

Wormington Compressor Station MCPD FEED Feasibility Project

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ABBREVIATIONS & GLOSSARY

Unless otherwise stated in this document, capitalised terms that appear in this document have the meaning given to them in the following table.

ASEP	Aggregated System Entry Point		
BNG	Biodiversity Net Gain		
CDM	Construction Design Management		
CSRP	Control System Restricted Performance		
DLE	Dry Low Emissions		
EPC	Engineering Procurement Construction		
FAT	Factory Acceptance Test		
FEED	Front End Engineering Design		
GT	Gas Turbine		
MCPD	Medium Combustion Plant Directive		
GIS	Geographic Information System		
NTI	Net Thermal Input		
NTS	National Transmission System		
PEA	Preliminary Ecological Appraisal		
RIIO	Revenue = Incentives + Innovation + Outputs		
SCR	Selective Catalytic Reduction		
SIMOPS	Simultaneous Operations		
TBC	To Be Confirmed		
VSD	Variable Speed Drive		

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1 Introduction

The Medium Combustion Plant Directive (MCPD) requires that existing gas turbine plant between 1 MW and 50 MW net thermal input must not exceed specified operational emission limits for oxides of nitrogen (NOx) 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 those units at Wormington Compressor Station. Investment is required to ensure the compression 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 (FES) to ensure the most cost-effective solution for end consumers:

- Upgrading non-compliant units to bring emissions within acceptable legislative limits;
- Replacement of non-compliant units with new low emissions gas turbines;
- 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 less than 500 hours per year (as a rolling average over a period of five years) under the derogation as defined in the MCPD legislation.

National Grid submitted a compressor emissions compliance strategy paper to Ofgem in 2019 within which compliance options for each site impacted by the MCP legislation were presented. Due to the uncertainty around the optimum solution for Wormington Compressor Station it was agreed that further review of options would be conducted, with the optimum (or preferred) solution presented to Ofgem in a Final Option 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 Background

2.1 Wormington Compressor Station

The Wormington compressor station, commissioned in 1990, is critical in transporting National Transmission System (NTS) gas entering through the Milford Haven terminal. The site is situated in Gloucestershire at the junction in the gas National Transmission System (NTS) shown in the figure below. The station maintains flow through six (6) feeders connecting at the multijunction located at the east of the Wormington site.

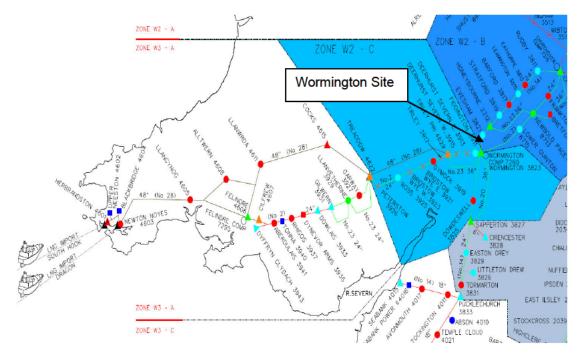


Figure 1 - National Transmission System Schematic Extract

The station has been subject to various modifications and upgrades over the past 30 years. Notably in 2009 the station underwent modifications as part of the South West Expansion Project to support flows onto the NTS from the aggregated system entry point (ASEP) at Milford Haven Terminal which includes South Hook and Dragon LNG import terminals.

In its current configuration the site can support bi-directional flow and compression is provided by two (2) Rolls Royce (now Siemens) Avon MK1533 gas turbine driven compressor units (referred to as Units A and B) and a Siemens variable speed drive electrically driven compressor unit (Referred to as Unit C). The VSD (unit C) was commissioned in 2009 as part of the South West Expansion Project and is the lead unit on site. Units A and B are utilised either when Unit C is unavailable due to planned or unplanned outages or when the flow through the site exceeds the capacity of Unit C, typically when flow from Milford Haven ASEP is high and demand in South Wales is low.

2.2 MCPD Compliance Options

The Avon gas turbines (Unit A and B) are not compliant with emissions limits for existing plant set out in the Medium Combustion Plant Directive which cannot be exceeded from 1 January 2030. The Womrington MCPD project has been initiated to review new build and retrofit options to provide enduring emissions compliant compression at Wormington which meets forecast network capability requirements.

2.3 **Document Objectives**

Limited were engaged by National Grid to undertake an engineering study to support the options selection process for MCPD compliance at Wormington. As part of the engineering study developed six potential layout options. Undertook safety, environmental, construction and engineering assessments of these options the details of which can be found in the FEED Report (20840-EN-RPT-000-0006) and supporting documents.

This document collates the output of **s** again into a consolidated comparative assessment to allow selection of a single preferred layout. The preferred layout will then be used as the basis for CBA and BAT assessment of the ten MCPD compliance options under review.

3 Development Options

3.1 General

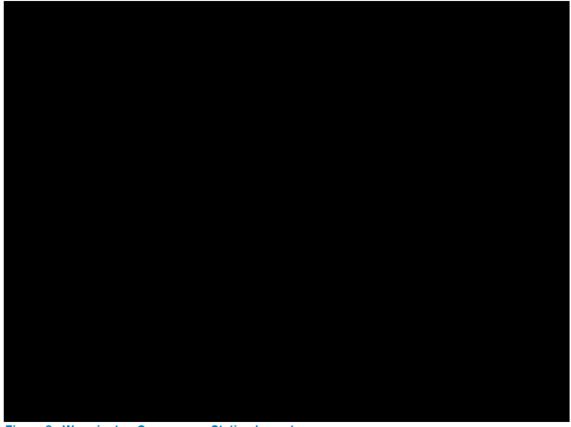


Figure 2 - Wormington Compressor Station Layout

Ten MCPD compliance options consisting of new unit and retrofit options as listed in table 1 are being considered as part of the options selection process.

Table 1 - Options Shortlist

Option	Description
1	Counterfactual - 500hr derogation on both Avons
2	Two CSRP Avons
3	Two SCR installations for Both Avons (upgraded to 1535)
4	One Retrofit DLE 1533 Avon & One 500hr derogated Avon
5	Two Retrofit DLE 1533 Avons
6	Two Retrofit DLE 1535 Avons
7	One New GT, One 500hr derogated Avon & One Decommissioned Avon
8	One New GT, One CSRP Avon & One Decommissioned Avon
9	One New GT, One Retrofit DLE 1533 Avon & One Decommissioned Avon
10	Two New GT's & Two Decommissioned Avons

Retrofit options will utilise the Avon driven compressors in their existing berths. Various locations for the installation of new compressors are under consideration, as discussed in this report. The same

assessment is conducted for the installation of two new units as for one and any considerations relevant to specific options are highlighted. Although it may be feasible to utilise the alternative locations discussed in this report for retrofit options, the cost and operational impact of relocating existing compressors is considered prohibitive and therefore has not been considered.

4 Layout locations for Options

4.1 General

National Grid undertook a GIS based site location review in February 2020 to identify suitable areas for new units. This study showed that installation of new units within the existing site footprint would not be possible without deviation from required safety separation distances specified in T/SP/G/37 and/or relocated existing equipment. Greenfield locations were also reviewed and an area of land within the current land ownership boundary to the south of the site was identified as a suitable location.

After this initial screening exercise, developed six layout options for further review consisting of options within the existing site boundary and utilising the area identified to the south of the site. Plant Layout drawings (20840-PI-XKY-000-0001-Sheets 1-6) and Piping layout drawings (20840-PEN-WO-00-DR-P-0000-S3-PO1-Sheets 1-6) for each option were developed by **Exercise**. The layout options developed by **Exercise** are summarised in Table 2.

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

As indicated in Table 2, the six options involve the use of five potential locations for new compressor machinery trains. Within this report these five areas are reviewed based on the output of the assessments and workshops lead by **Example** and a single preferred option selected. The preferred layout will then form the basis for new unit options considered in the subsequent cost benefit analysis and BAT assessments.

Table 2 - XXXXXX Layout Options

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

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

An overview of the five potential compressor locations is described in the following subsections.

4.2 Layout Option A - Existing Berths A/B

Retrofit Options will be carried out on the Avons in their existing berths (Unit A and B utilised for Options 1 to 6 and Unit A or B for Options 7-9 – see Table 1).

Preliminary design for the structural modifications required for the SCR option is described in the SCR report by (PJ20602-12-DDR-001). However, the proposed design presents constructability challenges and will therefore be reviewed in the next phase of the project if this option is selected. Specific risks associated with this option are highlighted in the risk report (PAC1050295-01-7260-NGG-0043).

A reagent (ammonia) storage and loading facility will also be required for the SCR option and a preliminary location for this equipment has been identified to the south of the existing control building. However, alternative areas will be assessed in the next phase of the project if this option is selected.

A photograph, taken May 2022, showing existing berths A and B is shown in Figure 3. The control building can also be seen immediately behind the compressor berths.



Figure 3 – Existing Berths Unit A (left) and B (right) – looking south

One or two new GT's could potentially be located here. The existing plinths would require re-sizing and reinforcement.

Safety separation distance between the existing berths and the control building are insufficient and therefore extensive mitigation would be required (potentially including relocation of the control building as shown in a layout option 6 -20840-PI-XKY-000-0001_Sht6).

4.3 **Layout Option B – Aftercooler Area**

The aftercoolers to the north east of berths A and B are no longer in use and are due to be decommissioned before the construction phase of the MCPD project commences. The location of the aftercoolers are shown in Figure 2 and a photograph (May 2022) included in Figure 4 below. Also, within this photograph, the exhaust stacks for units A and B can be seen behind the aftercoolers and the compressor building for unit C can be seen to the right of the image.



Figure 4 - Aftercoolers (looking southwest)

Following decommissioning and removal of this asset an area of approximately 33 m by 14 m will be available which could accommodate a single new compressor. This location just falls short of the T/SP/G/37 safety separation distance to the control building which should be more than 39 m. Therefore, some mitigation would be required (blast wall etc.) as noted in the layout review lead by (20840-EN-RPT-000-0002).

4.4 Layout Option C - Existing Control Building Area

This option involves extension of the existing site footprint to the south to allow relocation of the control building and installation of a new compressor machinery train in the current location of the control building. These Layout options (**Control** layout sheets 3, 4 and 6) were noted as highly problematic at the G37 review due to various construction issues working within an operational plant and the complexity of relocating the Control Building.

4.5 **Layout Option D1 – "Greenfield" North of Feeder 23**

An area of National Grid Owned Land to the south of the existing site perimeter fence has been identified as a potential "greenfield" area for the installation of new units. This location is shown on the satellite image in Figure 5 and in a recent photo (taken May 2022) in Figure 6.

The only other significant area of land within the current ownership boundary is to the west of the site. However, this area is unsuitable as it contains a pond and is crossed by two buried pipelines, feeder 2 and 23. There are alternative areas to the east and north of the site, but these would require land purchase which would have a cost and potentially schedule impact and therefore the identified area to the south has been selected.



Figure 5 - National Grid Land Ownership Boundary and Proposed Area for New Plant

As shown in Figure 6, the proposed area is predominantly grassed with a wooded area to the south. More detail on the environmental impacts can be found in the Environmental and Sustainability Report (20840-EN-RPT-000-0005) produced by





Two options utilising the area of land to the south of the current plot have been identified. In option D1 the new unit will be installed to the north of Feeder 23 which is a 900 mm buried natural gas pipeline from Tirley AGI which runs parallel to the southern extent of the site before entering the AGI from the south as shown in Figure 7.



Figure 7 - Layout D1 - North of Feeder 23

The plot extension, represented by the red line indicating the new fenceline, is required to maintain 39 m distance between the new compressors and the perimeter fence per T/SP/G/37. The 10 m corridor around feeder 23 represented by the yellow lines must be maintained and cannot be built over.

4.6 Layout Option D2 – "Greenfield" South of Feeder 23

In this option (D2) the proposed location for new compressor machinery trains is south of existing feeder 23 as shown in Figure 8.

The proposed route of the new fenceline is shown in faint red line in Figure 8. As shown the proposed plot extension encroaches on the wooded area to the south of the gravel access track to the electrical Distribution Network Owner (DNO) substation and therefore tree removal and rerouting of the access track would be required.

A buried crossing of feeder 23 has been assumed but this will be confirmed during the next stage of the project.



Figure 8 - Proposed Greenfield Layout - Option D2

5 Assessment Methodology

5.1 General

The following traffic light grading / classification shown in Table 3 has been used to select the preferred location for the installation of one and two new units.

Table 3 - Traffic Light Classification

Meets the specified criteria and/or offers the best option for the criteria
Marginally fails to meet the specified criteria and/or is slightly worse against the criteria than the best option
Fails to meet the criteria and/or is significantly worse against the criteria than the best option

Scores were assigned across the categories listed below based on the traffic light criteria described above.

5.2 **Project Development Cost**

Relative investment costs for each option are compared with lowest cost option(s) scoring highest and highest cost options scoring the lowest. Fully developed cost estimates for each option were not available so this was a qualitatively scored.

5.3 **Project Execution Schedule**

Score based on risk associated with achieving operational acceptance of new compressors prior to the MCPD deadline of 1 January 2030.

5.4 Impact on existing Operations

Score based on anticipated duration of total site shutdowns and/or unavailability of back-up compression facilities during construction.

5.5 Safety Assessment

Score based on compliance with plant separation criteria recommended by National Grid Specification for Site Location and Layout Studies and Reviews T/SP/G/37. Scores are based on assessment in the G37 Layout Review by (20840-EN-RPT-000-0002)

5.6 Environmental Impact

Scored based on any significant environmental, sustainability, planning and permitting impacts associated with the new compressor locations. Scores are based on environmental constraints identified in the preliminary GIS-based location review and the biodiversity net gain assessment and

carbon impact assessments carried out by and included in the Environmental and Sustainability report (20840-EN-RPT-000-0005_Rev01).

5.7 **Constructability**

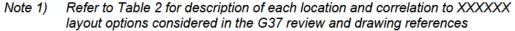
Scored based on the relative construction complexity of each option with regards to the overall construction scope; quantity of brownfield modifications required and SIMOPS risks; access to the construction location.

6 Assessment Results

The four potential locations for new unit(s) were scored as shown in Table 4. The scoring of these options is based on the installation of a single new unit in the identified area.



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



6.1 Project Development Cost

The brownfield options (A and B) are likely to be the lowest cost as they require minimal tie-in lengths and do not require extension of the plot. However, this assessment does not take into account potential cost of additional scope to mitigate safety risks due to the proximity to the control building which is assessed in the safety assessment.

Option C is considered the costliest option due to the cost of installing a new control building a new station control system and other associated equipment.

Options D1 and D2 will carry a lower cost than option C, but will have a greater cost than the brownfield options. If feasible, Option D1 should be more cost effective than option D2, however cost savings would be at least in part offset by less efficient construction due to brownfield scope. At this stage these options have been scored the same for cost but layout optimisation will be conducted in the next phase of the project if a new unit solution is selected.

6.2 **Project Development Schedule**

Option C would require construction and commissioning of the new control building prior to demolition of the existing control building. Tie in and commissioning of the new station control system would require

an additional summer outage which would increase the construction duration. This option therefore scores worse than other options which can all achieve the required operational acceptance prior to 1 January 2030.

6.3 Impact on Existing Operations

Options A, B & C have significant greater impact on the existing compressor site due to the extent of brownfield work and associated SIMOPS risks. Due to demolition works required for Options A, B and C and the proximity of these works to live plant, it is likely that significant outages would be required during construction. Option C also imposes a risk to Operations due to the complexity of migrating over a new control system location, therefore there would be significant impact on the operational availability of the Compressor Station.

Option A would require significant demolition of the exiting cab structure and removal of existing equipment. The foundations would need to be surveyed and assessed and it is likely that re-sizing and/or reinforcement would be required. There is therefore significant construction works that would need to be undertaken close to operational plant for this option. For two unit options a single unit would be installed at a time but it is unlikely that operation of the second unit could be maintained through demolition, construction and commissioning works were under taken. As a result the impact on operations of this option makes it unfeasible.

Construction work for Option D2 would be mostly conducted in a separate CDM area at a safe distance from existing plant. Minimal outages would be required for tie-ins and commissioning. A similar approach would be taken for option D1 but more brownfield work is required for this option and it could therefore have a slightly larger potential impact on operations.

6.4 Safety Assessment

The current Avon berths (unit A and B) are located close the control building and as a result are not compliant with the safety separation distance to occupied buildings specified in T/SP/G/37. The operational risk associated with the current site layout at Wormington has been assessed via QRA and mitigations applied to ensure risks are As Low As Reasonably Practicable (ALARP). The same berths and layout will be maintained for retrofit options but installation of new units within existing berths would change the risk profile and would require reassessment. Location option A (existing berths) for new unit(s) would therefore most likely require additional mitigations to be applied to ensure risks are ALARP.

Similarly for option B (aftercooler area) the distance to the existing control building is not compliant with T/SP/G/37 safety separation distances and would be subject to QRA and likely require additional mitigation measures. However, as the distance to the control building is larger this option scores better than for option A in terms of safety.

To avoid double counting in the scoring the cost has been assessed on the basis that minimal cost mitigations are required.

6.5 Environmental Impact

Although Option C and D requires the site to be extended, the extended footprint would remain within National Grid owned land. Although the plot extension required for options C and D would result in an

environmental impact this could be minimised through appropriate standards and procedures. A biodiversity net gain target would be achievable for all options (further detail can be found in the Environmental and sustainability report (20840-EN-RPT-000-0005). The brownfield options (A and B) score the highest as they will not have less environmental impact than greenfield options. Environmental assessment assumes new build option and comparative assessment of the environmental impact of retrofit options is included in the BAT assessment.

6.6 **Constructability**

Options A, B and C would require significant construction works close to existing plant which will result in SIMOPS issues and extended outage requirements (highlighted in G37 report 20840-EN-RPT-000-0002). The relocation of the control building and associated equipment presents significant challenges for option C which would require significant amount of construction works to be planned over multiple outages. Option A will be most problematic and likely not feasible as discussed in section 6.3.

Options D1 and D2 pose fewer problems as tie in works to the existing site can be undertaken during planned outages and the bulk of the construction will be within a separate CDM area away from operational plant. D2 would require the crossing of feeder 23 which would require specific crossing design, option D1 has more brownfield construction scope close to operational plant and therefore on balance these options score the same.

7 Conclusions

developed six layout options which include four distinct locations for new compressor machinery trains. These four locations (A-D) have been compared using a simple traffic light scoring system to allow a single option to be selected. Engineering and cost inputs for the CBA and BAT assessment will then be developed.

7.1 **Discounted Options**

7.1.1. Option A – Existing Berths

The brownfield options B and C potentially present cost savings vs greenfield solutions due to the shorter tie-ins for these options and the avoidance of costs associated with extending the site boundary. For Option A, existing berths, much of these costs would be negated by the cost of mitigating measures required due to proximity of new units to the control building.

Installation of new units onto the existing berth would most likely require significant demolition of the existing cab and supporting ancillary equipment to accommodate the new unit which would add to cost and construction challenges especially as the units are near the control building.

This option would also require significant outages to allow modification of existing berths to accommodate the new units and associated cab, air intake and exhaust structures. Accommodating these changes within the available footprint whilst maintaining adequate maintenance access would not be feasible. There are significant constructability issues with this option as it would require extensive construction works near the control building and operational plant. For two new unit options, construction would need to be staggered with construction on one unit at a time but it is highly unlikely that the second unit could continue operation during construction due.

For the above reasons this option is not considered feasible and has therefore been discounted.

7.1.2. Option B – Aftercooler Area

The potential cost savings offered by Option C (aftercooler area) vs greenfield options would, at least partially, be negated by additional mitigations required due to the proximity to the control building as less efficient construction due to the large amount of brownfield work. The brownfield scope, limited space and proximity to operational plant also introduces constructability challenges and SIMOPS risk.

There is insufficient space to accommodate two new units in this area and so this option would only be feasible for a new single unit installation in combination with a retrofit option.

However, this option scores worse than "greenfield" options and has therefore been discounted.

7.1.3. Option C – Control Building Area

Option C performs the worst overall as it is likely to be the most expensive option due to the additional cost of a new control building. The new control building would need to be constructed and commissioned along with the control system and other equipment prior to demolition of the existing control building. Commissioning of the new control system would require an additional summer outage and the construction schedule would be impacted.

The plot would need to be extended to the south to accommodate the new control building and the site earth bed would need to be relocated.

Following plot extension and relocation of the control building the new compressor machinery train would need to be installed close to the existing Avons which would present constructability challenges and SIMOPS risks.

For the above reasons this option has been discounted.

7.1.4. Option D1 – "Greenfield" North of Feeder 23

Of the two "greenfield" options this performed worse due to proximity to the Uninterruptable Power Supply (UPS) Kiosk, which is not compliant with separation distances specified in T/SP/G/37; the requirement to relocate the site ground bed; the additional brownfield construction and limited available space.

This option presents potential cost savings of the selected option due to reduced plot extension required; shorter tie-in distances and removal of the requirement to cross feeder 23. However, these cost savings are outweighed by risk associated with proximity to existing plant and feeder 23 which may require relocation equipment and would present construction challenges. This option has therefore been discounted in favour of option D2. However, this option will be reviewed as part of a plot optimisation process in the next stage of the project and an associated opportunity has been captured on the project risk register (PAC1050295-01-7260-NGG-0043).

7.2 Selected Option – Option D2 – "Greenfield" South of Feeder 23

The preferred option is to utilise the area of land to the south of the existing site perimeter which will require extension of the existing plot. Options to install new units north or south of existing feeder 23 were investigated and the area to the south has been selected. The area to the north of feeder 23 was

discounted due to construction constraints and likely restrictions on mechanical excavation due to proximity to the operational pipeline (Feeder 23).

This option performed the best against all assessment criteria other than environment and cost where it was scored amber. This layout option allows most of the construction to be carried out in a separate CDM area away from operational plant thus reducing SIMOPS risk and limiting the impact on site operations. The new compressors will be a safe distance from occupied buildings, other plant and the rerouted fenceline therefore from a safety perspective this option is also preferred.

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

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

8 References

8.1 Table of references

Document References	Document Title	Revision	Author
20840-EN-RPT-000-0006	FEED Report	Rev 01	
20840-EN-RPT-000-0002	G37 Layout Review	Rev 01	
20840-EN-RPT-000-0005	Environmental and Sustainability Report	Rev 01	
20840-PI-XKY-000-0001-Sheets 1-6	Plant Layout Drawing	Rev 01	
20840-PEN-WO-00-DR-P-0000-S3- PO1-Sheets 1-6	Piping Layout Drawing	Rev 01	
PJ20602-12-DDR-001	Wormington SCR Technical Feasibility Study	Rev A	
PAC1050295-01-7260-NGG-0036	Execution Programmes	Rev 01	National Grid
PAC1050295-01-7260-NGG-0011	GIS Site Screening Report	Rev 01	National Grid
PAC1050295-01-7260-NGG-0043	Risk Report	Rev 02	National Grid