

Engineering Justification Paper

Godstone PRS Pre-Heating System Replacement

Final Version

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Classification: Highly Confidential



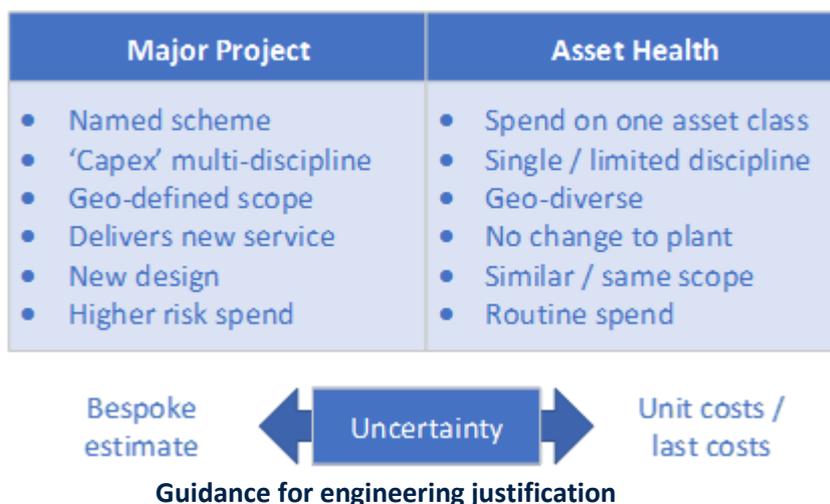
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2 Introduction

This project is one element 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.



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 Godstone PRS has been prepared in accordance with Appendix B.

This project is to replace the heating and systems at Godstone PRS and will remove the risks associated with the site for 5,000 customers. This component replacement has been identified as the only acceptable engineering solution, as there are no issues with the other key components on site. This project is to replace the existing heating systems and includes the installation of new boilers and heat exchangers.

General Background

Godstone PRS is in the county of East Surrey, within Tandridge District Council and supplies natural gas to around 5,000 customers within the local area. The site is next to the A22 dual carriageway and just off junction 6 of the M25 London orbital motorway.

The HP to MP PRS was designed and installed in 1997/98 to meet increasing gas demand and to reduce the demand from the neighbouring Whyteleafe PRS, that supplies the same outlet MP system 6.3 km to the north.

Security*Location of Godstone PRI*

Godstone PRS is contained within a compact, above ground and secure site at the foot of Godstone Hill, abutting Godstone Corner Wood on the escarpment of the North Downs. The existing PRS and gas pre-heating system was installed 22 years ago as a new 'green field' site to meet increasing gas demand. The system of pre-heating used at the time was considered an innovative, low cost, compact and a simplified approach. This heating equipment is now obsolete, worn, at the end of its operational life and does not meet the requirements of IGEM/TD/13. It also contravenes SGN's Policies and standards regarding security of gas supplies, safeguarding downstream pipework integrity and operational reliability. The existing pre-heat system is also based upon non-condensing technology and has an energy/heat transfer efficiency of around 50% to 60%, that falls far short of SGN's energy conservation and environmental impact targets and policies.

3 Equipment Summary

SGN's owned Godstone pressure reduction station reduces the gas pressure from High Pressure, up to 38BarG, into a 1.4BarG Medium Pressure network that runs from Whyteleafe to Limpsfield. The PRS is essential for supplying gas to fifteen, downstream Distribution, pressure reducing governors, to provide LP gas to customers at a temperature of not less than +0°C. The PRS at Godstone is critical for LP gas supplies to the towns Godstone, Limpsfield, Oxted and Hurst Green and is fed from a 750mm nominal size buried HP pipeline denoted Grid Main 23.

Security

This pre-heater is essential to heat the gas prior to pressure reduction. This will ensure the downstream system is protected from the freezing effect first identified by Joule-Thomson in the 1850's. For depressurising natural gas, this unavoidable freezing effect equates to around -0.5°C for every 1 bar of pressure drop. Without pre-heat at Godstone PRS, the outlet gas temperature could rapidly fall to -20°C during prolonged winter conditions.

Other site equipment:

- PRS stream inlet and outlet isolation valves
- Filters
- Pre-heating system pipework and connections
- Protective slam-shut valves
- Regulators
- Non return valves

80mm nom size 'Barton Firtop' gas process filters.



One water bath heater vessel fitted with a 'Lanemark Combustion Engineering Ltd' 'TX' series, gas fired, process burner, with immersion tubes and inlet air and exhaust fans.



An elevation of the WBH with thermal insulation



The 'Lanemark' gas burner assembly



38 BarG flow and return gas pipework

Two 50mm nominal size ‘Tartarini - BM5’ inlet slam-shut valves, that are the PSSR ‘primary protective devices’ for protecting the downstream system from PRS malfunction and over-pressurisation.



First stage pressure reducing regulator

Second stage pressure reducing regulator



Two per stream, 50mm nominal size ‘Mooney – Flowgrid’ regulators, configured for 2 stage pressure reduction

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 |

Pre-heating system

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

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

4 Problem Statement

Why are we doing it?

The Lanemark gas heating system at Godstone PRS was the last of its type to be installed by SGN and was considered an innovative approach to gas pre-heating. This type of heating system was first introduced in the early 1990's following a review of the heating requirements philosophy and was considered to offer better value due to its simplicity and reduced cost and infrastructure. The heating system at Godstone was installed in line with this philosophy, as part of a programme for sites with smaller gas demand. The system comprises of a small, singular, compact, carbon steel bodied, gas fired water bath heater, where hot exhaust gas heats a water vessel at atmospheric pressure. The heat is transferred to internally to the HP gas transmission pipework, so pumps are not required. After ten years operational experience and performance monitoring, this low cost, non-condensing, moderate risk-based approach was revoked. A new, fully compliant risk based approach has been adopted and implemented, with stand-by facility and far better reliability and temperature control.

With low cost installations of this type there is no stand-by heating capacity, contravening the philosophy and minimum standard set by the Institute of Gas Engineers and Managers design standard IGEM TD/13. There have been numerous heating system failures for this type, that have exposed the network to integrity, supply and safety risks, associated with freezing outlet gas and pipework temperatures.

At Godstone, the outlet transitions from Steel to polyethylene after only around 70 metres, this being susceptible to failure as there is minimal opportunity for heat recovery from the ground.

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 37BarG will result in the loss in temperature of around 18.5°C. Gas enters the site at temperatures down to around 5°C meaning that gas could leave the site at -13.5°C, far below the acceptable operating temperatures for PE pipelines, which starts 70m from Godstone PRS. The consequences include pipeline rupture, ignition and death, potential loss of supply to customers or frost heave along the pipeline route, across roads and other transport infrastructure.

Failure to deliver the intervention to replace the heating system, would lead to a prolonged outage if they were to fail. As the equipment is obsolete and no spares are available, the outcome would be a potential loss of supply to around 5,000 customers.

How do we know we have achieved the outputs

The project will be successful if delivered on time in budget and with no impact on customers. Monitor the sites performance of the site through the gas control DNCS monitoring the gas outlet temperature and gas outlet pressure and performance monitoring through routine maintenance.

Spend Boundaries

The project will replace the sites existing gas fired water bath heater, controls and dedicated auxiliary equipment. Exactly how this will be achieved will be determined at the start of the design and costing phase for the project. It is anticipated that this will entail modifications to the sites HP

inlet pipework, installing a new fuel gas supply for the pre-heating system and modifications to the on-site electrical and instrumentation systems associated with the replacement equipment. A small, preferably gas fired electrical generator will also be installed to ensure that the new pre-heating system will continue to operate in the event of loss of the sites incoming electrical supply. The existing stream filters, regulators, valves, including protective slam-shuts will not be replaced as part of this project but will be subject to further inspection for performance, condition and defects during RIIO-GD2.

The spend of this project is to replace the existing, twenty year old gas pre-heating system at Godstone PRS and associated electrical, instrumentation and auxiliary equipment. Dependent upon the type of replacement, this could include modifications to the HP inlet pipework for two new in-line heat exchangers, connected to a compact boiler house with stand-by facility and LP gas supply. The boiler house will require concrete foundations and at least two gas fired, condensing boilers and associated, thermally insulated flow and return, heated water pipework.

This work is to be completed as a PRS ‘partial rebuild’, which is the most cost effective method of reducing the current risks. Complete rebuild of the PRS has been discounted, as this would renew twenty year old components that do not require replacement within GD2 and therefore not a cost effective option.

This project will not change the filters, pressure control equipment or E&I equipment not associated with the Heating system.

5 Probability of Failure

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 any data modification made to the model.

Pre-heating

- **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 pre-heating 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 pre-heating 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 winter, downstream demand
- **General failure** - relates to other failures not leading to release of gas, low/high outlet temperature or capacity failures.

| Pre-heating | | |
|------------------------|---------------------------|---|
| Asset Attributes | Modification | Reason |
| CONDITION_SCORE | Score updated from 2 to 4 | No redundancy/stand-by - heating on single stream only |
| NO_EFFECT_PRI | Changed from 1 to 8.3 | Over the last 6 years there has been 50 pre-heating faults recorded. This equates to 8.3 faults per year. |
| LOW_OUTLET_TEMPERATURE | Updated from 5 to 1.3 | 8 low temperature faults recorded over the 6-year period from our telemetry data. This equates to 1.3 faults per year |

5.1 Probability of Failure Data Assurance

SGN's NARM's model has been developed based on methodology agreed for all gas networks with Ofgem which users require a set of base data. The base data for this site was the output of an extensive and component focused data collection exercise conducted in 2011.

| Health and Criticality – Godstone PRI Preheating | | |
|--|---------|--|
| Asset Attributes | Rating | Reason |
| CONDITION_SCORE | Score 4 | The WBH pre-heating system was commissioned in January 1998. The 2011 Asset Condition Score was derived as 4, based upon obsolescence and no essential spares. The site has not had any integrity, nor uprating work completed on the pre-heating system for 21.5 years operation. The pre-heating system, instruments, controls and associated fuel gas pressure breakdown are reaching the end of their operational lives. |

Below are the failure rates derived from the model for the failure mode:

Preheating

| Failure Mode | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 |
|------------------|------|------|------|------|------|------|
| Release of Gas | 0.07 | 0.08 | 0.09 | 0.11 | 0.12 | 0.15 |
| General Failure | 3.48 | 4.09 | 4.80 | 5.63 | 6.61 | 7.76 |
| High Outlet Temp | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 |
| Low Outlet Temp | 1.29 | 1.51 | 1.78 | 2.09 | 2.45 | 2.87 |

Failure Rate Table – Pre-heating

6 Consequence of Failure

In the NARM methodology Consequence of Failure is analysed for each failure mode and every Consequence of Failure has an assigned Probability of Consequence (PoC). This is determined through consequence analysis techniques such as:

- Statistical analysis of associated failure data
- HAZOP techniques (Risk assessment)
- Historic incident data
- GIS (Geographic Information System) analysis
- Network modelling analysis

Each Consequence of Failure in the model have an associated financial cost (Cost of Consequence), based upon the type and scale of impact, representing a monetary risk value. These Consequence of Failure are split into the following categories:

- Customer Risk – Loss of supply
- Health and Safety Risk – Death, injuries, property damage, etc.
- Environmental risk
- Other financial Risk – Repair, Maintenance, etc.

The below Matrix plots the credible failure modes against how severely it will affect each of the consequences. These are colour coded to give a visual representation of the likely impact:

| Failure Mode | Failure Consequence | | |
|---|---|--|--|
| | Security of Supply | Safety Impact | Environmental Impact |
| Pressure Regulating Equipment (Both Slamshuts Closed) | Security of Supply would be lost for a significant quantity of customers with both slamshuts closed | No direct effect | No direct effect |
| Pressure Regulating Equipment (Overpressurisation of Outlet) control equipment freezing as heating system failed. | If overpressurisation 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 | Carbon emissions proportionate to the volume of the escape |
| Preheating Equipment (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 |

7 Options Considered

Within this Engineering Justification Paper for there are 4 options which have been considered and discussed to address the pre heating at Godstone 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:

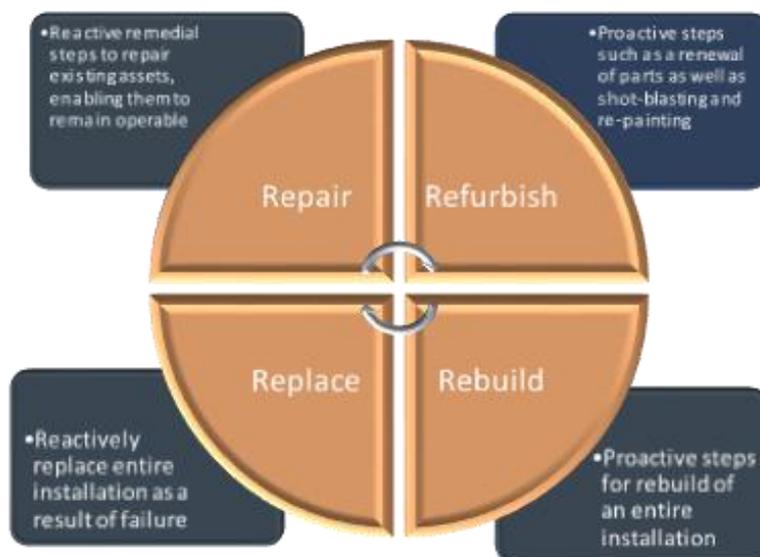


Diagram of 4R Strategy. Repair and Refurbish options at the top are considered before resorting to Replace or Rebuild at the bottom

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 Do nothing

This option has been discarded due to no redundancy or stand-by facility within the sites existing heating system. There is also limited heat capacity and lack of serviceable components such that breakdown of failure would lead to loss of gas supplies for significant periods.

7.2 Refurbish components

Refurbishment of components is not an option as the equipment is obsolete and spares are not available should derive a short-term extension of the life of the asset. However, refurbishment has already been attempted to both the pre-heating and volumetric control systems with limited or no success.

7.3 Replace on failure

With key replacement equipment being on long lead times, should the equipment fail, the heating system would not be available for a prolonged period. This would put the downstream system at high risk for supply failures and gas releases.

7.4 Repair on failure

This option has been discounted as there is no stand-by facility within the sites existing heating system. Component or system failure would quickly lead to sub-zero gas temperatures and potential long-term heating system outage. Unless the site is isolated, this will greatly increase the risks for loss of outlet gas supply, consequential pipework failure resulting in uncontrolled gas escapes.

7.5 Preheating replacement

The option to replace the sites heating system is the preferred option. The new and replacement system will be fully serviceable, include a stand-by heating facility, with increased thermal efficiency and more accurate temperature control.

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

The new heating system at Godstone PRS, has been designed to incorporate the predicted load growth for the next ten years, 4.8kscmh and has a heat requirement of 32Kwh, with 100% redundancy in accordance with IGEM TD/13.

The basis for the cost estimate/unit cost

Following an initial costed design by **Commercial Confidentiality** in report “SGN GD2 Mechanical & Civil Budget Analysis” SGN Trans - 009Gods - EJP Dec19. the costings were reviewed by SGN Major Projects using experience from GD1.

Commercial Confidentiality

The perceived benefits of the option

Removal of immediate risk to 5000 customers for both security of supply following a failure of the regulators, with the associated long lead time on key pieces of equipment and 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

2023 - Design

2024 - Procurement

2025 – Main Works Contractor

2025 – decommissioning and removal of redundant system

Key assumptions made

Major projects identified additional costs from the desk top exercise, these include bringing the below ground control room to a new kiosk above ground, demolition of the existing boiler house. With the cost of the main works contractors increasing significantly, based on experience of current projects.

Any other items that differentiate the option from the others considered

This is the only credible option.

7.6 Options Technical Summary Table

Table – Options Technical Summary

| Option | First Year of Spend | Final Year of Spend | Volume of Interventions | Total Cost |
|----------------------------|---------------------|---------------------|-------------------------|------------|
| 1 (Preheating replacement) | 2023 | 2025 | 1 | £1.69 |

7.7 Options Cost Summary Table

Table – Cost Summary

| Option | Cost Breakdown | Total Cost (£m) |
|----------------------------|---|-----------------|
| 1 (Preheating replacement) | See report attached “SGN Trans - 009Gods - EJP Dec19” | £1.69 |

Projects costing have been achieved through the following process and includes contingency numbers, efficiencies and overheads to give the total gross cost:

- Initial scoping of works including design parameters,
- Desk-top feasibility study using design consultants with full awareness of GD1 projects,
- Contact with manufacturers,
- Additional assessment by Project Managers to take into account local site conditions, constraints and costing information based on recent projects. Including increasing significantly the cost for the main works contractors.
- Review by Asset Manager (client).

8 Business Case Outline and Discussion

The system is a critical supply to the MP system. The main drivers for a complete a heating system replacement, is non-compliance with IGEM TD/13 no stand by heating availability and the heating system is obsolete equipment, which would have a prolonged outage if a component failed. Failure to deliver this work, will put the 5,000 customers at risk pf losing their gas supplies, potentially for up to a year. A number of interventions have been considered. However, the benefits are considered inadequate in mitigating the current issues.

8.1 Key Business Case Drivers Description

Table – Summary of Key Value Drivers

| Option No. | Desc. of Option | Key Value Driver |
|------------|------------------------|---|
| Baseline | Repair on failure | Potential, long term loss of supply to customers, safety and environmental impact due to cold fracturing |
| 1 | Preheating replacement | License condition for the continuity of supply to 5,000 customers Reduction in both safety and environmental risks associated with the loss of heating and brittle failure of the downstream systems |

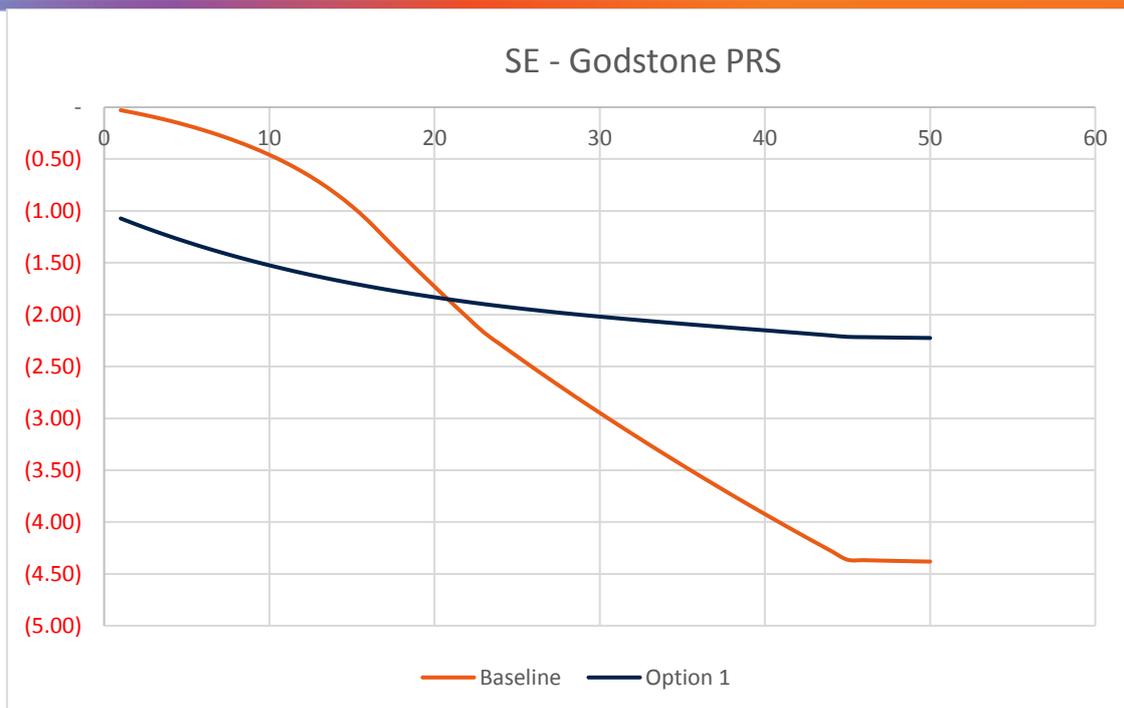
Table – Summary of CBA Results

| NPVs based on Payback Periods (absolute, £m) | | | | | | | | |
|--|-----------------------------------|------------------------|---------------------------------|-----------|-------|-------|-------|-------|
| Option No. | Desc. of Option | Preferred Option (Y/N) | Total Forecast Expenditure (£m) | Total NPV | 2030 | 2040 | 2040 | 2050 |
| Baseline | Repair on failure | N | -0.12 | -4.38 | -0.39 | -0.83 | -1.58 | -2.84 |
| 1 | Option 1 Absolute NPV | Y | -1.78 | -2.22 | -1.48 | -1.67 | -1.81 | -2.00 |
| 1 | Option 1 NPV relative to Baseline | Y | -1.78 | -2.22 | -1.09 | -0.84 | -0.23 | 0.84 |

8.2 Business Case Summary

Table - Business Case Matrix

| | Preheater Replacement |
|---|-----------------------|
| GD2 Capex (£m) | 1.69 |
| Number of Interventions | 1.00 |
| Carbon Savings ktCO ₂ e (GD2) | 217.23 |
| Carbon Savings ktCO ₂ e /yr | 43.45 |
| Carbon Emission Savings (35yr PV, £m) | 0.36 |
| Other Environmental Savings (35yr PV, £m) | 0.00 |
| Safety Benefits (35yr PV, £m) | 2.47 |
| Other Benefits (35yr PV, £m) | 0.01 |
| Direct Costs (35yr PV, £m) | -1.48 |
| NPV (35yr PV, £m) | 1.36 |
| High Carbon Scenario | |
| Carbon Emission Savings (35yr PV, £m) | 0.55 |
| High Carbon NPV (35yr PV, £m) | 1.55 |



9 Preferred Option Scope and Project Plan

9.1 Preferred option

The preferred option for Godstone PRS is to replace the sites existing pre-heating system with two heat exchangers, new connecting pipework, a boiler house with multiple gas fired, condensing boilers, with stand by capacity.

9.2 Asset Health Spend Profile

The anticipated asset spend profile is as follows:

| Asset Health Spend Profile (£m) | | | | | | |
|---------------------------------|---------|---------|---------|---------|---------|----------|
| | 2021/22 | 2022/23 | 2023/24 | 2024/25 | 2025/26 | Post GD2 |
| Preheater Replacement | 0.00 | 0.00 | 0.20 | 0.56 | 0.93 | 0 |

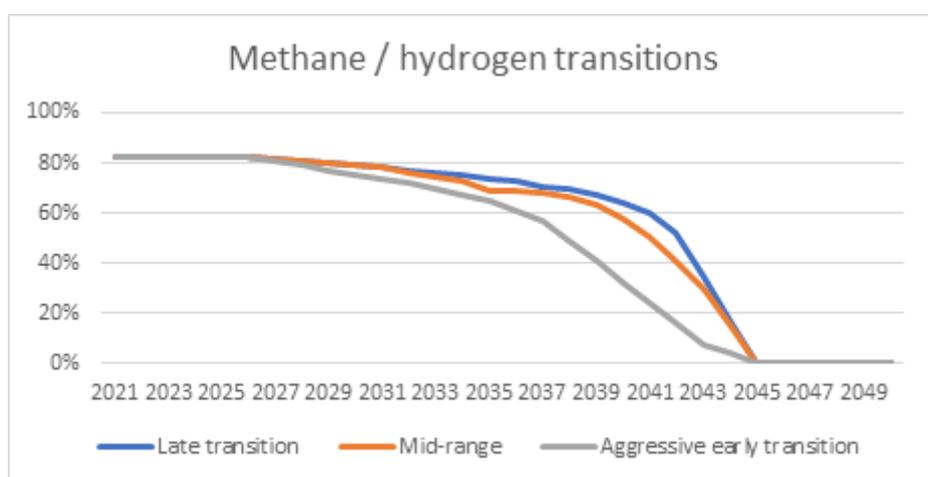


9.3 Investment Risk Discussion

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.

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 CO₂. 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) | 1.52 | 1.69 | 2.03 |
| Number of Interventions | 1 | 1 | 1 |
| Carbon Savings ktCO ₂ e (GD2) | 217 | 217 | 217 |
| Carbon Savings ktCO ₂ e /yr | 43 | 43 | 43 |
| Carbon Emission Savings (35yr PV, £m) | 0.4 | 0.4 | 0.4 |
| Other Environmental Savings (35yr PV, £m) | 0 | 0 | 0 |
| Safety Benefits (35yr PV, £m) | 2.5 | 2.5 | 2.5 |
| Other Benefits (35yr PV, £m) | 0.0 | 0.0 | 0.0 |
| Direct Costs (35yr PV, £m) | -1.3 | -1.5 | -1.8 |
| NPV (35yr PV, £m) | 1.5 | 1.4 | 1.0 |

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.

Consumers fund our Totex in two ways – opex is charged immediately through 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 | 3 | 4 |
|-------------------|-------|-------|-------|-------|
| Capex (%) | 65 | 38 | 100 | 0 |
| Opex (%) | 65 | 38 | 0 | 0 |
| Repex (%) | 100 | 100 | 100 | 0 |
| Output | | | | |
| NPV (20yr PV, £m) | -0.04 | -0.10 | 0.23 | |
| NPV (35yr PV, £m) | 1.36 | 1.36 | 1.49 | |
| NPV (45yr PV, £m) | 2.14 | 2.15 | 2.23 | |
| Payback | 20.00 | 20.00 | 16.00 | 21.00 |

Appendix A - Acronyms

| Acronym | Description |
|--------------|--|
| BarG | Measurement of pressure above atmospheric pressure (gauge) in units of Bar |
| CBA | Cost Benefit Analysis |
| CGS | City Gate Station – A pressure reduction system supplied from the intermediate pressure system and feeding either low or medium pressure systems |
| DS | Downstream |
| GD1 | Gas Distribution – Price Control for 2013 to 2021 |
| GD2 | Gas Distribution – Price Control for 2021 to 2026 |
| HAZOP | Hazard and Operability Study |
| HI4 | Health Index – Asset condition approaching or at end of serviceable life, intervention required |
| HP | High Pressure (Natural Gas above 7 barg) |
| IGEM | Institution of Gas Engineers and Managers |
| IP | Intermediate Pressure (Natural gas 2 barg to 7 barg) |
| KPI | Key Performance Indicator |
| LTS | Local Transmission System |
| LP | Low Pressure (Natural gas less than 75 mbarg) |
| MP | Medium Pressure (Natural Gas 75 mbarg up to 2 barg) |
| NARM | Network Asset Risk Measure |
| PE | Polyethylene |
| PoC | Probability of Consequence |
| PRI | Pressure Reducing Installation |
| PRS | Pressure Reduction Station |
| PSSR | Pressure Systems Safety Regulations 2000 |
| RIIO | Revenue = Incentives + Innovation + Outputs |
| Scm/h | Standard cubic metres per hour (Flow) |
| TD/13 | IGEM/TD/13, Pressure regulating installations for natural gas, liquefied petroleum gas and liquefied petroleum gas/air |
| µm | Micron, Micrometre = one-millionth of a meter |
| WBH | Water Bath Heater |

Appendix B - References

Commercial Confidentiality, Security