Engineering Justification Paper

E&I Minor Works Repair Programme

Final Version

Date: December 2019

Classification: Highly Confidential

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2 Introduction

2.1 General Background

This paper sets out SGN's investment proposal of a minor works programme regarding our electrical and instrumental assets.

This minor works programme is to ensure replacement or repair of defective components, and to ensure a 'low regret' strategy to integrity repair and replace issues. It is envisaged this low cost repair fund will extend the asset life of the mechanical equipment it's monitoring/controlling.

The Electrical and Instrumentation (E&I) Operations annual maintenance programme is the main source for reporting these types of faults. E&I Fault forms and E&I CM4 surveys will allow SGN to identify large scale programmes of works. These large-scale works are covered in the E&I Upgrade Programme (Reference: SGN E&I – 005E&IUpgrades – EJP Dec19).

2.2 Site Specific Background

As reporting regimes are being improved it is expected that there will be an increase in the number of smaller projects required during GD2. There have been no sites specifically targeted for this programme of works as this is not a proactive repair or replacement programme.

Under the Electricity at Work Regulations, SGN have an obligation to ensure its electrical systems and equipment are in a safe condition to operate and maintain. SGN also have an obligation to comply with the IET Wiring Regulations (BS7671:2018)

3 Equipment Summary

The equipment which will form the scope of works is the electrical, instrumentation and control equipment on above 7 bar pressure reduction stations and offtake sites.

SGN currently have 32 Offtakes across Scotland the South LDZ's and ~295 Pressure Reduction Stations (PRS'). Of this, SGN will be carrying out electrical and instrumentation minor repairs for 15 sites in Scotland (mainly PRS') and 20 sites in the South and South East LDZ's.

Section 4.1 gives examples of similar repair works carried out in GD1.

This includes distribution equipment which provides power to key systems on site such as telemetry, pre-heating and pressure and temperature sensors which are fed back to SGN's gas control centre via telemetry.

SGN have taken historical failures/faults and their associated costs and put together this workstream to allow for a low-cost repair/replacement fund for low cost/high risk repair works.

This would include the replacement of faulty instrumentation and control equipment such as pressure or temperature sensors, or minor heating elements as well as other items such as failing instrument cabinets or faulty sight lighting etc.

The E&I Minor works programme will also include the replacement of low cost / high risk consumables such as battery replacements and non-compliances with DSEAR requirements as they're found.

4 Problem Statement

Why are we doing this work and what happens if we do nothing?
There is an ongoing requirement for SGN Network E&I to respond to E&I equipment asset integrity issues reported/arising on Offtakes and PRS' which are out of the scope for Opex maintenance budgets and don't form part of larger GD2 programs of work.
These are limited to smaller projects where condition replacement of E&I assets are required which cannot be repaired due to poor condition e.g. severe corrosion, kiosk deterioration, equipment failure, damage due to lighting strikes etc.
If SGN do not include for this work package, it would result in potential loss of power on site and also loss of telemetry and loss of site monitoring by way of no pressure, temperature of gas flow rates being returned to Gas Control. This would result in an increase of OPEX cost for SGN as these sites will require more frequent site visits to monitor the site. This also has an environmental impact due to increased travel requirement to and from site, especially for the more remote sites.
If certain items are in a state of disrepair such as damaged cables or electrical kit with failing insulation, this could result in a non-compliance with the electricity at work regulations and potential harm of electrical shock to our E&I operatives.
UPS' and essential services battery back-up systems (please see Appendix A and B) also form part of this package of works. Batteries generally all have an optimum number of charge-discharge cycles, and a design life based on optimum site conditions which are rarely met in real-life. While most batteries may have a predicted lifespan of 5 or 10 years, from operational experience and best practice guidance from manufacturers it's advised to replace them in year 3 or 4 (for 5-year versions) or 7 or 8 (in 10-year models) as optimal environmental temperatures/conditions cannot always be met.

What is the outcome that we want to achieve?
The outcome of this work programme would be to ensure SGN operational kit is safe and reliable and complies to meet the requirements of the 18th edition IET wiring regulations (BS 7671) thus conforming to the Electricity at Work Regulations.

How will we understand if the spend has been successful?
Network E&I will revisit the sites which have undergone repair works, and each site will be surveyed and the asset and health criticality scores of each site will be revised accordingly. Through careful project management and supervision, SGN should ensure the required outcome be achieved within the set budget and timescales allowed for.

4.1 Narrative Real-Life Example of Problem

The below projects are examples of small-scale replacement or repair works which have been undertaken in GD1 and represent a sample of similar types work which will be required in the GD2 price control period.

Minor Telemetry/Barrier repair:
The scope was to fit an additional Pepperl+Fuchs Elcon 3040 temperature I.S. barrier I/O module to the existing telemetry Elcon I.S. barrier termination board to split Temperature 1 & Temperature 2 outlet temperatures into separate barriers. A new PAK file was uploaded and full end to end testing to GCC was also completed.

This was because the two RTD's were tied into the same barrier, and SGN wanted to separate them out. This was a common cause failure as previously the barrier failed, and SGN lost functionality of both RTD devices.

Figure 1: Dumfries Barrier Replacement

Table 1: Barrier Replacement Costs

Project Costs:	
Design	£1,500
Approval	£500
Appraisal	£500
PAK File Upgrade	£500
Total:	£3,000

Meter re-range - 2017-2018

Meter capacity issues were found at five National Offtakes in Scotland which have Orifice Plate type metering which required re-ranging of the metering system.

Table 2: Meter Re-Range Costs

Project Costs:	
Design	Completed in house – No Cost
Approval	£500 x 5
Appraisal	£500 x 5
PAK File Upgrade	£500 x 5
3rd Party works	£15,000
Total:	£22,500

Router and Switch install for Bio Sites - 2017-2018

Retrospective works were required for three Bio-Methane sites. As part of these works a new router switch, DC-DC converter and battery packs were installed.

Table 3: Biomethane Comms Modification Costs

Project Costs:	
Design	£1,500 x 3
Approval	£550 x 3
Appraisal	£550 x 3
Equipment costs	£2,000 x 3
Total:	£13,800

Replacement of Up and Over Cabinets:
Both Rhonehouse and Alloa PRS cabinets on site had suffered from corrosion and required replacing. Additionally, impulse pipework within the cabinets were needing replacement. This is a common issue in both Scotland and South and South East LDZ's

Table 4: Up and Over Kiosk Replacement Costs

Project Costs:	
Design	£3,000 x 2
Approval	£500 x 2
Appraisal	£500 x 2
Equipment costs	£4,000 x 2
Pak File upgrade	£500
3rd Party Works	£9,000 (Total for two sites)
Total:	£25,000

Aberdeen Knock Out Pots Install - 2018
Traces of oil were found within the Orifice Plate carrier at Aberdeen Offtake. Lubrication of the compressors at Aberdeen Offtake was found to be cause.

A knock out pot which collects the oil was installed at the location the oil was found to be dropping out.

Figure 2: Knock out pot installation on impulse pipework at orifice plate carrier

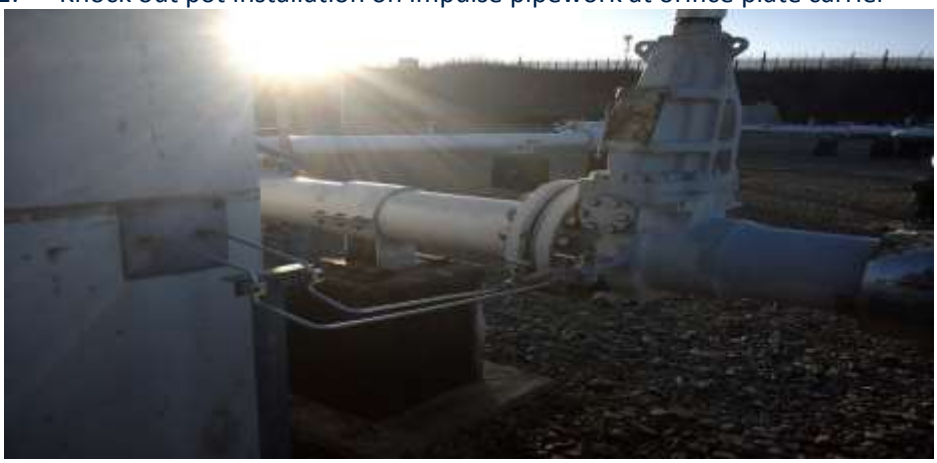

Table 5: Knock-Out pot Installation Costs

Project Costs:	
Design	£1,300
Approval	£335
Appraisal	£335
Equipment costs	£7,618
3rd Party Works	£2,455
Total:	£12,043

Removal of redundant cables at Provan LNG – 2018

Provan LNG had a number of redundant overhead cables which began at the Instrumentation control room and ran along the above metal gas pipeline, which are held in place by a number of cable trays and chains. These were removed from site as they were no longer required.

Figure 3: Redundant cabling at Provan Holder Station

Table 6: Redundant Cable Removal Costs

Project Costs:	
3rd Party Works	£12,385
Total:	£12,385

Henfield:

This emergency, critical gas supply and safety project was to relocate the sites electrical equipment and pre-heater controls to a safe location, to ensure that the PRS remained operational for the 2018/19 winter.

Subject to recent extreme weather conditions, the ground underneath the control room building at Henfield PRS in Sussex had dried out, sunk and caused building subsidence. This subsidence had caused the end wall of the building and inner concrete base to crack, dislocate and sink. The brick wall, to which the sites electrical switchgear and pre-heating control system is attached, had significant cracks and was leaning outward by 70mm to 80mm. The failing wall also had 'UK Power Networks' owned electrical equipment, isolation fuse, incoming power supply and cabling attached.

Figure 4: Henfield Subsidence

Table 7: Henfield Control Room Relocation Costs

Description	E&I	Mechanical	Total
UKPN Isolation	£1,500		£1,500
Electrical Equipment Removal	£500		£500
PS6 E&I Temporary Work	£5,000		£5,000
PS6 Civil Temporary Works		£5,000	£5,000
CDM & Welfare Facilities	£2,500	£2,500	£5,000
MWC Specialist Demolition Contractor		£40,000	£40,000
Temporary Electrical Distribution & Heating Control Cabinet	£15,000		£15,000
Cabinet Base and Temporary Surface Ducting	£6,500		£6,500
E&I Install (Temporary Works)	£2,500		£2,500
E&I Install Materials (Cable, Gland and Containment)	£1,000		£1,000
Permanent Electrical Supply and Intake Kiosk	£20,000		£20,000
PID Security	£2,500	£2,500	£5,000
Total	£57,000	£50,000	£107,000

Replacement of Temperature Switch at Kemnay STRS

In early 2019 the water bath heater temperature switch at Kemnay STRS failed to operate and required replacement.

Figure 5: Water Bath Heather at Kemnay STRS

Table 8: Kemnay STRS Costs

Project Costs:	
Design	£600
Approval	£300
Appraisal	£300
Total:	£1,200

4.2 Spend Boundaries

The projects covered would typically include the following, but this list may not be exhaustive:

- Replacement/Repair of individual failed instruments.
- Repair of dilapidated fibreglass cabinets and kiosks which cause leaks onto E&I equipment.
- Replacement of obsolete Fire and Gas detectors providing alarms for safety mitigation.
- Replacement of unsafe electrical equipment that cannot be repaired.
- Replacement/repair of Functional Safety equipment that has failed.

The scope of works will not include for the replacement or rebuild of whole systems E&I installations such as full electrical distribution systems or diesel generator replacements or full site instrumentation replacements.

The majority of known obsolete/unsupported equipment and equipment with known faults have been identified in the GD2 strategy under the larger scale programme of works. It is envisaged this budget will be used to cover small scale works with a budget smaller than or equal to £20k because of asset failure due to unforeseen or unpredictable circumstances.

5 Probability of Failure

As this workstream targets multiple assets and for multiple/unpredictable failure modes, a probability of failure cannot be applied. This budget is for ad-hoc works which concentrate on repair works to extend asset lifecycle. Section 4.1 gives a detailed list of typical failures which are included in this scope of works.

5.1 Probability of Failure Data Assurance

As stated previously, it is difficult to predict when a 'minor works' project is required. However, using the Scottish Local Distribution Zone (LDZ) a total of 12 minor projects were completed from 2015-2019.

Table 9: Scotland LDZ GD1 Minor Works

Scotland	2015	2016	2017	2018	2019
E&I Minor Projects	0	2	3	6	1

Taking the above data into consideration, a total of 3 Scottish sites will be completed each year during the GD2 period. As data is not available for the Southern LDZ, a total of 5 sites per year has been taken as a guidance due to the larger number of SGN sites within the network.

6 Consequence of Failure

As this work stream is across various assets, the consequences of failure are varied also, below are some examples of possible consequences of failures for various asset groups:

- Loss of telemetry

The consequence of having a telemetry or communications failure can be catastrophic if not addressed in a timely manner. Telemetry helps to reduce the risk of a hazard occurring by providing GCC with situational awareness and network visibility of remote sites to maximise optimum operation of the networks.

The telemetry monitors many parameters which ensures notification of site issues before major problems occurs. It provides GCC with situational awareness, network visibility, and enables optimum operation of the gas network.

- Loss of Gas Quality

The GC is a crucial piece of kit SGN must continue to maintain. As the equipment is crucial to the fiscal element of the company, SGN are required to obtain accurate readings in order to remain GSMR compliant. If the GC was to fail at any SGN site, that site would be required to stop flow as SGN would no longer be compliant with GSMR regulations. As a Gas Transporter SGN are obliged under statute, license conditions and Network Code for the management of the quality and quantity of gas conveyed on its Network, document 'SGN/PM/GQ/8' highlights the legal requirements which must be met. SGN will be liable to fines/penalties if failure to meet GSMR regulations occur.

- Metering

Customers would not be lost due to a fault or failure on the metering system. Gas will still pass through the network and supply customers as normal. However inaccurate readings can lead to severe ramifications in the area of billing and fiscal revenue for SGN.

- Gas Odorisation

Natural gas is odourless and therefore causes an immediate risk to the general public. In the case of a complete LGT system failure, un-odourised gas would not be allowed to flow in to the network which would then lead to a Gas site being shut down until odourised gas can flow again. This has the potential of affecting thousands of customers, therefore it is critical that LGT equipment always remains operational.

Loss of Supply to Customers

In relation to E&I minor works, loss of supply to customers has not been considered as possible failures in relation to this type of equipment would not lead to reduced gas supply to the network.

Safety Impact of Failure

Prolonged failure to assets on site can lead to severe corrosion which was apparent at both Alloa and Rhonehouse PRS. Corrosion on cabinets and cabinet stands can lead to a full collapse of equipment which poses a safety issue to the SGN Operations team. Furthermore, issues such as those at Provan LNG, where redundant cables were removed from site, if not completed could lead to electrical safety issues for SGN Operations teams.

Environmental Impact

Specific failures in relation to E&I minor works are difficult to specify. However SGN have previously not had any environmental issues due to minor failures and therefore do not envisage any future impact.

7 Options Considered

Repair/Replace on Failure
This option is the most cost-effective strategy as the remedial works which are being proposed as part of this workstream are low cost but high-risk assets and can be critical to the operation of SGN's above 7 bar gas sites. The repair or replace on failure of these assets are fairly low cost and items such as project management, design and installation can be done in house.

Pre-emptively Repair/Replace
This option represents the only alternative to the approach this paper is adopting – that is the proactive replacement of electrical and instrumentation equipment on operational gas sites.

The issue with this option is that SGN will have to roll a proactive replacement programme for a large number of sites – with the aim to predict failure and repair/replace before those failures take place.

For the level of spend which is being proposed, this option is disproportional to the risk which is present, however this option has been factored into the CBA accompanying this paper.

Do Nothing
Do nothing is not an option, as doing nothing could result in SGN not complying with the Electricity at Work Regulations 1989 with regards to safe working practices and the safe design, maintenance and operation of SGN electrical systems and equipment and also non-compliance with the Dangerous Substances and Explosive Atmospheres Regulations 2002.

The Do-Nothing option has been considered in this report for the purposes of the CBA, and to demonstrate the risk costs associated with this option and increased opex costs of repeat visits to manage failures on site.

If the do-nothing option was adopted, then there would be an inherent safety risk to the mechanical assets and the pipelines, and the E&I Operational systems and equipment are in place to monitor and protect the mechanical equipment and pipeline. The risk value in the below table has been derived from IGEM/SR/15 and the Greenbook model.

Table 10: Cost Avoidance Summary

Category	Numbers	Greenbook methodology figures	Maximum Tolerable Individual Risk	PRI pipeline depreciation period in years	Resulting cost
Fatalities	2	£16,170,000	0.000001	45	£1,455.30
Non-fatal incidents	1	£185,000	0.000001	45	£8.33
Major offsite incident affecting water, supply, food chain, or housing for a period circa 1 month	1	£5,000,000	0.001	45	£225,000
Non-serious "nuisance" / odour incident	1	£50,000	0.01	45	£22,500
Total/site					£248,963.63
Scotland	15				£3,734,454.45
South	20				£4,979,272.6

7.1 Replace/Repair on Failure Option Summary

The technical detail of the option i.e. capacity, system rating, availability etc.
This option is to replace E&I Kit when they are close to and or have failed. As E&I Minor Works is extremely varied it is difficult to give a technical breakdown of works. However, the majority of works will include a full PS/6 pack, which will include designs, new drawings and potentially new kit as outlined in the projects carried out in section 4.1.

The basis for the cost estimate/unit cost
As discussed E&I Minor works are extremely varied therefore prices can fluctuate from one project to another, however taking quotations from previous Minor works during the GD1 period into consideration (See section 4.1 for detail), SGN will allocate £20,000 for each site which requires minor works during the GD2 period.

The perceived benefits of the option
The benefit of this option is that the costs may be spread out greater than a period of five years. If there is not a greater population of assets requiring integrity replacements over the GD2 period.

Delivery timescales
The delivery here is varied. Upon failure, depending on materials, design and site labour availability, a single ad-hoc replacement on failure could take a matter of months.

Key assumptions made
Assumptions not made within this report.

Any other items that differentiate the option from the others considered
The cost base used have the same source, however the pre-emptively replace cost has made assumptions on additional costs due to a wider number of sites and works being completed.

7.2 Pre-emptively Replace/Repair Option Summary

The technical detail of the option i.e. capacity, system rating, availability etc.
This option is to replace E&I Kit pre-emptively before a failure occurs. As E&I Minor Works is extremely varied it is difficult to give a technical breakdown of works. However, the majority of works will include a full PS/6 pack, which will include designs, new drawings and potentially new kit as outlined in the projects carried out in section 4.1.

The basis for the cost estimate/unit cost
As discussed E&I Minor works are extremely varied therefore prices can fluctuate from one project to another, however taking quotations from previous Minor works during the GD1 period into consideration (See section 4.1 for detail), SGN would allocate £25,000 (Increase in price is due to assuming more works would be completed) for each site which requires minor works during the GD2 period.

The perceived benefits of the option
Reduces possibility of Minor failures taking place on site.

Delivery timescales
The delivery here is varied. Upon failure, depending on materials, design and site labour availability, a single ad-hoc replacement on failure could take a matter of months.

Key assumptions made
Assumptions not made within this report.

Any other items that differentiate the option from the others considered
The cost base used have the same source, however the replace on failure cost has made assumptions on cost reductions based on economies of scale savings.

7.3 Options Technical Summary Table

Table 11: Options Technical Summary

Option	First Year of Spend	Final Year of Spend	Volume of Interventions	Equipment / Investment Design Life	Total Cost
Scotland LDZ					
Do Nothing	2022	2022	0	25	0.21*
Replace on Failure	2022	2026	156	25	0.50
Pre-emptively Replace	2022	2026	166	25	0.91
South of England LDZ's					
Do Nothing	2022	2022	0	25	0.21*
Replace on Failure	2022	2026	208	25	1.46
Pre-emptively Replace	2022	2026	223	25	2.06

*OPEX cost of increased maintenance and repair.

7.4 Options Cost Summary Table

Table 12: Cost Summary

Option	Cost Breakdown	Total Cost (£m)	
		Scotland LDZ	South of England LDZ's
Do Nothing	There is no CAPEX investment for this options. There is purely an OPEX increase as stated in section 7.	0.21	0.21
Replace on Failure	Please see Appendix C	0.50	1.46
Pre-emptively Replace	Please see Appendix C	0.73	2.06

8 Business Case Outline and Discussion

The tables below highlight the key options that SGN have investigated in detail. As E&I Minor works has a low risk of causing major gas flow interruptions, SGN have decided that replacing/repairing on failure was the optimum choice for the GD2 period.

Taking the probability of failure into account SGN will look to carry out minor works on 35 sites across the network during GD2 (See section 5 for detail). The pre-emptive option has an increase of 60 sites which would be due to SGN taking a 'pro-active' approach to repairing potential failures and therefore targeting a larger number of sites in order to reduce the possibility of repairing on failure. Whilst a larger number of sites could potentially be completed, SGN regard this to be excessive due to low risk nature of Minor works. The tables below highlight the costs for each option considered.

8.1 Key Business Case Drivers Description

Table 13: Summary of Key Value Drivers

Option No.	Desc. of Option	Key Value Driver
1	Do nothing	This option is not viable as it will result in noncompliance with SGN's license conditions if key systems are faulty and are not repaired such as telemetry, power supply etc. SGN could also be in noncompliance with key regulations such as the electricity at work act. Increased operational costs due to increase number of site visits if there is a fault on site.
2	Replace/Repair on failure	• A total of 35 sites over a period of 5 years (at £20,000 per site). • UPS and battery replacement at St Mary Cray (£125,000) • Battery replacements across Scotland, South and South East LDZ (£232,120) • DSEAR Compliance works (£494,000) • Please see Appendix A and B for further detail
3	Pre-emptively replace/repair	• A total of 60 sites over a period of 5 years (at £25,000 per site). • UPS and battery replacement at St Mary Cray (£125,000) • Battery replacements across Scotland, South and South East LDZ (£232,120) • DSEAR Compliance works (£494,000)

Table 14: 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	2035	2040	2050
Scotland LDZ								
Baseline	Do Nothing	N	-0.21	-3.94	-0.93	-1.41	-1.85	-2.65
1	Replace on Failure Absolute NPV	Y	-0.50	-0.66	-0.34	-0.38	-0.42	-0.55
1	Replace on Failure NPV Relative to Baseline	Y	-0.50	-0.66	0.59	1.02	1.44	2.10
2	Pre-emptively Replace Absolute NPV	N	-0.91	-1.20	-0.85	-0.85	-0.85	-1.13
2	Pre-emptively Replace NPV Relative to Baseline	N	-0.91	-1.20	0.08	0.56	1.01	1.51
South of England LDZ's								
Baseline	Do Nothing	N	-0.21	-4.94	-1.18	-1.78	-2.34	-3.32
1	Replace on Failure Absolute NPV	Y	-1.46	-1.68	-1.05	-1.16	-1.24	-1.50
1	Replace on Failure NPV Relative to Baseline	Y	-1.46	-1.68	0.13	0.62	1.10	1.82
2	Pre-emptively Replace Absolute NPV	N	-2.06	-2.47	-1.48	-1.64	-1.75	-2.17
2	Pre-emptively Replace NPV Relative to Baseline	N	-2.06	-2.47	-0.30	0.14	0.59	1.15

8.2 Business Case Summary

Option	Rational
Do-Nothing	• No allocation of repair fund to extend life of critical assets • Avoided risks costs associated with this option is £8,713,727.05 (over 45 years) • Could leave SGN potentially non-compliance with key legislation and regulation such as the Electricity at Work Regulations and the Dangerous Substances and Explosion Regulations.
Replace/Repair on failure (Baseline Option)	• Repair/Replace critical assets as and when they fail • These are assets which can be repaired/replaced with a quick turnaround time • Design, Procurement, Install and Commissioning can be done in house due to asset types

Pre-emptively replace/repair (Option 1)	• Proactive replacement/repair would require a large works programme to capture all potential failures • This is not cost effective and represents poor value for money

Table 15: Business Case Matrix

	Replace on Failure	Pre-emptively Replace	Replace on Failure	Pre-emptively Replace
	Scotland		South of England	
GD2 Capex (£m)	0.50	0.91	1.46	2.06
Number of Interventions	141.00	141.00	186.00	186.00
Carbon Savings ktCO2e (GD2)	0.00	0.00	0.00	0.00
Carbon Savings ktCO2e /yr	0.00	0.00	0.00	0.00
Carbon Emission Savings (35yr PV, £m)	0.00	0.00	0.00	0.00
Other Environmental Savings (35yr PV, £m)	0.00	0.00	0.00	0.00
Safety Benefits (35yr PV, £m)	2.28	2.28	3.04	3.04
Other Benefits (35yr PV, £m)	0.00	0.00	0.00	0.00
Direct Costs (35yr PV, £m)	0.17	-0.43	-0.81	-1.55
NPV (35yr PV, £m)	2.45	1.86	2.23	1.49
High Carbon Scenario				
Carbon Emission Savings (35yr PV, £m)	0.00	0.00	0.00	0.00
High Carbon NPV (35yr PV, £m)	2.45	1.86	2.23	1.49

9 Preferred Option Scope and Project Plan

9.1 Preferred option

The preferred option here is the base-case of replace or repair assets on failure. As mentioned previously a proactive replacement/repair programme could prove to be costly compared the risk reduction benefits.

The majority of assets in question in this workstream are low cost/high frequency items such as replacement/repair of up and over kiosks, batteries, cables etc.

9.2 Asset Health Spend Profile

Table 16: Spend Profile

Asset Health Spend Profile (£m)					
Pre-emptively replace	2021/22	2022/23	2023/24	2024/25	2025/26
Scotland LDZ	0.10	0.10	0.09	0.10	0.11
South of England LDZ	0.30	0.28	0.28	0.28	0.31

9.3 Investment Risk Discussion

Table 17: Investment Risk Discussion

Risk Description	Impact	Likelihood	Mitigation/Controls
Budget	Over Spend	<=20%	As this workload is very varied and cannot be predicted, there is the risk that some projects may be a higher spend that requested (per site) in the EJP. However this risk is minimal as history (section 3.1 in EJP) shows that a number of projects will also be lower so overall the budget should balance to being neutral. If there are any failures which require an excessive amount (site rebuild) then SGN would raise this through the SGN Investment Committee before committing a spend and the major rebuild scopes have been captured in another EJP for that type of work.
Budget	Over Spend	<=20%	Network have not built in any risk/contingency costs for this works.

Capex Sensitivity

Table 18: Sensitivity Results

	Scotland LDZ			South of England LDZ's		
	Low	**Mid**	**High**	**Low**	**Mid**	**High**
GD2 Capex (£m)	0.45	0.50	0.60	1.31	1.46	1.75
Number of Interventions	141	141	141	186	186	186
Carbon Savings ktCO2e (GD2)	-	-	-	-	-	-
Carbon Savings ktCO2e /yr	0	0	0	0	0	0
Carbon Emission Savings (35yr PV, £m)	0.0	0.0	0.0	0.0	0.0	0.0
Other Environmental Savings (35yr PV, £m)	0	0	0	0	0	0
Safety Benefits (35yr PV, £m)	2.3	2.3	2.3	3.0	3.0	3.0
Other Benefits (35yr PV, £m)	0.0	0.0	0.0	0.0	0.0	0.0
Direct Costs (35yr PV, £m)	0.2	0.2	0.0	-0.6	-0.8	-1.1
NPV (35yr PV, £m)	2.5	2.5	2.3	2.4	2.2	1.9

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.

Network E&I believe the preferred option is pre-emptive replacement. For the purpose of sensitivity analysis, the following has been applied to the preferred option of pre-emptive replacement:

Low Case: SGN have applied a reduction of 10% CAPEX costs – this can be applied if there are not many large scale integrity repair works required and if SGN can delivery small scale designs in house.

Mid Case: no changes have been applied, this is the expected output required for the GD2 time period.

High Case: SGN have applied an additional 20% on the CAPEX expenditure, to represent larger scale repair works which may require external resource for install or design.

Capitalisation Sensitivity

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.

Table 19: Capitalisation Rate Sensitivity Results - Scotland

Scenario	1	2 SC	3	4
Capex (%)	65	46	100	0
Opex (%)	65	46	0	0
Repex (%)	100	100	100	0
Output				
NPV (20yr PV, £m)	1.48	1.52	1.70	
NPV (35yr PV, £m)	2.44	2.45	2.61	
NPV (45yr PV, £m)	3.01	3.03	3.11	
Payback	0.00	0.00	0.00	0.00

Table 20: Capitalisation Rate Sensitivity Results – South of England

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)	1.20	1.19	1.48	
NPV (35yr PV, £m)	2.24	2.23	2.45	
NPV (45yr PV, £m)	2.92	2.94	3.03	
Payback	0.00	7.00	0.00	9.00

Appendix A - St Mary Cray UPS and Battery System

Description of Workstream

The natural gas pressure reduction station at St Mary Cray has been modified to generate electrical power to supply the local electrical distribution network. A new facility takes high pressure gas from the transmission System and reduces the pressure through a St Mary Cray compressor coupled to an 11-kV generator. The high-pressure gas is pre-heated using a combined heat and power (CHP) unit which is supplemented by a hot water boiler system depending on demand.

The Pressure Control Unit, CHP unit and Boiler System have their own independent control systems, each system interfaces with a supervisory process control system (PCS) via hard wired signals and serial communications. The purpose of the PCS is to provide high level automatic control of these vendor supplied packages; and control the sequencing and interaction of these three units and the associated SGN auxiliary plant. Control of the plant is via a combination of manual procedures and automatic operations via the PC, the plant is unmanned and monitor by telemetry system.

Figure 6: St Mary Cray PRS

The system has been in operation for the past five years and will have run some 40,000 hours and is reaching its half-life point. The system onsite consists of dual redundancy 24v battery charger units feeding the low voltage control and SIL2 rated protection loops with a 230v UPS system feeding the site PC, the emergency shutdown shut system and human machine interface, providing fault data logging and a system overview.

What is in the scope:

The 230V UPS on site is critical to the safe operation of the pressure control system and feeds directly into the emergency shutdown system, the UPS also supports the site control PC and human machine interface providing fault recording and a system overview of the installation.

At present the UPS system is made up of an Erskine / Dale UPS. This has proved to be unreliable since its installation and has required replacement in its entirety three times since the site was commissioned. The unit is now considered unfit for purpose due to its poor reliability and the installation locations detrimental effects on the equipment. The UPS is experiencing issues with moisture ingression due to its location effecting the UPS electronics and causing corrosion to the batteries.

The proposed solution for the UPS system to be replaced with a bespoke duel redundancy system designed for the site's specific operational requirements. This system would have incorporated redundancy within its design and will be installed into a more hospitable location.

Along with the increased reliability of the UPS system it would benefit from of having hot swappable module capability and will have supported spares in the event of any future component failure.

The additional redundancy and hot swap option would minimise downtime for the pressure control system. An additional benefit of this option will be the critical systems the UPS supports would experience minimal disruption to their sensitive safety equipment and pressure management systems.

The pumps and motors are essential to the working of the pressure reduction system and should be given consideration within this scope. They are in constant use and the operational strain they undertake, and the hours run mean that on average one a year will go to fault and require replacement.

The fire detection system requires consideration in order to keep the fire detection system operating to the highest standards protecting the installation and pressure reduction associated equipment.

BS EN 61508, Functional safety of electrical/electronic/programmable electronic safety related systems and BS EN 61511 Safety instrumented systems for process industry sector.

Under the Electricity at Work Regulations will have to be complied with throughout the GD2 period and should be considered to ensure compliance.

Table 21: GD2 Costs associated with SMC PRS

	2021	2022	2023	2024	2025	2026	Cost (£)
Replacement of UPS	X						£50,000
UPS battery replacements						X	£5,000
Fire detection system battery replacement	X					X	£10,000
Pump, motor & actuator replacement	X	X	X	X	X	X	£60,000
Total	£125,000						

The costs for these works have been provided to Network E&I by Operations Maintenance who maintain the PRS at St Mary Cray.

What is out of scope:
Overhaul of heat exchangers, generator, pressurisation unit, CHP and heating systems are excluded from the E&I GD2 submission. This will be considered within the mechanical submission.

No consideration has been made to replace the telemetry, PLC, VSD or ESD system as these are deemed to currently be fully supported

Consequence of leaving the existing UPS system:
Should the decision be made to retain the current UPS system rather than install a site specific replacement the following implications should be expected:

- Increased operational expenditure due component failures and increased site visits to repair the faulty equipment.
- Increased downtime of the pressure reduction system.
- Total failure of the UPS system whilst the PRS is running would mean the loss of the PCS & ESD screens and servers. The loss of the servers during a fault would result in the site having no trend data during the outage or any operator capability. If the servers are not shutdown correctly we could corrupt the hard drives and lose all data from the last backup.
- Increased Integrity / Capex spending due to multiple equipment failures.
- The PRS essential services operate by being fed via the UPS system, Total failure of the UPS system would mean the total loss of all services supplied by the 230V essential services distribution board.

Appendix B - Cost Breakdown

The costs for this paper have been compiled from various sources, the table below highlights these:

Item	Costs	Source
E&I Repair Works	£20,000 per site	This is purely an estimate by Network E&I based on previous similar types of works (demonstrated in section 4.1)
Battery Replacements	~£700 per battery system • 141 Scotland • 184 South and South East £232,120	 Quote 0022012263 [Ref. TBA KENNY].pdf  VXI PSU Quote.pdf  Q RAY 180126 02.pdf
St Mary Cray	£125,000	This cost has been provided to Network E&I from E&I Operations Projects team who are based in the South and South East Patch and operate and maintain the St Mary Cray PRS
Functional Safety	£494,000	This is an estimate from Network E&I and is based on previous DSEAR remedial works in GD1.

Appendix C - Acronyms

Table 22: Table of Acronyms

Acronym	Description
PRS	Pressure Reduction Sites
SPRS/STRS	Small Pressure (Transmission) Reduction Sites
GSMR	Gas Safety Management Regulations
MTBF	Mean Time Between Failure
CBA	Cost Benefit Analysis
LDZ	Local Distribution Zone
LNG	Liquid Nitrogen Gas

Table 23: Table of Standards

Standards
The Gas Act (1986),
Gas Safety (Management) Regulations – 1996 (GSMR)
HSE Operational Guidance document 0086 Cyber Security for Industrial Automation and Control Systems (IACS).
Dangerous Substances and Explosive Atmospheres Regulations 2002
BS EN 61508 - Functional safety of electrical/electronic/programmable electronic safety related systems
BS EN 61511 Safety instrumented systems for process industry sector.
Under the Electricity at Work Regulations
The IET Wiring Regulations (BS7671:2018).