgem for Retrofit Options).

- **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 (currently the New Build Options are the preferred option for internal stakeholders).
- **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, a critical risk has been identified regarding potential cost escalation.
- **Planning Applications** – For the New Build Option and SCR Retrofit Option, planning permission is required. A critical risk has been identified regarding extension to schedule due to planning consent taking longer than anticipated. This was an issue experienced on the ERP3 Project.

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

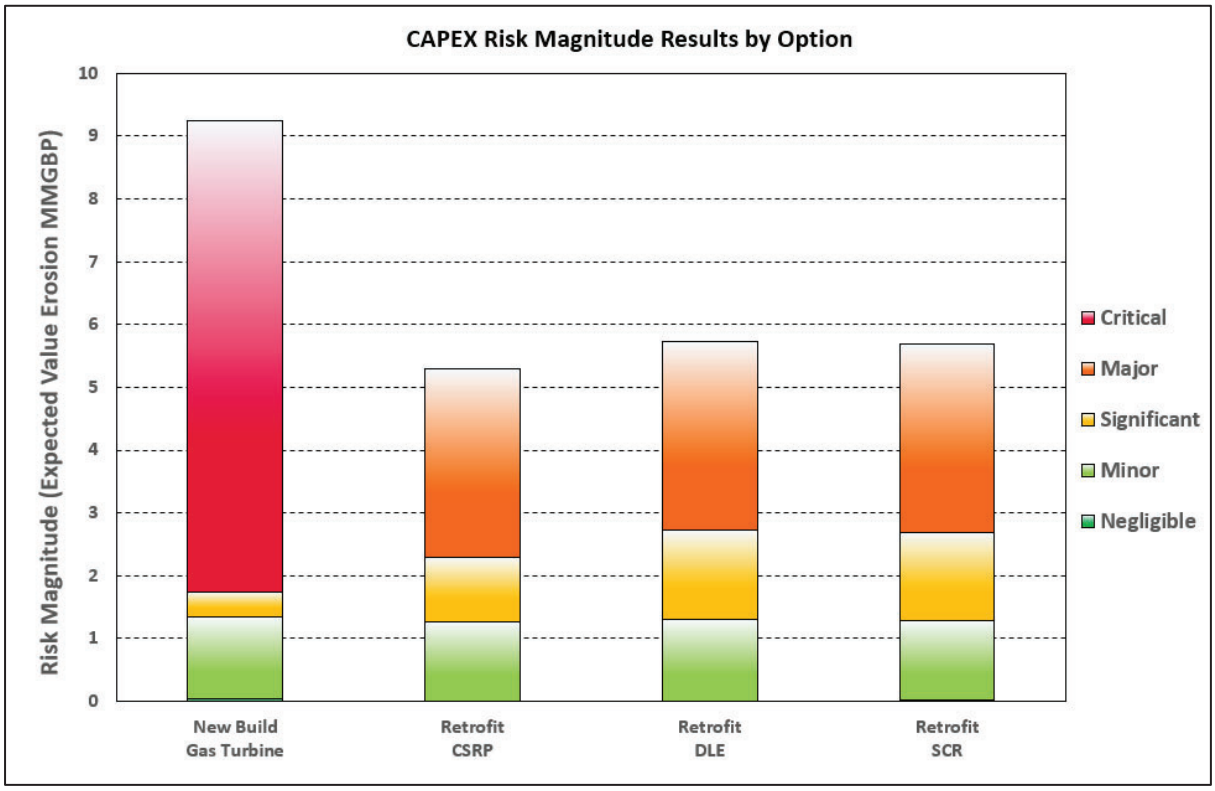
- **Refurbishment Scope for Avon Unit** – For the Retrofit Options, a major risk was identified around the Avon Unit refurbishment scope. As this is a conceptual phase project, no in-depth condition assessment surveys have been carried out for the existing Avon Unit A. Therefore, there is uncertainty 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.
- **Re-Use of Existing Underground Production Piping** – For the Retrofit Options, a major risk was identified around the condition of the existing underground production piping. As this is a conceptual phase project, no in-depth underground piping survey has been carried out. Therefore, there is potential for more extensive damage/ lower integrity of pipework than currently expected (more of a concern for the Retrofit Options). There could be requirement to replace large sections of underground piping and as a result, CAPEX increase.
- **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, test bed trials are currently ongoing which may help to mitigate / alleviate these concerns.
- **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 regarding cost escalation based on potential scope growth of unknown additional brownfield modifications.

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 Risk Results

Figure 5-2 provides a summary of the total combined CAPEX specific risk per Option which has been calculated from the sum of the individual risks identified in the risk register (provided in Appendix A).

Figure 5-2 CAPEX Risk Magnitude and Risk Breakdown



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:

- **Tie-in to Existing Underground Production Piping** – For the New Build Option, high level Navisworks model review has identified the potential for complications with the tie-in to / extension of the recycle line and the existing route of the compressor D & E discharge header. Existing project basis is that the common recycle line is to be re-routed under the discharge piping. There is the potential for more piping to require replacement than currently anticipated, resulting in associated cost increase.
- **DLE Technology Cost** – For the DLE Retrofit Option, a provisional cost estimate has been provided by [redacted] [Ref. 1]. 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 (i.e., Siemens Technology) with an associated cost increase.
- **Existing Compressor Vent Line (Blowdown Line)** – The existing Avon Unit A compressor blowdown vent route is not compliant with NG standards; HAZ/19 and IGEM/SR/23. Upgrade of the compressor seals from wet to dry gas will require controlled venting to prevent explosive decompression, increasing the scope associated with life extension of the unit and corresponding cost for the Retrofit Options.

- **SCR Equipment Clash** – The SCR Unit potentially clashes with drawpits installed around Avon Unit A as part of the ERP3 project, specifically local to the proposed SCR exhaust and tanker loading and storage bay locations. If required to avoid equipment clash there is the potential for scope growth associated with re-design of stack/ catalyst bed or schedule impact dependent on the demolition of Avon Units B and C to free up alternative space prior to installation. Either considered outcome would result in impact to CAPEX as well as schedule. Note, if the SCR option is selected by the MCPD Project, the location of the SCR facilities needs to be confirmed following detailed site surveys including assessment of all existing underground pipework / channels etc.,
- **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.
- **Asbestos Management** – For the Retrofit Options, there is potential for asbestos contamination in existing cabs, trenches and old buildings. There may be a requirement for increased decontamination of equipment, 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.

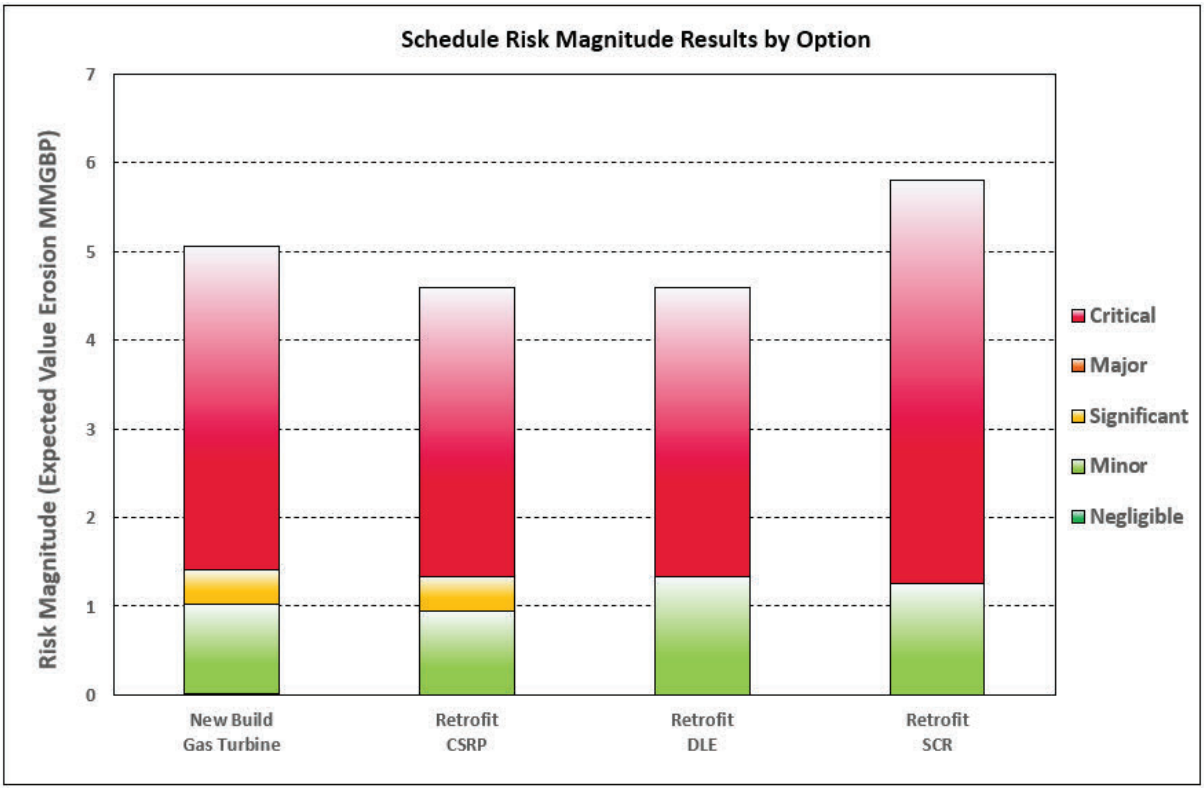
5.4 OPEX Risk Results

No critical, major or significant OPEX risks were identified under the scope of the assessment. All OPEX risks identified have been classified as either minor and negligible and are detailed under the risk register provided in Appendix A.

5.5 Schedule Risk Results

Figure 5-3 provides a summary of the total combined schedule specific risk per Option which has been calculated from the sum of the individual risks identified in the risk register (provided in Appendix A).

Figure 5-3 Schedule Risk Magnitude and Risk Breakdown



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

- **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) [Ref. 2]. The planned outage is currently not confirmed and there is a risk that the allowed outage may be shorter than anticipated or at a less optimum time for construction, thus resulting in a schedule delay. Therefore, for the New Build Option, this has been ranked as a significant schedule risk.

Post Workshop Note

- **Environmental Permitting Approvals** – For the CSRP Option, a significant schedule risk was identified in regard to obtaining environmental permitting approvals. This is because the CSRP technology is currently unproven for emissions reduction and thus could result in a potential schedule delay.

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

5.6 Production Outage /Availability Risk Results

No critical or significant production outages / availability risks were identified. The major risk identified under this impact range is discussed in Section 5.2.

All other production outage / availability risks identified have been classified as either minor and negligible and are detailed under the risk register provided in Appendix A along with any schedule improvement opportunities.

6.0 REFERENCES

References	
Ref. 1	Peterborough Compressor Station Cost Estimate (Phase 2), doc. no. 203513C-002-RT-0301.
Ref. 2	Peterborough Compressor Station Level 2 Schedules (Phase 2), doc. no. 203513C-002-PLG-0301.
Ref. 3	Peterborough Compressor Station Option Review Report (Phase 1), doc. no. 203513C-002-RT-0503.

APPENDIX A RISK REGISTER

[redacted]

National Grid Peterborough Compression Station Risk Register

Type	No.	Uncertainty Area	Risk Description (Cause, Effect, Consequence)	Key Impact Area	Opportunity (Y/N)	Option Block	Risk Block Ranking			Other Comments
							Probability	Impact	Value Erosion	
Compressor Modifications										
CM	1	Refurbishment Scope for Avon Unit	**Cause:** Conceptual phase engineering to date. No in-depth condition assessment survey carried out for Avon Unit A. **Effect:** Uncertainty in the 're-life' scope modifications and whether all areas of concern have been captured. Potential for 're-life' component scope growth. **Consequence:** CAPEX increase.	CAPEX	N	Avon Unit Re-Use Options	H	M	Major	Includes destruct elements. Wet seal system is elderly. Uncertainty in scope division between 'asset health' and project scope. Some scope growth may be covered under asset health rather than project expenditure. No current survey of unit and accurate understanding of refurbishment scope. External part of cab has been refurbished previously (8 years ago).
CM	2	Production Outage Window for Avon Unit Refurbishment	**Cause:** Conceptual phase engineering to date. No in-depth condition assessment survey carried out for Avon Unit A. **Effect:** May not be possible to undertake work within planned production outage window. Additional shutdown required. Loss of production. **Consequence:** Production outage.	Production Outage	N	Avon Unit Re-Use Options	L	L	Minor	Avon A Unit is currently the preferred unit to run due to improved operational flexibility in comparison with the other compressors (Avon Units B and C). No fixed annual T&I to coordinate with - planned summer outage period. Work can be performed over two seasons. 6 month period available over the summer. Potential additional isolation considerations for continuing into winter period. Mitigation is full site survey and detailed construction planning/scheduling. Avon Units B + C available to support during mods to Avon A.
CM	3	Tie-In to Existing Underground Production Piping	**Cause:** Conceptual phase engineering to date. Based on a high level desktop review (Navisworks Model), potential issue with tie-in to / extending existing recycle line due to piping clash with Compressors D & E discharge line. The current project basis is that the recycle line is to be re-routed under the existing discharge pipe. **Effect:** Potential for brownfield scope increase. May need to remove more sections of pipe than expected/replace damaged pipe etc., **Consequence:** CAPEX increase.	CAPEX	N	New Build Option	M	M	Significant	Current Navisworks model is outdated. Design change underway with considerable changes foreseeable. To be reviewed post model update (next phase of engineering).
CM	4	Re-Use of Existing Underground Production Piping	**Cause:** Conceptual phase engineering to date. No underground piping survey has been carried out. Requirement to re-use existing production piping infrastructure for all options. **Effect:** Potential for more extensive damage/lower integrity of pipework than currently expected (more of a concern for the Retrofit Options). Requirement to replace large sections of underground pipework. **Consequence:** CAPEX increase	CAPEX	N	New Build Option	VL	M	Minor	**New Build Option:** Newer U/G piping in comparison to Retrofit Options. Therefore, ranked VL probability. **Retrofit Options:** Original pipework, although very little is buried. Condition is questionable, and a lot of issues with piping on Avon A. Mitigation - survey to be carried out prior to FEED.
				CAPEX	N	Avon Unit Re-Use Options	H	M	Major	
CM	5	Increased Flows Through Site Pipework	Potential velocity limitations. Wider site review required and focused assessment for any changes to overall site capacity. Being reviewed by others. No intention for project to increase flow rates above current design limits.							No known increased flows or velocity limit issues through site pipework at Peterborough.
CM	6	Reliability of Avon Unit	**Cause:** All retrofit options rely on use of existing Avon compressor. Compressor is approximately 50 years old. **Effect:** Risk that ageing asset does not meet availability requirements (even with re-life works) and experiences a higher degree of production outages than currently anticipated. **Consequence:** Loss of availability and increased OPEX.	Availability & OPEX	N	Avon Unit Re-Use Options	L	M	Minor	CBA analysis will account for reduced availability and increased OPEX of retrofit machine. Avon Unit is a back-up unit.
CM	7	Lack of Vendor Support	**Cause:** Avon Units are obsolete and no longer supported by OEM. **Effect:** Avon Units are unsupported from a maintenance perspective for the design lifetime. Become increasingly reliant on used parts, with potential issues associated with wider package support and ancillary equipment items. Risk that machine is not viable to keep in operation, resulting in a requirement to replace. **Consequence:** CAPEX impact.	CAPEX	N	Avon Unit Re-Use Options	VL	VH	Minor	Currently licensed service providers that can support. NG have other Avon units that can potentially be cannibalised.
CM	8	Existing Control Systems (DCS/ ESD/ F&G) Tie-In	Conceptual phase engineering / no extensive electrical site survey has been carried out. Existing control systems are old and/or obsolete. Ongoing plan to replace entire station control system in place. Not considered to be a project risk.							Space provision for a 3rd unit at Peterborough is in place. The existing Avon units are all connected and managed from the new control building so no additional control system modifications are anticipated. For the Avon Units, the unit control system is old (40 years). Uncertainty in scope division between 'asset health' and project scope and whether it will be included in MCPD Project estimates. Currently the replacement of the Compressor Control System (UCP) forms part of the MCPD project cost estimates.
CM	9	Remote Control Upgrades	**Cause:** No modifications to central remote control systems currently included in scope for tie-in of new build options. **Effect:** Potential increase in scope to modify remote controls. **Consequence:** CAPEX increase.							Space provision for a 3rd unit at Peterborough is in place. The existing Avon units are all connected and managed from the new control so no additional control system modifications are anticipated. Relatively well understood - Peterborough has a precedent for new machines installation. Pre-investment has already been considered.
CM	10	HV Connection Scope and Execution	**Cause:** Electric drive compressor option requires HV grid connection. Unknown/undefined scope elements at present regarding HV connection. **Effect:** Potential for cost and schedule escalation to enable HV grid connection. Reliant on third party executing works within timely manner. **Consequence:** Schedule and CAPEX increase. Schedule is primary impact area due to potential third party delays.							The Electric VSD Compressor Option has been screened out as part of the Option Review Workshop [Ref. 203513C-002-RT-0503 Rev B Peterborough Compressor Station Option Review Report (Phase 1)]
CM	11	Compressor Selection	**Cause:** Current basis for new compressors is a Solar Titan compressor, as per existing units D and E, which has been used for generation of cost estimates. No other machines have been considered to date. **Effect:** Potential for different machine to be selected at increased cost or changes to the pre-investment of piles and foundations which currently suit a Solar Titan unit. **Consequence:** CAPEX impact.	CAPEX	N	New Build Option	VL	VL	Negligible	Cost is conservative in terms of footprint size etc. Cost includes all National Grid compliance elements. Solar tend to be the more conservative cost compared to other vendors. Any change in equipment size/weight/configuration may mean that the preinvestment is no longer suitable and may need to be removed/adapted at increased cost.
CM	12	Compressor Footprint	Conservative basis with regard to space/footprint requirement for new build compressors. Opportunity to optimise and reduce.	CAPEX	Y	New Build Option				Not applicable to Peterborough. More of an opportunity at King's Lynn as there could be a reduction in site fence extension zone.
CM	12a	Compressor Steelwork - simplification	For the new compressor, there is a potential to reduce the steelwork associated with the operation and maintenance of the unit to reduce cost.	CAPEX	Y	New Build Option				Additional scope (e.g., architectural cladding) was added during later stages of design due to planning consent requirement.
CM	13	New Technology Qualification	**Cause:** DLE technology is currently not proven for use on National Grid sites. **Effect:** Potential for extended qualification periods or concept recycle. **Consequence:** Schedule impact.	Schedule	N	DLE Option	M	L	Minor	[redacted]
CM	14	New Technology Reliability	**Cause:** DLE is a new technology retrofit. Potential operability issues are currently unknown. Potential wider system dynamics issues. **Effect:** Operability issues/teething troubles are discovered during initial operational period leading to poor availability. **Consequence:** Availability impact.	Production Outage/Availability	N	DLE Option	H	M	Major	Test bed trial planned in Q3 but limited learnings from this compared with use during operation. Two potential suppliers.
CM	15	DLE Technology Cost	[redacted]	CAPEX	N	DLE Option	M	M	Significant	
CM	16	SCR Retrofit	**Cause:** SCR would need to be fitted to existing exhaust system. Current exhaust system has not been designed for SCR addition. **Effect:** Potential for increased complexity of retrofit. Potential for increased utilities requirements e.g. nitrogen and instrument air. **Consequence:** CAPEX increase.	CAPEX	N	SCR Option	M	L	Minor	
CM	17	SCR Reliability	**Cause:** Lack of familiarity with SCR operation. **Effect:** Potential operational issues and teething troubles. **Consequence:** Reduced availability.	Availability	N	SCR Option	L	L	Minor	Relatively simple system. Systems in use by other operators.
CM	18	SCR Technology Cost	[redacted]	CAPEX	N	SCR Option	L	L	Minor	
CM	19	Electrical Load Requirements	**Cause:** No full electrical load assessment to date. **Effect:** Requirement to increase electrical load capacity. **Consequence:** Increased CAPEX.	CAPEX	N	New Build Option	VL	L	Negligible	New equipment installed as part of the ERP3 Project with additional electrical infrastructure for a future 3rd unit. Planned to decommission Avon units, freeing up electrical load capacity.
CM	20	Area 1 Plinth Information for New Units	**Cause:** Only have data/drawings for one plinth. Current cost estimating is based on existing Avon data. **Effect:** Potential for scope growth for foundations etc. for actual installation. **Consequence:** CAPEX increase.	CAPEX	N	New Units				Not applicable to Peterborough as sufficient information is available for location of Unit F.

[redacted]

[redacted]

National Grid Peterborough Compression Station Risk Register

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Type	No.	Uncertainty Area	Risk Description (Cause, Effect, Consequence)	Key Impact Area	Opportunity (Y/N)	Option Block	Risk Block Ranking			Other Comments
							Prebability	Impact	Value Erosion	
CM	21	Re-Use of Unit A	Unit A is currently mothballed equipment. Opportunity to re-use. Potential degree of risk due to equipment integrity concerns.	CAPEX	Y	Retrofit Options				Refer to CM 24 for Peterborough alternative
CM	22	SCR Stack / Catalyst Section	**Cause:** Based on current design, the SCR stack / catalyst section will block an existing road on site. **Effect:** Potential to impact site access, however, other adjacent site roads are still available. Potential for scope growth if re-design of the stack / catalyst is required to avoid road impact (i.e., vertical stack). **Consequence:** CAPEX increase	CAPEX	N	SCR Option	L	L	Minor	This issue was noted during the Peterborough Layout review and it was highlighted that the access road to the east of Unit A and also the perimeter road still provides access to north of Unit A therefore, not a significant concern. Placing of the SCR unit to the east of Unit A is not preferred as the LER is located on that side and so the SCR ducting would need to span over it and potentially block access to it. Unit B would also need to be demolished prior to installation in order to make space. Alternatively, it may be possible to extend the SCR ducting at high level east/west and support it with a bridge construction, moving the SCR further west. Height restrictions for access would still apply. Vendor data and surveys would be required to assess this. At the moment we have utilised dimensions available for horizontal SCR from [redacted] Use of a vertical SCR could be considered but this would impose more loads on the compressor cab and hence may not be feasible. Configuration and location of the SCR should be confirmed if the option is selected by the MCPD project.
CM	23	Existing Compressor Vent Line (blowdown line)	**Cause**: The existing compressor vent line for Avon Unit A is currently not compliant with the following NG standards; HAZ/19 and IGEM/SR/23. **Effect:** If the plan is to upgrade the Avon Unit seals to dry gas from wet gas seals, then controlled venting will be required to prevent explosive decompression, which hasn't been accounted for, thus increasing the scope. **Consequence**: CAPEX.	CAPEX	N	Avon Unit Re-Use Options	H	L	Significant	The upgrade of the Avon Unit seals to dry gas is currently not part of the MCPD Project scope. Further assessment is required to confirm the adequacy and also the potential upgrades required for dry gas seals - i.e., this will involve additional vent modifications to include an orifice and modulation valve. Uncertainty in scope division between 'asset health' and project scope.
CM	24	Avon Unit A is not the preferred Unit for retrofitting	**Cause:** Following an in-depth condition assessment of the three Avon Units, Unit A is no longer the preferred unit for retrofitting. **Effect:** Potential CAPEX and Schedule impact as the SCR package location will need to be reconsidered. **Consequence:** CAPEX and Schedule	CAPEX/ Schedule	N	SCR Option	L	L	Minor	Preliminary indications are that Unit A is the most reliable unit (Ref. 203513C-002-RT-0500 Rev B Peterborough Compressor Station Site Visit Report). Low probability based on no in-depth assessment to date. All Avon units should form part of the condition assessment in future phases.
CM	25	Avon Units are not compliant with separation distances	**Cause:** Currently the Avon Units are 29m from the site fence / boundary. This is less than the required minimum 39m separation distance as outlined in T/SP/G/37. **Effect:** Additional land will need to be procured to ensure the existing Avon Units are compliant. **Consequence:** CAPEX and Schedule	CAPEX/ Schedule	N	SCR Option	L	L	Minor	Dispensation will be required on the T/SP/G/37 Spec. This is not considered to be a significant risk. Hence, low probability.
CM	26	SCR Equipment Clash	**Cause:** Potential clash with the drawpits installed around Avon Unit A (as part of ERP3 project) and the SCR exhaust and tanker loading and storage bay preliminary location. **Effect:** Potential for scope growth if re-design of the stack / catalyst bed is required to avoid equipment clash or SCR schedule dependent on the demolition of Units B and C prior to installation to free up space. **Consequence:** CAPEX / Schedule	CAPEX/ Schedule	N	SCR Option	M	M	Significant	Based on new information detailing the location of the drawpits around Unit A, there is a potential clash of equipment for the SCR Option. [Ref. 100056AI-MMD-P007-XX-GA-C-0002] Placing of the SCR unit to the east of Unit A is not preferred as the LER is located on that side and so the SCR ducting would need to span over it and potentially block access to it. Unit B and C would also need to be demolished prior to installation in order to make space. Alternatively, it may be possible to extend the SCR ducting at high level east/west and support it with a bridge construction, moving the SCR further west. Height restrictions for access would still apply. Vendor data and surveys would be required to assess this. At the moment we have utilised dimensions available for horizontal SCR from [redacted] Use of a vertical SCR could be considered but this would impose more loads on the compressor cab and hence may not be feasible. **Configuration and location of the SCR should be confirmed if the option is selected by the MCPD project.**
Utilities and Tie-Ins										
U	1	Capacity of Existing Fuel Gas	Current basis is new fuel gas package for new build options. Opportunity to use existing package but would potentially need modification.	CAPEX	Y	New Build Option				Not applicable for Peterborough as the New Build Option will have it's own fuel gas package.
U	2	Capacity of Existing Instrument Air	**Cause:** Basis is to tie-in to existing package. No capacity assessments to date. **Effect:** Potential for additional instrument air package requirement. **Consequence:** CAPEX increase.	CAPEX	N	New Build Option				Not an issue at Peterborough as there is sufficient capacity within the Instrument Air Package installed as part of ERP3 Project for a 3rd Solar Titan Unit.
U	3	Avon Actuators - Upgrade from Natural Gas to Instrument Air	**Cause:** Current actuators do not use instrument air. May need to change to meet current regulations. **Effect:** Potential for additional instrument air package requirement plus change out of actuators. **Consequence:** CAPEX increase.	CAPEX	N	Avon Unit Re-Use Options	VL	L	Negligible	New instrument air package installed as part of ERP3 Project has sufficient capacity. Opportunity to use electrically actuated valves.
U	4	SCADA Interconnections and Networking	**Cause:** SCADA system is being replaced but network isn't. **Effect:** Potential issues with data speeds and network capacity. Requirement to upgrade network to accommodate additional loads imposed by project requirements. **Consequence:** CAPEX increase.	CAPEX	N	All Options				Not applicable to Peterborough as new system in place following ERP3 Project Implementation
Site Location, Preparation and Brownfield Tie-Ins										
S	1	Site Area Preparation	**Cause:** Conceptual phase engineering to date. No in-depth underground piping survey of redundant equipment. Uncertainty in the extent of underground piping requiring removal. Uncertainty in general level of site preparation required e.g. soil contamination, other buried obstructions etc. **Effect:** Potential for additional site remediation activities. **Consequence:** CAPEX increase.	CAPEX / Schedule	N	New Build Option	VL	L	Negligible	For the New Build Option - very low probability of impact on site area preparation as there is plenty of information on the area around the Solar Titans following ERP3. For the SCR Option, uncertainty with the general level of site preparation required with no piping / underground surveys completed. Uncertainty over what lies below ground in area of proposed SCR retrofit option. Potential for contaminated soil. As well as CAPEX risk, there is a schedule impact - High ground water has been known to be an issue and temporary abstraction licenses and de-watering permits required - which has an impact on schedule. However, this is a known risk, so can be accounted for and provisions put in place in advance.
						SCR Option	M	L	Minor	
S	2	Space in Existing Cable Trenches	**Cause:** All options require routing of new cables via existing trenches, however, variation in volume of cabling required between options. Existing cable routes may be at capacity for retrofit options. Adequate segregation may not be possible. Unknown condition and space of existing Avon Unit cable trenches. **Effect:** Potential to expand trench space or remove redundant cables to make space. May need new trenches due to separation distance issues. **Consequence:** CAPEX increase.	CAPEX	N	Retrofit Options	M	L	Minor	New Build Option - space for 3rd unit already provided. NG confirmed that Costain's cable drawpit design is unchanged therefore, there is enough capacity to accommodate a new unit (Unit F) within the existing ducts. Risk probability is VL. Retrofit Option - No survey to date, however, potential to clear redundant cabling from B and C units to enable capacity in trenches. These are very old unit ducts - restrictive. Potential for more onerous separation distance requirements. Requirement for more instrumentation / cabling / electrical equipment than is currently present. NG to review current spacing in existing Avon trenches. Opportunity to use the new ducting to Avon Unit A, but would be mean longer cable lengths.
						New Build Option	VL	L	Negligible	
S	3	Access to Existing Trenches	**Cause:** Old trenches have concrete coverings. Trenches for the new Solar Titan's are easily accessible. **Effect:** May be difficult to remove and access trench for cable works for the retrofit options. **Consequence:** CAPEX increase.	CAPEX	N	Retrofit Options	M	VL	Minor	Avon units - tight access / confined space with large concrete covers. Cast Iron. Last survey carried out in 2018.
						New Build Option	VL	L	Negligible	No issues perceived based on ERP3 Project.
S	4	New Trench for HV Cable	**Cause:** Preliminary routing for HV cable. Requirement to cross existing trenching and other obstructions. **Effect:** Potential for scope growth/routing deviation to accommodate HV cable routing and obstructions. **Consequence:** CAPEX increase.	CAPEX	N	Electric Drive Options				Not applicable. The Electric VSD Compressor Option has been screened out as part of the Option Review Workshop [Ref. 203513C-002-RT-0503 Rev B Peterborough Compressor Station Option Review Report (Phase 1)]
S	5	Construction Near Live Pipeline (Feeders to Pig traps)	**Cause:** Live main feeder lines / Pig traps close to Plinth F. **Effect:** Increased excavation scope / duration. **Consequence:** Schedule impact.	Schedule	N	New Build Options	L	L	Minor	Crane location would need to be reviewed. Additional protection covers may be required for main feeder lines.
S	6	Extension of Drainage System	**Cause:** For the existing Avon units, the existing drainage system capacity and scope of modifications is not fully defined (local surface water drainage). Better information is available for the New Build Option. **Effect:** Potential for scope increase. **Consequence:** CAPEX increase.	CAPEX	N	New Build Option	VL	VL	Negligible	No issues perceived as sized for three new Solar Titan Units.
						SCR Option	M	L	Minor	For the SCR option, there is less known about the surface water system. There is an old drainage system but parts of this would have been demolished/modified as part of the ERP3 project but to what extent remains is unknown. The new drainage layout shows the new only. No overall drainage layout (old and new overlayed) is depicted. However, as only one Avon Unit remains in operation, the risk and impact is classified as Low.

[redacted]

[redacted]

National Grid Peterborough Compression Station Risk Register

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Type	No.	Uncertainty Area	Risk Description (Cause, Effect, Consequence)	Key Impact Area	Opportunity (Y/N)	Option Block	Risk Block Ranking			Other Comments
							Probability	Impact	Value Erosion	
S	7	Tie-in to Existing Vent Structure	**Cause:** New compressor vent stack to be tied into existing vent structure. Limited structural assessment to date. **Effect:** Additional support maybe required. **Consequence:** CAPEX increase.	CAPEX	N	New Build Option				Not considered a risk at Peterborough as the existing and new vent lines tie-in to a new Vent Stack with additional spare capacity.
S	8	Blowdown Capacity	**Cause:** New build unit integration impacts wider production system performance and blowdown scenarios. **Effect:** Potential for impact on main vent capacity and size of sterile area. Potential for vent system expansion requirement. N.B. Issues would be with main blowdown vent rather than route from individual compressors. **Consequence:** CAPEX increase.	CAPEX	N	New Build Option				Not considered a risk at Peterborough as the existing and new vent lines tie-in to a new Vent Stack with additional spare capacity.
S	9	Construction Disruption Due to Flooding	**Cause:** Areas of site prone to flooding. **Effect:** Potential for construction delay due to flooding. **Consequence:** Schedule delay.	Schedule	N	All Options	L	L	Minor	Flood Risk - The EA flood map indicates that the west of the site is located in an area with a "Moderate" risk of flooding. The chance of flooding each year is 1.3% (1 in 75) or less, but greater than 0.5% (1 in 200). This should be taken into consideration during design works. However, detailed flood risk assessment for ERP3 has revised risk of flooding (Zone 2 / 3) due to actual site levels from topography survey. (Peterborough MCP GIS screening vFINAL)
S	10	Subsidence	Potential on-site subsidence. Not due to construct in areas subject to subsidence. Not considered to be a project risk.							No risk around the areas for New Build Option and Retrofit Options.
S	11	Crossing Bacton Pipeline - Construction Activities	**Cause:** Crossing of Bacton Pipeline is required by suction and discharge lines to new compressor. **Effect:** Risk of damage during construction to existing pipeline. **Consequence:** Production outage and CAPEX increase.	CAPEX & Production Outage	N					Not applicable to Peterborough.
S	12	Crossing of live pipelines - Construction Activities	**Cause:** Crossing of live Pipeline is required to install a new road North of the plant. **Effect:** Risk of damage during construction to existing pipeline. **Consequence:** Production outage and CAPEX increase.	CAPEX & Production Outage	N	New Build Option	VL	L	Negligible	ERP3 construction team (Ref. PB Site Visit Report) advised that access for construction of a third unit would not be possible from the east due to installations associated with units D and E. However, access could be achieved past the old control building, Avon unit compressors and along a new asphalt road which is due to be constructed along the western perimeter to the AGI area. An existing construction road exists from the AGI area to the proposed location of Unit F. Thus, crossing of buried pipes already occurs as part of ERP3 project and hence is feasible. Unsure whether a permanent feature. No concrete plinths. The new road is required for construction access to Plinth F and can also be used for maintenance access to the area. ERP3 project has already shown that crossing of the pipelines is feasible and therefore this is not considered to be a significant risk.
Operations										
O	1	Construction SIMOPs	**Cause:** SIMOPs with ongoing operations during construction works. **Effect:** Construction disruption. **Consequence:** Schedule delay.	Schedule	N	All Options	M	VL	Minor	
O	2	Operational Disruption Due to Flooding	**Cause:** Areas of site prone to flooding. **Effect:** Potential for operational disruption due to flooding. **Consequence:** Production outage.	Production Outage	N	All Options	L	L	Minor	Flood Risk - The EA flood map indicates that the west of the site is located in an area with a "Moderate" risk of flooding. The chance of flooding each year is 1.3% (1 in 75) or less, but greater than 0.5% (1 in 200). This should be taken into consideration during design works. However, detailed flood risk assessment for ERP3 has revised risk of flooding (Zone 2 / 3) due to actual site levels from topo survey. (Peterborough MCP GIS screening vFINAL) Compressor raised on plinths. Some actuated valves within pits. Flood risk assessment required to support design.
HSSE and HSSE Approvals										
HSSE	1	Ammonia On Site	**Cause:** SCR requires use of aqueous ammonia. Potential for use of anhydrous ammonia. **Effect:** On site storage of re-agents or other dangerous substances if anhydrous ammonia selected as reagent. Additional safety and waste management measures required. **Consequence:** Increased CAPEX & OPEX.	CAPEX & OPEX	N	SCR Option	L	VL	Negligible	Will need bunded area and tank. 40 m^3 allowed for under design. Sizing based on 1 tanker volume. Usage is very low. Current concentration is 24.5% aqueous ammonia.
HSSE	2	Fire Water Filling	**Cause:** Water connection required to re-fill fire system bottles. No connection provision at present for new units. **Effect:** Potential cost increase to provide adequate fire water tie-ins. **Consequence:** CAPEX impact.	CAPEX	N	New Build Option				Not applicable to Peterborough as fire water connection already in place for Units D & E and provision for a 3rd Solar Titan.
HSSE	3	Excessive Noise	**Cause:** New air blowers required (80kW) for SCR option, which are source of additional noise. Peterborough sensors are tighter than on King's Lynn and have not been reviewed with a third New Build Option. **Effect:** HSE and regulatory/permitting limitations on acceptable noise levels. Potential requirement to install additional noise mitigation measures. **Consequence:** CAPEX impact.	CAPEX	N	New Build Option	M	VL	Minor	Peterborough sensors tighter than King's Lynn and with the addition of a thrid new build unit, noise limitations levels will need to be further reviewed. Additional noise mitigation measures might be required.
						SCR Option	M	VL	Minor	Equipment will be specified to within noise limitations. Low cost additional measures. Industrial area with overall noise levels.
HSSE	4	Ammonia Release to Atmosphere	**Cause:** Full dispersion modelling and slippage of ammonia not currently quantified. Potential for higher ammonia releases to vent. **Effect:** Requirement for additional ammonia mitigation measures to remain within consent limits. **Consequence:** CAPEX increase for additional equipment.	CAPEX	N	SCR Option	L	L	Minor	
HSSE	5	Air Pollution from GT Compressor	Part of deterministic results to compare against electric compressor. Not a project risk - fundamental selection driver.							
HSSE	6	Failure to Meet Emissions Requirements	**Cause:** Future changes to pollution requirements or stricter requirements applied at permitting stage. Energy efficiency requirements may come in. **Effect:** Inability to achieve required regulatory limits with selected scheme, or requirement for additional modifications to meet limits. Cost increase for replacement machine or modifications. **Consequence:** CAPEX increase.	CAPEX or OPEX	N	New Build Option	VL	H	Minor	All options meet current requirements. Have a lot more flexibility with new units to meet changes in requirements than for retrofit options. If changes are required, then all options would require a significant change. Regulations are not typically applied retrospectively.
						Retrofit	L	H	Significant	
HSSE	7	Presence of NORMS	**Cause:** NORMs experienced in wider network. **Effect:** Potential for construction delay due to cleaning and decontamination requirements. **Consequence:** Schedule delay.	Schedule	N	New Build Option	H	VL	Minor	Standard procedures in place to manage this. Testing to be scheduled as part of construction planning process. As per the Peterborough Site Information Document - "NORMS in pipework is a known site hazard". Benzene safety risk at site. Standard procedures are in place to manage this.
HSSE	8	Pipework Isolation and Cleaning	**Cause:** Potential for contamination due to condensate, MEG etc. carryover from incoming sources. **Effect:** Potential for increased cleaning and decontamination of equipment and pipework. **Consequence:** Schedule delay.	Schedule	N	New Build Option	L	VL	Negligible	Not known at the moment - but the issue at KL may have impacted PB. Two new scrubbers have condensate (installed 2019).
HSSE	9	Asbestos Management	**Cause:** Potential for asbestos contamination in existing cabs, trenches and old building (existing facilities). **Effect:** Potential for increased decontamination of equipment. **Consequence:** CAPEX increase.	CAPEX	N	Retrofit Options	H	L	Significant	Part of UAP at present - no dedicated contingency.
HSSE	10	COVID/Pandemic Disruption	**Cause:** Potential for disruption to construction activities due to COVID or other pandemic/health issues in workforce. **Effect:** Potential for increased construction schedule. **Consequence:** Schedule increase.	Schedule	N	Retrofit Options	VL	L	Negligible	Larger workforce in place for new build option. Procedures in place to deal with COVID disruption.
						New Build Option	VL	M	Minor	
HSSE	11	Environmental Permitting Approvals	**Cause:** The CSRP technology is currently unproven for emissions reduction. **Effect:** Potential impact on obtaining environmental permit **Consequence:** Schedule increase.	Schedule	N	CSRP	L	H	Significant	Probability ranked low but high impact as the CSRP option has not been implemented as an emissions compliant solution and there is a risk that the Environment Agency will not approve an environmental permit to operate without run-hour restrictions. NG are due to meet with the Environment Agency to discuss permitting for retrofit options on 5 October 2022

[redacted]

National Grid Peterborough Compression Station Risk Register

nationalgrid

Type	No.	Uncertainty Area	Risk Description (Cause, Effect, Consequence)	Key Impact Area	Opportunity (Y/N)	Option Block	Risk Block Ranking			Other Comments
							Probability	Impact	Value Erosion	

[redacted]

Commercial, Political, Organisational										
CPO	1	Crossing Becton Pipeline - Permitting	**Cause:** Crossing of Becton Pipeline is required by suction and discharge lines to new compressor. Permitting required from operations. **Effect:** Risk of not obtaining permit due to dropped object concerns, loss of containment etc. Risk of concept recycle. **Consequence:** Schedule delay.	Schedule	N	New Build Option				Not applicable to Peterborough.
CPO	2	Catalyst Sole Supplier	**Cause:** Single supplier for SCR catalyst. **Effect:** Tied into single supplier, with potential for increased costs, supply security issues or inability to source supplies. May need to alter unit to accommodate alternative supplier. **Consequence:** CAPEX increase & production outage.	CAPEX & Production Outage	N	SCR Option	L	L	Minor	Generic technology by catalysts may be proprietary in terms of design compatibility. Framework in ducting may not be compatible with alternative suppliers.
CPO	3	Rental of Land for Construction	**Cause:** Land rental required for construction phase for new unit. Includes offices, car parking etc. to accommodate construction workforce. No cost allowance and no negotiations undertaken. **Effect:** Potential for cost escalation. Potential for schedule delay. **Consequence:** CAPEX & schedule increase.	CAPEX & Schedule	N	New Build Option	L	VL	Negligible	[redacted]
					N	Retrofit Options	VL	VL	Negligible	[redacted]
CPO	3a	Rental of Land for Construction	Opportunity to utilise existing ERP3 construction area to save on mob/demob costs before land is sold back to the farmer.	CAPEX	Y	All Options				Although, this might be a low likelihood as ERP3 is near completion - on going discussions are underway.
CPO	4	Increase to Station Flow Capacity	**Cause:** Potential for future increase to overall station flow capacity. **Effect:** Modifications required to accommodate capacity changes. **Consequence:** Future cost increase. General site risk. Not considered to be a project risk.							Not applicable to Peterborough.
CPO	5	Change to Hydrogen Network	Opportunity for future change to hydrogen production.	Revenue	Y	All Options				
CPO	6	Coordination with Other Projects	Potential to coordinate with decommissioning and other projects. Optimise workforce etc.	CAPEX	Y	All Options				
CPO	7	Coordination and Alignment with External Stakeholders	**Cause:** Coordination with external stakeholders required (Ofgem etc.). **Effect:** Potential delay with regard to gaining alignment on preferred option. **Consequence:** Schedule delay.	Schedule	N	New Build Option	H	H	Critical	Ofgem are likely to require low cost option to reduce cost to consumer. Initial engagement between Ofgem and National Grid indicate a strong preference from Ofgem for Retrofit Options
						Retrofit Options	VL	M	Minor	
CPO	8	Coordination and Alignment with Internal Stakeholders	**Cause:** Coordination with internal stakeholders required. **Effect:** Potential delay with regard to gaining alignment on preferred option. **Consequence:** Schedule delay.	Schedule	N	New Build Option	VL	M	Minor	Risk of issue with internal stakeholders due to cost inflation.
						Retrofit Options	H	H	Critical	
CPO	9	Network Outage Scheduling and Coordination	**Cause:** Planned network outage period is currently unknown. **Effect:** Allowed outage may be shorter than anticipated or at less optimum time for construction. **Consequence:** Schedule delay.	Schedule	N	New Build Option	L	H	Significant	Currently assuming that April - September period is available. Shorter duration required for retrofit option and more float. However, outage only required for new build option tie-ins - other work can be undertaken during production. For the New Build Option, based on units A-C being available as back up units, probability is **Low**. Based on Units B & C being available as back-up units, probability is **Low** for retrofit options.
						Retrofit	L	M	Minor	
CPO	10	Land Use / Extension	**Cause:** New units require extension of existing site boundary. Permitting and consent requirement. Environmental and commercial negotiations. **Effect:** Potential for delays managing multiple stakeholders and gaining consent. **Consequence:** Schedule delay.	Schedule	N	New Build Option				Not applicable to Peterborough.
CPO	11	Geopolitical Issues	**Cause:** Country specific and worldwide geopolitical issues affecting equipment supply and workforce. **Effect:** Potential for cost escalation. Potential for schedule delay. **Consequence:** CAPEX & schedule increase.	CAPEX	N	Retrofit Options	H	M	Major	Economic sensitivities to be conducted.
						New Build Option	H	VH	Critical	
CPO	12	Planning Applications	**Cause:** Planning permission required for all options. **Effect:** Extension to schedule due to planning consent taking longer than anticipated. Issue experienced on the ERP3 Project. **Consequence:** Schedule	Schedule	N	New Build Option	L	H	Critical	For the New Build Option, this is a known issue, and part of the original planning application for ERP3 (installation of New Compressors). For the SCR Option, this has been ranked as a medium risk on the basis that this is new equipment for Peterborough.
				Schedule	N	SCR	M	H	Critical	

[redacted]

APPENDIX B WORKSHOP PRESENTATION

Appendix B
National Grid Peterb