Engineering Justification Paper

# Reading PRS

Final Version

Date: December 2019

Classification: Highly Confidential

# 1 Contents

# 2 Introduction

This project forms part of the Transmission Integrity programme within Southern Network for RIIO GD2. The integrity programme is generally health driven considering the health of transmission assets - offtakes, local transmission system (LTS) pipelines, pressure reduction stations (PRS) and ancillary assets. ‘Health’ includes condition (corrosion, cracking, spalling etc.) and reliability (in-service defects etc.).

In terms of engineering justification, the Authority has proposed the following model to differentiate between ‘major projects’ requiring justification in accordance with Appendix A guidance and ‘asset health’ projects justified in accordance with Appendix B.

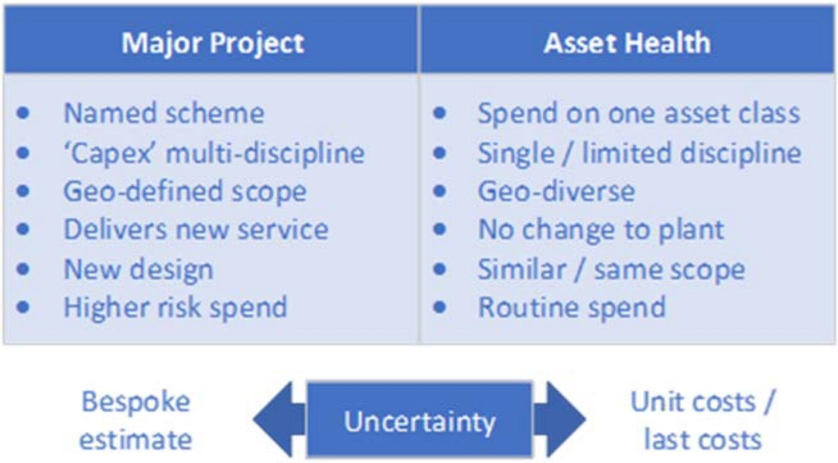


*Figure 1: Engineering Justification Guidance*

**Guidance for engineering justification**

The engineering justification for the majority of Transmission Integrity projects has been classified as ‘asset health’ and has been drafted in accordance with Appendix B since they are related to one asset class, are of limited discipline, relate solely to refurbishment or replacement of plant and have limited uncertainty. The Engineering Justification for the interventions at Reading PRS ‘A’ system has been prepared in accordance with Appendix B.

This project is to replace the heat exchangers and filter system at Reading PRS ‘A’ system.

**General background**

Reading ‘A’ System PRS lies alongside the river Kennet in a former gas holder site within the county of Berkshire

Security

Gas enters the site from the east off the local transmission system at 26 bar passing through a stand-alone filter bank, actuated slam shut valves, preheating and pressure regulation system. The gas pressure now reduces to 7 bar enters a common outlet manifold before splitting two ways to supply further on-site pressure regulation system’s and the local intermediate pressure network.

Today, the primary roles of a PRS are as follows:

- Filter the gas to at least 50µm,
- Pre-heat the gas prior to pressure reduction to combat the effects of the Joule-Thomson effect,
- Control the pressure of gas into the IP while ensuring pressures do not exceed the Maximum Operating Pressure within the downstream system.

Filtration, pressure control and pre-heating are typically designed in accordance with the Institution of Gas Engineers and Managers (IGEM) recommendations, IGEM/TD/13, Pressure regulating installations for natural gas, liquefied petroleum gas and liquefied petroleum gas / air.

**Site specific background**
'A' system PRS at Reading consists of three 24" vertical tower filters that form a standalone filter bank, hot water boiler gas pre heat system and triple stream gas regulation systems. Gas is supplied from the Local Transmission System (LTS), PO81 at pressures up to 26 barg. It is proposed to replace the filters and the shell and tube heat exchangers including the associated electrical and Instrumentation systems pre-emptively, prior to failure and the loss of supplies that would result.

Security

# 3 Equipment Summary

Gas enters the site from Grid main PO81 at pressures up to 26 bar in pipework rising above ground within the site boundary. Passing through a site isolation valve on to a common manifold supplying three 24'' vertically mounted tower filters. Two of the three filters would be in operation with one isolated for standby duty. The gas flow then continuous onto a common manifold before entering three individual streams of pressure reduction. Each pressure reduction stream has an in-line shell and tube heat exchanger to preheat the gas by utilising hot water from the modular condensing boilers on site.

The gas leaves the pressure reduction system at intermediate pressure before splitting into two further mains with one traversing the site to the south before existing to supply the local intermediate pressure network within Reading and Wokingham. The other forms a common manifold supplying a triple stream pressure reduction system on site known as 'B' system. Passing through the Intermediate to medium pressure reduction system, the gas continues on to provide gas to the medium pressure network in Reading and supply another pressure reduction system on site known as' C' system. The gas pressure here is again reduced this time to Low Pressure then leaves the site to the west via a dedicated pipe bridge over the river Kennet.

The project comprises the component replacement of the following:

- Pre-heating system and associated instrumentation systems.
- Filtration system and associated instrumentation systems.

It is not intended to intervene on the following assets:

- Pressure reduction system,
- Other instrumentation systems on site.

**Global Population**

SGN has the following numbers of Offtakes and PRS within Scotland and Southern networks (as reported during the 2018/2019 RRP):

| Network | Offtakes | PRS |
|---|---|---|
| **Southern** | 12 | 157 |
| **Scotland** | 18 | 131 |

*Table 1: No of Offtakes and PRS by Network*

**Pre-heating system**

The majority of these sites have gas pre-heating systems as follows:

| | Southern | | Scotland | |
|---|---|---|---|---|
| | Offtakes | PRS | Offtakes | PRS |
| **Boilers / heat exchangers** | 6 | 133 | 6 | 44 |
| **Water-bath heaters** | 6 | 19 | 10 | 61 |
| **Electrical element** | - | 3 | - | 4 |

*Table 2: Types of Pre-heating systems by Network*

Security

*Figure 4: 'A' System vertical tower filters*

# 4 Problem Statement

Heat exchangers and Filters are subject to the Pressure Systems Safety Regulations requiring a periodic inspection to be undertaken. An inspection is completed in accordance with a prescribed written scheme of examination.

All three in line heat exchangers of Reading ‘A’ system PRS require replacement due to known faults. Replacement of these heat exchangers and the installation will ensure continued integrity of the pre heat system, delivering greater security of supply

The heat exchangers have been classified as HI4 (material deterioration – intervention requires consideration, because of an independent defect assessment and fault condition

Filters are also subject to detailed inspection under the Pressure Systems Safety Regulations at periods of 6 and 12 years. Faults from these inspections are considered when assessing the continued fitness for purpose of these assets.

The filter system has been classified as HI4 (material deterioration – intervention requires consideration, because of an independent defect assessment.

**Impact of “do nothing” approach**

Failure to deliver the intervention to replace the pre-heating system will leave the existing system at a real risk of failure. The pre-heating system negates the loss of gas temperature during pressure reduction, a phenomenon known as the Joule-Thomson effect. A pressure reduction of up to 24.2bar will result in the loss in temperature of around 12$^0$C. Gas enters the site at temperatures down to around 5$^0$C meaning that gas could leave the site at -7$^0$C, below the acceptable operating temperatures for high pressure steel pipelines. The consequences include pipeline rupture, ignition and death, loss of supply of up to 96,210 customers or frost heave along the pipeline route, across roads and other transport infrastructure.

## 4.1 Narrative real-life example of problem

During GD1 SGN undertook several filter and heat exchanger replacements as both part of an agreed investment program and in-service failure.

Filters and heat exchangers are inspected under the pressure systems safety regulations at prescribed periods. Identified faults are proactively managed to ensure that the potential consequences of failure do not materialise. Faults found are subsequently reviewed by a competent inspectorate and a suitable remediation measure is recommended to ensure the continued safe operation of the asset. These recommendations are reviewed by SGN to ensure the best cost benefit solution for the expected life of the asset is implemented. Management of this nature has been completed during GD1 at sites such as Stoneham Lane PRS.

Further information on the potential consequences of not completing this work are described in section 6.

## 4.2 Spend Boundaries

The project will replace three heat exchangers and a triple stream tower filtration system. Exactly how this will be achieved will be determined during the detailed design phase of the project, but it is anticipated that this will entail modifications to the site pipework, a new fuel gas supply to a new preheating system and modifications to the electrical and instrumentation systems on site associated with the replaced equipment.

# 5 Probability of Failure

The failure rate and deterioration applied to calculate the CBA is consistent with the NARMs methodology. The key principle adopted in the methodology to facilitate the assessment of risk are:

- Asset health equates to the probability that the asset fails to fulfil its intended purpose and thus gives rise to consequence for the network.
- The consequences can be assessed in monetary terms
- The risk is determined from the product of the number of failures and the consequence of those failures

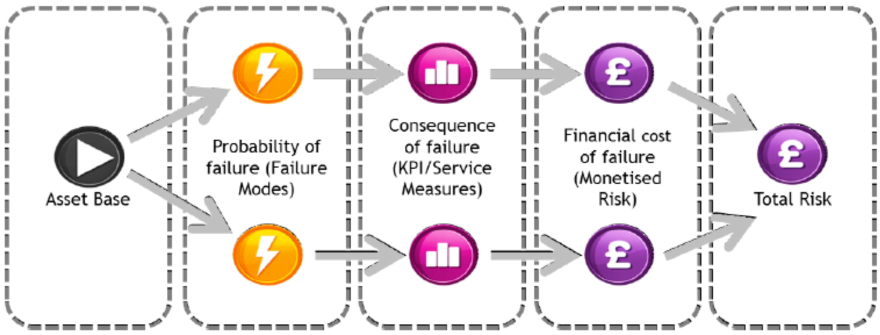


*Figure 4 : Outline of NARM's Model*

**Failure rate**

In the NARM framework 'failure rate' is used to calculate the Probability of Failure. The failure rate gives the rate of occurrence (frequency) of failures at a given point in time and may also include an age/time variable, known as asset deterioration, which estimates how this rate changes over time. The failure rate can be approximated by fitting various parametric models to observed data to predict failures now and in the future. Therefore, data that contributes towards monetised risk value has been thoroughly reviewed for each system under this investment.

**Failure modes**

In the NARMs methodology the failures are categorised into different Failure Modes. Below is list of all failure modes considered in the methodology and the resulting failure rates from the model, grouped by system.

**Preheating**

- **Release of Gas** - relating to the failure of a pressure containing component on site leading to an unconstrained release of gas within and possibly off the site
- **High Outlet Temperature** - relating to the failure of the preheating system to provide the correct heat input for that associated site gas flow rate resulting in high outlet temperatures
- **Low Outlet Pressure -** relates to the failure of the preheating system to provide the correct heat input for that associated site gas flow rate resulting in low outlet temperatures
- **Capacity -** where the system has insufficient capacity to meet a forecast 1:20 peak day downstream demand
- **General failure -** relates to other failures not leading to release of gas, low/high outlet temperature or capacity failures.

| Failure Mode | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 |
|---|---|---|---|---|---|---|
| Release of Gas | 0.20 | 0.28 | 0.38 | 0.53 | 0.73 | 1.00 |
| General Failure | 0.64 | 0.88 | 1.21 | 1.67 | 2.30 | 3.16 |
| High Outlet Temp | 0.03 | 0.05 | 0.06 | 0.09 | 0.12 | 0.17 |
| Low Outlet Temp | 3.62 | 4.98 | 4.98 | 4.98 | 4.98 | 4.98 |

*Table 3:Failure rate - Preheating*

**Pressure control and Filter**

- **Release of Gas** - relating to the failure of a pressure containing component on site leading to an unconstrained release of gas within and possibly off the site
- **Low Outlet Pressure** - relates to the failure of the Filter and Pressure Control system to supply gas at adequate pressure leading to partial or total loss of downstream supplies
- **Capacity** - where the system has insufficient capacity to meet a forecast 1:20 peak day downstream demand.
- **General failure** - relating to other failures not leading to either a safety, environmental or gas supply related consequence

| Failure Mode | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 |
|---|---|---|---|---|---|---|
| High Outlet Pressure | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Low Outlet Pressure | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Release of Gas | 0.23 | 0.23 | 0.25 | 0.28 | 0.32 | 0.35 |
| General failure | 0.10 | 0.10 | 0.11 | 0.13 | 0.14 | 0.16 |

*Table 4: Failure rate - Filters*

## 5.1 Probability of Failure Data Assurance

SGN's NARM's model has been developed based on methodology agreed for all networks with Ofgem which requires a set of base data. The base data for this site was originally the output of a data collection exercise conducted in 2011 and has been reviewed to more accurately reflect the current position. Any changes are summarised in the tables below.

| Preheating | | |
|---|---|---|
| **Asset Attributes** | **Modification** | **Reason** |
| **CONDITION_SCORE** | Score updated from 1 to 4 | The heat exchangers have PSSR faults following inspection, but the boiler system is in good working order. A risk assessment has been carried out on deferring replacement of the heat exchangers until GD2, hence why the score has only been increased to 4 rather than 5. |
| **KIOSK_CONDITION** | Score updated from 0.5 to 1. | There is no kiosk over the pressure reduction skid, filters or heat exchangers so the score should be changed to 1 to reflect this rather than having it half the risk. |
| **FENCE_CONDITION** | Score updated from 0.8 to 1 | The fence is in a serviceable condition, neither exceptional or poor so the score should be amended to reflect this |
| **Criticality** | Score updated from 0.01 to 0.1. | Analysis shows that Reading can be isolated from May to October for works to be undertaken which demonstrates that while the site is backed up it is not supported by strong multiple sources. |

*Table 5:Base data review – Preheating*

| Filter | | |
|---|---|---|
| **Asset Attributes** | **Modification** | **Reason** |
| **KIOSK_CONDITION** | Score updated from 0.5 to 1. | There is no kiosk over the pressure reduction skid, filters or heat exchangers so the score should be changed to 1 to reflect this rather than having it half the risk. |
| **FENCE_CONDITION** | Score updated from 0.8 to 1 | The fence is in a serviceable condition, neither exceptional or poor so the score should be amended to reflect this |
| **Criticality** | Score updated from 0.01 to 0.1. | Analysis shows that Reading can be isolated from May to October for works to be undertaken which demonstrates that while the site is backed up it is not supported by strong multiple sources. |

*Table 6: base data review - Filters*

# 6 Consequence of Failure

The consequences of failure at Reading PRS vary depending upon the way in which a failure occurs. A matrix of the failure modes and consequences are shown in Table 7 and the worst-case scenario for each of the main impact areas considered is discussed further.

| | Failure Consequence | | |
|---|---|---|---|
| **Failure Mode** | **Security of Supply** | **Safety Impact** | **Environmental Impact** |
| **Filter - release of gas** | If gas escape is significant, security of supply could be affected | Safety impact from risk of ignition, proportionate to the volume of the escape | Carbon emissions proportionate to the volume of the escape |
| **Preheating Equipment**<br>**Low outlet temperature (Failure at winter, brittle fracture due to cold temperatures)** | If brittle fracture causes a significant escape, security of supply could be affected | Safety impact is elevated compared to escape within the site, as this could affect pipework within proximity to the general public (although chilling will be most severe closer to the site). | Carbon emissions proportionate to the volume of the escape. Contamination of ground water from antifreeze /corrosion inhibitor |

*Table 7: matrix of Failure Mode against Failure Consequence*

**Loss of supply to customers**

Reading 'A' system PRS is a strategic supply within the heart of Berkshire supplying gas to customers in Reading and Wokingham to the north totalling failure to complete this works could affect supplies to 96,210 customers particularly during winter service.

**Safety impact of failure**

Reading 'A' system is located in a predominantly urban area, although flooded gravel pits dominate the area immediately to the north.

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An industrial / commercial estate lies beyond the site's eastern boundary, and residential areas lie beyond the site's southern boundary. There are risks for employees if they are present on site during a failure and this depends on the nature of the failure, and a failure of the filters are likely to disrupt operations of both railway services. There is a safety impact downstream because of a pipe failure which could occur if the site was operated without pre-heating for a prolonged period. This is the case for a lot of the year, including all the winter period.

**Environmental impact**

There are several potential environmental impacts possible if an asset failure were to occur at Reading 'A' System PRS were to occur. Firstly, there is the possibility of a release of gas at pressures up to the maximum operating pressure of the Local Transmission System (LTS) which supplies the site. This would result in a significant release of gas into the atmosphere until remedial actions could be taken to stop the leak. The water system used to provide preheating on site contains both glycol and corrosion inhibitors any potential loss of containment could cause potential contamination of the ground water and the local environment.

# 7 Options Considered

Within this Engineering Justification Paper there are several options which have been considered and discussed to address the issues at Reading PRS. The 4 core options being considered are as follows:

- Replace on Failure
- Repair on Failure
- Pre-Emptively Replace
- Pre-Emptively Repair

When considering this intervention, we have done so following our 4R strategy. This strategy is designed to maximise the asset life and minimise the capital expenditure of intervention and in doing so sets out an order of preference for the intervention type. This order is key in delivering customer value and focuses on the lighter intervention options of repairing and refurbishing the asset before considering more severe interventions such as full replacements of the existing assets. See below for an illustration of our 4R strategy:

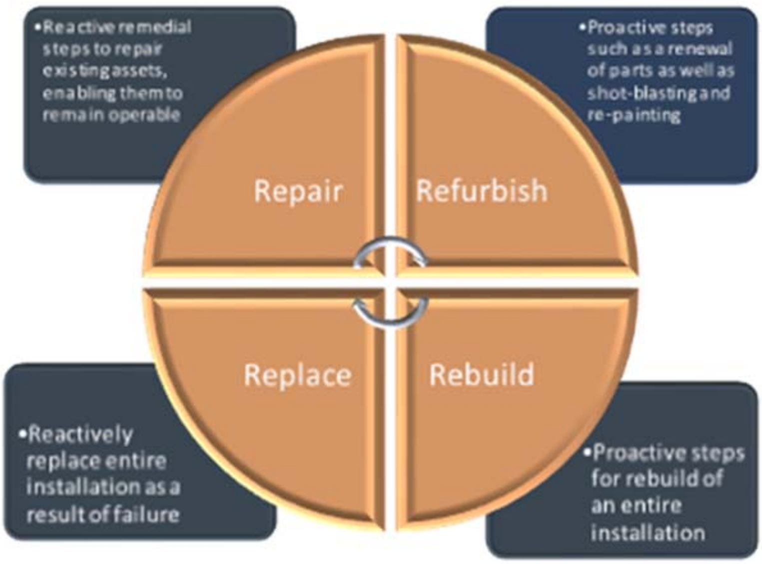


*Figure 5: 4R Strategy*

Following this strategy, the options of a reactive repair or proactive refurbishment are typically considered ahead of proactively rebuilding the site or carrying out a replacement reactively.

## 7.1 Replace on Failure

This option was rejected as the loss of the pre-heating system on site would lead to security of supply issue during the winter period. The lead time for a replacement unit can be 6-9 months based on SGN's experience during RIIO-GD1 during which time SGN couldn't meet its licence obligations.

Failure of the Filters would be catastrophic with the potential to harm both members of the public and on-site personnel in the event of a release of stored energy, along with the associated environmental impact of a large volume natural gas release. In addition, the PRS is adjacent to a major rail line so a failure would have significant impacts on the rail network.

**Not viable – License condition breach**

## 7.2 Repair on Failure

The option to repair on failure was considered but rejected due to the PSSR faults on the heat exchangers and filters and the method in which the filters would fail. It is not possible to undertake a repair on the heat exchangers due to the location of the defects.

Failure of the Filters would be catastrophic and instantaneous. A repair has been previously attempted and was unsuccessful. In addition, the PRS is adjacent to a major rail line so a failure would have significant impacts on the rail network.

**Not viable – License condition breach & not technically possible**

## 7.3 Refurbishment

The option for equipment refurbishment was considered but rejected due to the location of the defects on the heat exchangers and the previously attempted grind operation on the filters. The filters have PSSR faults and grind repairs have been undertaken in the GD1 without success so further refurbishment is not practical.

**Not viable – Not technically possible**

## 7.4 Pre-Emptive Replacement of the Pre-Heating System and Filters

This is the preferred option as it addresses the condition of the equipment and safeguards security of supply to customers.

**Viable – Preferred option**

**The technical detail of the option i.e. capacity, system rating, availability etc.**

The replacement pre-heating systems at Braishfield C PRS, have been designed to incorporate the predicted load growth for the next ten years, 114.5 kscmh and has a heat requirement of 393 Kwh. The PRS is rated for an inlet pressure range from 26.2BarG to 9.0BarG, with the outlet pressure range from 7.0BarG to 3.5BarG.

Security

**The basis for the cost estimate**
A budget estimate for the cost of delivering the proposed project at Reading PRS has been undertaken jointly by Commercial Confidentiality SGN. This draws on the expertise of one of the design houses we have partnered with to deliver projects in RIIO-GD1 as they understand many of the problems with a cost impact that have been encountered while delivering projects in GD1

This was done by conducting a desktop pre-feasibility study assessment of the project and how it could be delivered. The outturn cost estimate is considered to have an accuracy of -10% & +30% as there are still many uncertainties prior to starting the design process. SGN has experienced projects within RIIO-GD1 where the scope of the project had to be changed during the design process when it became evident that the original proposal was not viable due to operational or environmental constrain

Examples of this can be remediation to existing plant uncovered as result of implementing the proposed construction plan. Remediation is sound engineering judgement but adds significant cost to the project that had not been forecast earlier in the project life cycle.

To develop the budget, estimate a number of sources were used to derive aspects of the price. These were:

1) Indicative estimate of the cost from a supplier of the activity. While this cost estimate was being provided by a service provider or supplier relevant to the activity or item it is being done prior to any tender documentation, specifications or design work having been undertaken. This was the method by with the following were estimated:
    a. Design costs
    b. Materials whenever possible but this does also include some use of previous projects. Materials costs is an area which experienced a significant upward pressure during GD1 as all networks were tendering at the same time.

2) Based on previous costs incurred during RIIO-GD1. There have been many projects delivered offering a wide variety of interventions during GD1 which provide a selection of similar costs

to draw from when estimating future costs. This was the method by which the following were estimated:

a. Cost control, covering tender preparation and evaluation, Quantity surveying and post construction evaluation.
b. Specialist Services such as construction supervisor, CDM management, Pipeline Inspector, hydrostatic pressure testing and radiographic inspection of all welds.
c. Main Works Contractor (MWC). This is an area which had a significant upward pressure during GD1 due all networks tendering at the same time. These costs are very market dependant, based on how much work the contractors have at the time.
d. E&I costs. These are the costs other than those already covered within the design and MWC for a specialist E&I contractor and materials.
e. Miscellaneous other costs such as records collection, planning permission, land purchase, direct labour and removal of redundant equipment.

All values in Table 8 are net costs before any adjustments for efficiencies, overheads, operational difficulties and other factors.

**The perceived benefits of the option**

Removal of immediate risk to customers, for both security of supply following a failure of the filters and the risk of exposing the outlet to extremely cold gas with the potential creating gas leaks, frost heave or poor control of the regulators.

**Delivery timescales**

2021 to 2022 - Design

2022 to 2023 - Procurement

2023 to 2024 - Main Works Contractor, including decommissioning and removal of redundant systems

**Key assumptions made**

The desktop feasibility study is based on replacing the pre-heating system and filters in a parallel build due to lack of space in the existing stream to undertake an in-line replacement. This will be finalised during the detailed design process. Major projects identified additional costs from the desk top exercise, to the cost of the main works contractors and major skids increasing significantly, based on experience of current projects.

**Any other items that differentiate the option from the others considered**

This is the least cost fit for purpose option. The only other viable option would be to undertake a complete site rebuild costing millions of pounds more.

## 7.5 Complete Site Rebuild

The option to undertake a complete site rebuild was considered. While it also resolves the issues on site but replacing only the preheat and filtration systems also achieves this objective for a considerably lower cost, so it has been rejected. However, this option would lower the inherent risk associated with the PRS proximity to a major rail line.

**Viable – Rejected as not least cost option**

## 7.6 Do Nothing or Defer to GD3

This option was rejected as it doesn't address the risk to gas supplies presented by the condition of these assets and the risk of a major gas supply incident increases the longer equipment in this condition is continued to be operated. There are PSSR faults on the filters and heat exchangers and grind repairs have already been undertaken in GD1. This option was rejected as action is required to continue to comply with the Pressure System Safety Regulations (PSSR).

**Not viable – License condition breach & Legislative non-compliance.**

## 7.7 Options Technical Summary Table

The following options all generate catastrophic consequences and are therefore deemed unacceptable:

- Refurbish components,
- Replace on failure,
- Repair on failure,
- Do nothing.

Therefore, only one practicable option remains – **the component replacement of the filters and the gas pre-heating system**.

Other options, such as full rebuild of all systems, have not been considered as they represent unnecessary expenditure to replace functioning, fit for purpose assets.

| Option | First Year of Spend | Final Year of Spend | Volume of Interventions | Design Life (Yrs) | Total Cost (£m) (Gross) |
|---|---|---|---|---|---|
| **Replace on failure** | Not viable option | | | | |
| **Repair on failure** | Not viable option | | | | |
| **Refurbishment** | Not viable option | | | | |
| **Pre-Emptive Replacement of Preheating and Filter systems** | 2021/22 | 2023/24 | 2 systems | 40 | 3.23 |
| **Complete Site Rebuild** | Viable option but not costed as would cost significantly more than replacing only the systems at risk. | | | | |
| **Do Nothing** | Not viable option | | | | |

*Table 9: Options Technical Summary Table*

## 7.8 Options Cost Summary Table

The costs in Table 10 Table 10are net costs, before any efficiencies, operational difficulties, overheads and other factors are considered.

| Option | Cost Breakdown (£m) (Net) | Cost (£m) (Net) |
|---|---|---|
| **Replace on failure** | Not viable option | |
| **Repair on failure** | Not viable option | |
| **Refurbishment** | Not viable option | |
| **Pre-Emptive Replacement of Preheating and Filter systems** | Commercial Confidentiality | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | **Total** | **2.62** |
| **Complete Site Rebuild** | Not viable option | |
| **Do Nothing** | Not viable option | |

*Table 10 : Options Cost Summary Table*

# 8 Business Case Outline and Discussion

The failure of the heat exchanger and filtration systems of Reading 'A; System PRS is a High Impact Low Probability event (HILP). Several options to resolve this have been investigated but most have proved to not be viable. This is discussed further in section 7 and summarised in Table 9 and Table 10 .**Error! Reference source not found.** The two viable options are to replace the water bath heaters or to undertake a complete site rebuild. The lowest cost option is therefore to replace the obsolete water bath heaters which have been assessed through SGN's NARM's model Commercial Confidentiality . The resulting 35yr NPV for this option is £6.39m.

## 8.1 Key Business Case Drivers Description

The Cost Benefit Assessment (CBA) for both the baseline position and the preferred option is as follows shown in Figure 7.

Note: This data has been extracted from the Authority's RIIO GD2 CBA template and using the output from SGN's Monetised Risk solution Commercial Confidentiality , which has been fully validated against the Network Output Measures methodology.

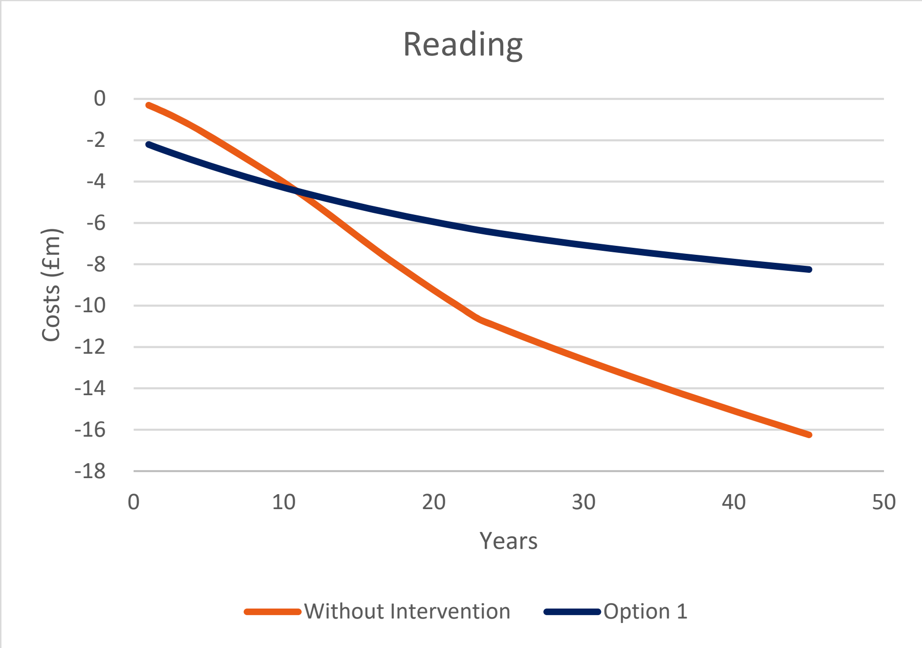


*Figure 8: CBA for preferred option*

The detail behind these trends are as follows:

| NPVs based on Payback Periods (absolute, £m) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Option No.** | **Desc. of Option** | **Preferred Option (Y/N)** | **Total Forecast Expenditure (£m)** | **Total NPV** | **2030** | **2035** | **2040** | **2050** |
| Baseline | Repair on failure | N | -0.17 | -16.28 | -3.57 | -6.14 | -8.76 | -12.35 |
| 1 | Pre-Heating & Filter System Replacement (Absolute NPV) | Y | -3.40 | -8.28 | -4.09 | -5.02 | -5.81 | -6.98 |
| 1 | Pre-Heating & Filter System Replacement (Relative to Baseline NPV) | Y | -3.40 | -8.28 | -0.52 | 1.12 | 2.95 | 5.37 |

*Table 11: Summary of CBA Results*

Data for the CBA has been taken directly from the Monetised Risk / NARMs methodology as coded and validated within the Commercial solution.

The modelled failure modes are expected to generate repairable failures (failure rates > 1) rather than end-of-life failures (maximum failure rate = 1). The current version of NARMs Methodology (V3.2) duly provides escalating long-term benefit. The failure rates calculated are based on exponential degradation which increases significantly over long term. To realistically assess the CBA produced by NARMs, the values used in this CBA calculation are capped based on engineering judgement and to take into account 'mean time to repair' and increased observation post failure.

The failure node for transmission assets are grouped into the following categories:

1. **Catastrophic Failure**: End-of-life failure leading to an unconstrained *Release of Gas*.
2. **System Failure**: failure leading to lack of control such as:
    - *High Outlet Pressure*
    - *High Outlet Temperature*
3. **General Failure**: minor issues not leading major consequence.

| Failure Node | Failure category | Capped at |
|---|---|---|
| **Preheating - Release of Gas** | Catastrophic Failure | 1 |
| **Preheating - General Failure** | General Failure | 10 |
| **Preheating - High Outlet Temp** | System Failure | 5 |
| **Preheating - Low Outlet Temp** | System Failure | 5 |
| **PC&F - Release of Gas** | Catastrophic Failure | 1 |
| **PC&F - General failure** | General Failure | 10 |
| **PC&F - High Outlet Pressure** | System Failure | 5 |
| **PC&F - Low Outlet Pressure** | System Failure | 5 |

*Table 12: Probability of Failure Capping*

The capping is implemented from 2021 so some systems may already have exceeded the limit by that point and will be capped at that level onwards.

This capping eliminates the noise created by exponential degradation which an asset realistic would never be in operation. These capped failures refine the CBA to a more realistic output in accordance with the asset management principles.

| Option | Key Value Driver |
|---|---|
| Replace on failure | • long term loss of supply to customers while the project is being undertaken.<br>• Unknown amount of damage caused by failure.<br>• Impact on national rail network. |
| Repair on failure | • long term loss of supply to customers while the project is being undertaken.<br>• Unknown amount of damage caused by failure.<br>• Impact on national rail network. |
| Refurbishment | • long term loss of supply to customers while the project is being undertaken. |
| Pre-Emptive Replacement of Preheating and Filter systems | • Continuity of supply and reduction in both safety and environmental risks associated with the loss of heating and brittle failure of the downstream systems. |
| Complete Site Rebuild | • Continuity of supply and reduction in both safety and environmental risks associated with the loss of heating and brittle failure of the downstream systems. |
| Do Nothing | • Potential, long term loss of supply to customers, safety and environmental impact due to cold fracturing. Protection of the downstream system, ensuring SGN does not have a "system failure" means the unintentional release of stored energy from a pressure system. |

*Table 13: Key Value Driver Summary*

## 8.2 Business Case Summary

Only one option is deemed adequate to reduce the probability of failure of the pre-heating systems and Pressure reduction systems and to mitigate the consequences of failure at Reading.

The preferred option is therefore to undertake a full site rebuild at a gross cost of £3.23m.

| | System Replacement |
|---|---|
| GD2 Capex (£m) | 3.23 |
| Number of Interventions | 0.00 |
| Carbon Savings ktCO2e (GD2) | 4808.70 |
| Carbon Savings ktCO2e /yr | 961.74 |
| Carbon Emission Savings (35yr PV, £m) | 3.05 |
| Other Environmental Savings (35yr PV, £m) | 0.00 |
| Safety Benefits (35yr PV, £m) | 6.50 |
| Other Benefits (35yr PV, £m) | 0.00 |
| Direct Costs (35yr PV, £m) | -3.17 |
| NPV (35yr PV, £m) | 6.39 |
| **High Carbon Scenario** | |
| Carbon Emission Savings (35yr PV, £m) | 4.58 |
| High Carbon NPV (35yr PV, £m) | 7.91 |

*Table 14: Business Case Matrix*

# 9 Preferred Option Scope and Project Plan

## 9.1 Preferred option

The preferred option is to replace the pre-heating and filter system alongside the associated electrical and instrumentation (E&I) equipment at Reading 'A' System PRS

## 9.2 Asset Health Spend Profile

| Asset Health Spend Profile (£m) | | | | | | |
|---|---|---|---|---|---|---|
| | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 | Post GD2 |
| System Replacement | 0.43 | 1.11 | 1.69 | 0.00 | 0.00 | 0 |

*Table 15: Asset Health Spend Profile*

## 9.3 Investment Risk Discussion

**Sensitivity Analysis**

Sensitivities have been applied to the Transmission Integrity CBAs as follows:

- Variations in Capex project cost have been applied for the range -10% to +20%. These are considered realistic ranges based on our experience in GD1 and the likely pressures on cost in relation to the procurement of materials and main contracts.
- Variations in methane levels (and therefore environmental impact) have been considered to take account of the anticipated introduction of hydrogen. SGN have committed to a 'net zero' carbon network by 2045. In practice that means no methane by that date. Also, while the use of hydrogen in distribution is being actively investigated and hydrogen is currently being introduced into a network for the first time since the conversion to natural gas, it is considered very unlikely that hydrogen will be injected on a wider scale until RIIO-GD3. For these reasons, methane levels have been considered in three ranges: aggressive early transition, mid-case and late transition.

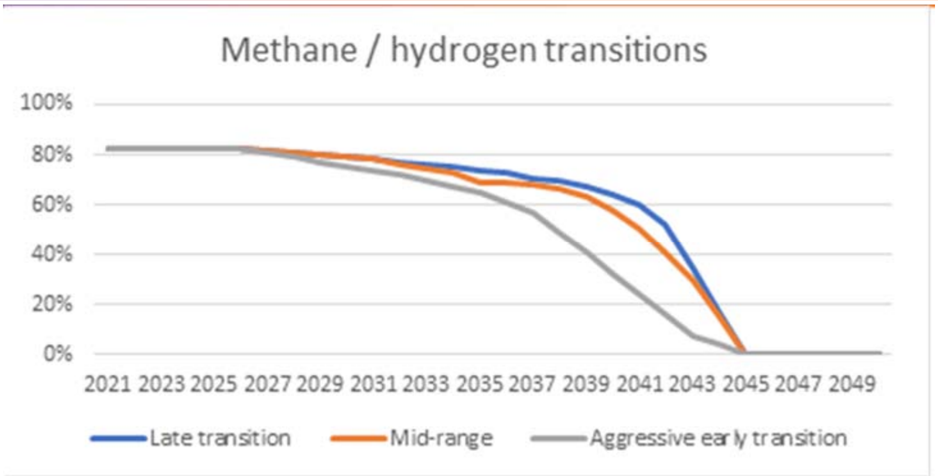


*Figure 9: Methane / Hydrogen transition - Sensitivities*

The current version of the CBA template, version 4, already acknowledges that methane is estimated to be 28 times more damaging than $CO_2$. This figure is taken from the IPCC Fifth Assessment Report published in 2014. Since this figure is derived from the latest science, it is not considered prudent to test for sensitivity in this area.

Sensitivity in the value / cost of carbon is already included within the CBA template with base-case and high-case scenarios mapped out. These sensitivities are considered sufficient in our CBA.

| | Low | Mid | High |
|---|---|---|---|
| GD2 Capex (£m) | 2.91 | 3.23 | 3.88 |
| Number of Interventions | 0 | 0 | 0 |
| Carbon Savings ktCO2e (GD2) | 4,809 | 4,809 | 4,809 |
| Carbon Savings ktCO2e /yr | 962 | 962 | 962 |
| Carbon Emission Savings (35yr PV, £m) | 3.1 | 3.1 | 3.1 |
| Other Environmental Savings (35yr PV, £m) | 0 | 0 | 0 |
| Safety Benefits (35yr PV, £m) | 6.5 | 6.5 | 6.5 |
| Other Benefits (35yr PV, £m) | 0.0 | 0.0 | 0.0 |
| Direct Costs (35yr PV, £m) | -2.9 | -3.2 | -3.8 |
| NPV (35yr PV, £m) | 6.7 | 6.4 | 5.7 |

*Table 16: Sensitivity Results*

Project payback has not been carried out as part of this analysis due to the effect of the Spackman approach. For a cash-flow traditional project payback period please see scenario 4 of our Capitalisation Sensitivity table.

**Capitalisation Rate Variation**

Consumers fund our Totex in two ways – opex is charged immediately though bills (fast money – no capitalisation) and capex / repex is funded by bills over 45 years (slow money – 100% capitalisation). The amount deferred over 45 years represents the capitalisation rate. Traditionally in 'project' CBA's the cashflows are shown as they are incurred (with the investment up front which essentially is a zero capitalisation rate). Therefore, we have developed scenarios that reflect both ways of looking at the investment – from a consumer and a 'project'.

The scenarios are summarised as follows:

- Scenario 1 - we have used the blended average of 65%, used in previous iterations of this analysis.
- Scenario 2 - we have represented the Capex and Opex blend for the two networks, as per guidance.

- Scenario 3 - addresses our concerns on capitalisation rates whereby Repex and Capex spend is deferred (100% capitalisation rate) and Opex is paid for upfront (0% capitalisation rate).
- Scenario 4 - this reflects the payback period in 'project' / cash-flow terms and provides a project payback.

We have taken a view of the NPV in each of the scenarios, with the exception of scenario 4, at the 20, 35 and 45 Year points, to demonstrate the effect of Capitalisation Rate on this value.

| Scenario | 1 | 2 SO | 3 | 4 |
|---|---|---|---|---|
| Capex (%) | 65 | 38 | 100 | 0 |
| Opex (%) | 65 | 38 | 0 | 0 |
| Repex (%) | 100 | 100 | 100 | 0 |
| **Output** | | | | |
| NPV (20yr PV, £m) | 3.45 | 3.30 | 3.91 | |
| NPV (35yr PV, £m) | 6.40 | 6.39 | 6.63 | |
| NPV (45yr PV, £m) | 7.99 | 8.00 | 8.14 | |
| Payback | 9.00 | 10.00 | 0.00 | 12.00 |

*Table 17: Capitalisation Rate Variation*

# Appendix A - Glossary of Terms

**Cost benefit analysis (CBA)** – economic assessment of available options to resolve a problem.

**CPNI** - Centre for the Protection of National Infrastructure.

**Engineering Research Station (ERS)** - A research and development arm of British Gas that no longer exists.

**Electrical and Instrumentation (E&I)** – commonly used acronym for all electrical, instrumentation and control systems on operational gas sites.

**High Impact Low Probability (HILP)** – A term to explain an event which would create a very significant impact if it were to occur but has a very low likelihood of occurring.

**Local Distribution Zone (LDZ)** – A geographic area used determined based the configuration of the gas network and used for billing. Southern Gas Network consists of South and South East LDZ's.

**Liquified Natural Gas (LNG)** – Gas that has been cooled sufficiently to cause it to change from a gas into a liquid. Commonly used to transport natural gas by ship around the world.

**Local Transmission System (LTS)** – A high pressure gas transportation network within a distribution networks control. These are supplied from the NTS and transport gas to town and cities before using PRS to supply lower pressure tiers.

**Main Works Contract (MWC)** – For large engineering projects a contract with a principal contractor is tendered to construct the project.

**Non-Destructive Testing (NDT)** – inspection methods used to assess the condition of equipment that doesn't have any impact on the integrity of the equipment being inspected. An example would be using X-Rays to inspect pipeline welds to ensure that they meet the specification.

**Network Asset Risk Models (NARM's)** – The methodology used to create a common monetised risk for all gas distribution network assets.

**National Transmission System (NTS)** – The bulk transportation system for gas in the UK from major inputs such as gas terminals and LNG stations to LDZ offtakes and very large users such as power stations.

**Pressure Reduction System (PRS)** – Installation used to reduce the pressure of gas between pressure systems.

**Water Bath Heater (WBH)** – A type of gas pre-heating system that heats a large volume of water through which gas pipes are run in order to exchange heat from the water into the gas. They were used on sites with a high heating requirement.

# Appendix B - References

1. Commercial Confidentiality