Engineering Justification Paper

Cathodic Protection Transformer Rectifier Replacement Program

Final Version

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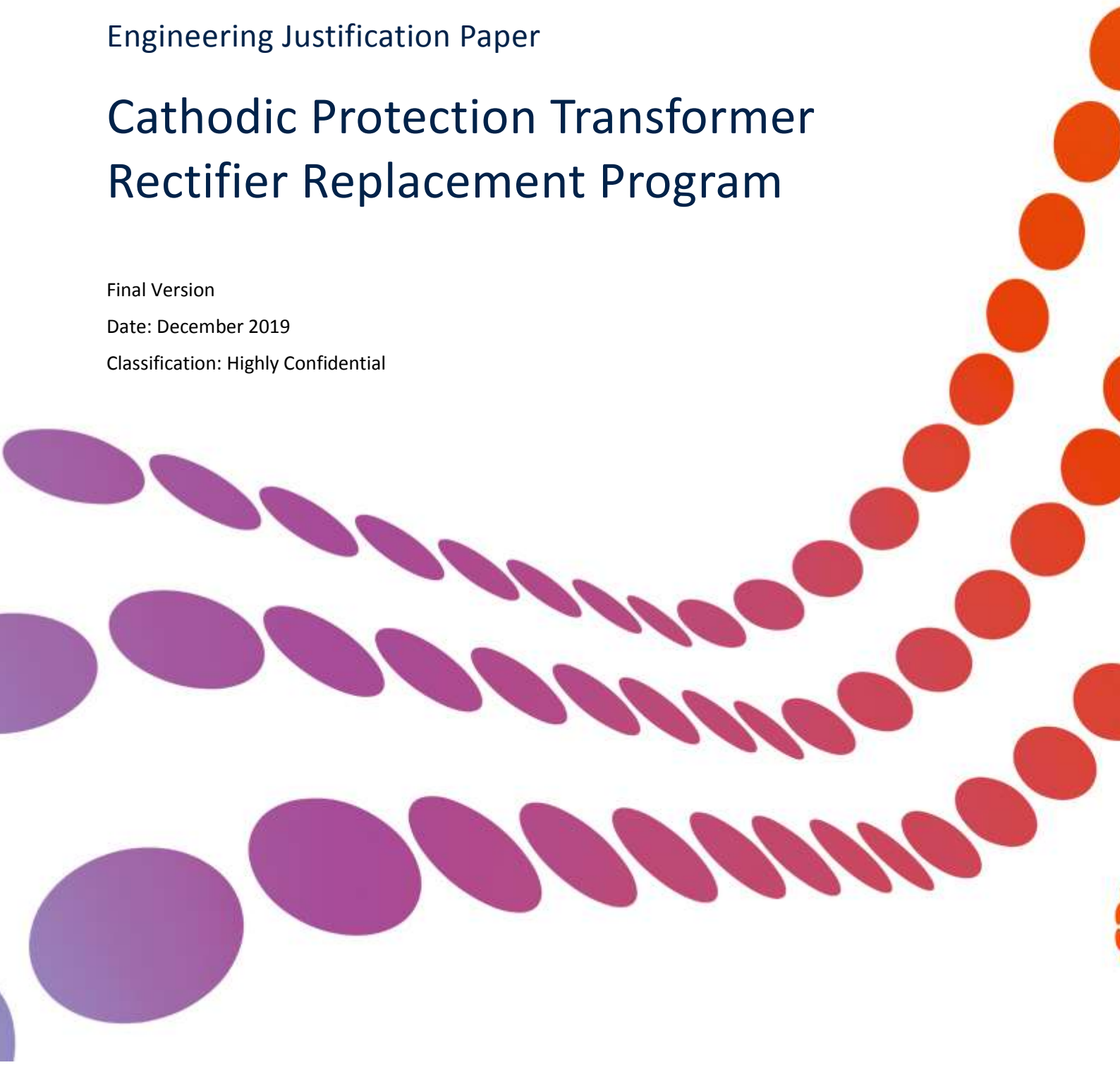

1. Table of Contents

2 Introduction

This paper is focused on the replacement of stand-alone Cathodic Protection Transformer Rectifier (CPTR) installations across the Scotland and South of England Local Distribution Zone's (LDZ's).

The work list has been formulated by using the annual reports received from the technicians tasked with carrying out the maintenance of the Transformer Rectifiers (TR's). Focusing on the installations reported as health and safety concerns due to location and accessibility issues and the installations highlighted as causing additional electrical risk to the public and livestock due to deterioration of the enclosures.

2.1 General Background

This work programme concentrates on the replacement of the aged and failing existing TR's which protect SGN's above 2bar pipelines against corrosion. Furthermore this programme will also address the increasing risk of electrical safety for livestock and public that may come into contact with the TR installations located in rural locations.

This work stream will not cover assets below 2bar, nor will it look at Cathodic Protection systems in relation to pipeline protections and ground beds. This workstream is covered in Appendix 021 – Transmission and Integrity.

2.2 Site Specific Background

As this is a programme of works, SGN will not go into detail of specific sites at this stage. The sites which are included in this programme of works are those located in rural settings and are accessible to livestock and potential members of the public.

SGN must ensure that these installs are of a condition which will allow the continued cathodic protection to SGN pipelines, but also maintain asset integrity to a level which will protect SGN, livestock and members of the public from the risk of electricity and thus complying with the Electricity at Work Act.

3 Equipment Summary

To ensure a high level of safety and reliability in operation, it is essential that buried steel pipework associated with the transmission and distribution of natural gas is designed, installed and commissioned to withstand the potentially harmful effects of corrosion, and those corrosion control systems are monitored to ensure continued effectiveness.

SGN's steel pipelines are normally protected against corrosion by impressed current cathodic protection (CP) schemes utilising TR installations and ground beds located at suitable locations to achieve optimum system effectiveness.

SGN Policy Document SGN/PM/ECP/2 - Management Procedure for Cathodic Protection of Buried Steel Systems – provides guidance on such work.

SGN/PM/ECP/2 is followed in accordance with The Pressure Systems Safety Regulations 2000 (PSSR) and the Pipelines Safety Regulations 1996.

The Document requires all existing buried steel mains operating at pressures >2bar to have an effective CP system installed and recognises that the continued effective operation of such a CP system is totally dependent upon a satisfactory level of monitoring and maintenance, and that forms an essential part of the overall pipeline management system.

A conventional impressed current CP system utilises a single-phase 230V AC supply to energise a TR. Where such a power supply is not available, but all other factors are favourable, solar, thermoelectric or wind power sources can be used.

The TR units include internal timers, facilities to install remote timers for Close Interval Protection (CIP) surveys, meters and circuit protection. The procedure states that all equipment should be accessible from ground level and should be housed in lockable enclosures to prevent interference by, or hazard to, livestock and unauthorised persons.

Where equipment is installed on an SGN operational site, TR units must be located outside of any hazardous area (IGE/SR/25).

TR's must be fitted with appropriately scaled instruments for the indication of DC output current and voltage, alternating current (AC) & direct current (DC) circuit protection and the maximum TR unit DC output voltage shall be less than 50V for electrical safety.

All new and existing electrical installations must comply with the requirements of BS 7671.

SGN's Network has a total of 370 TR installations, some of which are located on existing operational sites while others are stand-alone installations located along pipeline routes. The following Table indicates the various type of TR installation to be found in SGN.

Table 1: CPTR Installation Types Across SGN

Site Location	Total Sites	Operational Site Installation	Stand-alone Installation			
			Total	Pole Mount	GRP Kiosk	Concrete Kiosk
Ex South LDZ	116	20	96	27	39	30
Ex South-East LDZ	121	47	74	6	35	33
Scotland LDZ	133	18	115	5	110	
Network Total	370	85	285	38	74 + Scotland	63 + Scotland

4 Problem Statement

Why are we doing this work and what happens if we do nothing?

A significant number of the stand-alone installations have pole-mounted TR's, they are often located in rural locations such as farmers' fields and only accessible by foot.

Most of the installations pre-date the 1990's, some still retain their original Mapel rectifiers which are no longer a preferred unit and the metallic equipment housings are at varying stages of deterioration due to the environment in which they are located.

All are in the public domain, often in close proximity to livestock. Failure to secure or replace the equipment housings will place both the public and livestock at increased risk from electric shock and would mean SGN could be in breach of the Electricity at Works Regulations 1989, The Electrical Equipment (Safety) Regulations 1994 and The Health and Safety at Works Act (1974)

SGN and its predecessors, have maintained a policy of gradually replacing pole-mounts with ground-level installations, housed in GRP kiosks, ensuring they are not only safer in terms of access and working environment but also compliant with current electrical standards. The GRP kiosk installations have the added benefit of a heater installed to protect the electrical installation and TR from adverse weather condensation.

These installations are key to maintain the integrity of the pipelines which they're protecting, therefore it is vital these are installed, maintained and operated in a manner which provides continuity of supply as well as safety and protection to SGN's employees and members in the public and livestock from electrical risks and hazards.

What is the outcome that we want to achieve?

The outcome SGN want to achieve here is to ensure its existing population of TR's are compliant with the requirements of the Electricity at Work Act and the Health and Safety at Work act. This will mean the relocating of pole mounted TR' to ground level and the upgrade of those TR's which have shown significant signs of deterioration and also damage due to lighting strikes.
This programme of works is not for 100% of the assets as this is an ongoing process. SGN will be concentrating on the 'known-known' assets which constitute for < 20% of the asset population.

How will we understand if the spend has been successful?

The successful relocation/replacement of known TR installations which pose health and safety risks and ensure the continuity of supply to provide integrity and protection to SGN's pipelines.
This spend does not include the upgrading of ground beds and other associated pipelines infrastructure. The scope of this work is to purely concentrate on the electrical infrastructure of the TR installations.

4.1 Narrative Real-Life Example of Problem

The existing TR's are fed via a 30 mA Residual Current Device (RCD) for additional protection and have various perishable electrical and electronic components within. These include the Variac transformer, direct current rectifiers, measurement dials etc. all of the which are sensitive to moisture and adverse weather conditions thus increasing their failure rate with age.

This coupled with the increased risk posed to the public and livestock by the failing equipment housings and precarious location of some of the CPTR's will also increase the risk to SGN personnel during routine maintenance visits.

Below are some Examples of the TR's illustrating the difficulties in carrying out maintenance and the risks some the existing installations pose to the public and SGN personnel.

The Mapel T/R

The Mapel T/R is dated pre-1990's, it's housed in a steel enclosure that is prone to rust and corrosion due to adverse weather conditions. The door seals of the enclosures are often perished leaving the ingress protection (IP) rating of the enclosure compromised.

If the IP rating of the Mapel enclosure is not upheld moisture collects on the base of the enclosure causing it to corrode and in some cases the base to rot away.

Figure 1: Example of Maple TR Installation

The Pole Mounted TR

The TR's mounted on poles are often located in rural locations a considerable distance away from any road and only accessible by foot. Due to the nature of the TR's being pole mounted and only being accessible by ladder or pop up scaffolding, this means the ladder or scaffolding requires to be transported to the location of the TR manually and often over uneven or muddy fields incorporating cattle grids and gates presenting an additional hazard to the operative and in the case of scaffolding the additional cost of hiring.

This risk can be nullified by relocating the TR to a GRP kiosk at ground level situated on a concrete foundation. Housing the kiosk within a fenced corral will also prevent interference to both the operative and kiosk by any livestock within the field.

Having the TR at ground level will also eradicate the manual handling issues of carrying a ladder the health and safety issues of using a ladder on questionable ground and working at height regulations.

Figure 2: Example of a pole mounted TR

The Concrete Kiosk T/R

A number of TR installations are housed in ageing concrete Kiosks.

The kiosks are showing various signs of decay some of which include moisture ingression, rodent and bird infestation, damaged roofs and sides and ill-fitting and rotten doors.

The kiosks suffering with rodent or bird infestation are subject to damage caused during the infestation. The damage includes chewed cables and nesting material blocking ventilation grills adding an additional fire risk in the event of an electrical fault.

Where possible existing concrete kiosks located in close proximity to busy carriageways will be relocated to nullify the additional risk posed to the TR installation and maintenance operatives by fast moving traffic.

Figure 3: Example of concrete built TR Kiosks

The GRP Kiosk

The GRP kiosk is the preferred method of installation of modern TR's. Housed within a sturdy environmentally friendly kiosk and sat on a purpose-cast concrete foundation. Protecting the equipment within, and the public and livestock externally from contact. Maintenance friendly and with increased IP for the electronic and electrical equipment within improving asset health and lifespan.

Figure 4: Example of modern GRP installed TR

4.2 Spend Boundaries

The spend for this programme of works will address the issues highlighted in section three and four within this paper (pole mounted, concrete kiosk and Maple TR's).

The spend will consist of the following:

- Replacement of the kiosk to a GRP kiosk onto a solid concrete foundation and housed within a corral fenced border which will allow for additional protection from livestock.
- Replacement of electrical distribution equipment installed to BS 7671 18th Edition Wiring Regulations
- Replacement of the TR equipment required to provide integrity protection to the pipeline.

Excluded from the scope of works and this paper are the following:

- Cathodic protection ground beds are not included as they do not form part of the electrical and instrumentation asset.
- The associated loggers which are deemed to be suitable for requirements.

5 Probability of Failure

The TR installations are made up of various components prone to failure all of which will result in the TR not working correctly and no impressed current being put onto the gas main and the main returning to its natural potential and corroding.

The components most likely to cause failure of the T/R within the installation are:

- The RCD causing the electrical system to fail in its entirety leaving the pipeline unprotected against corrosion.
- The Variac Transformer used to control the current level impressed onto the pipeline. The Variac's failure would prevent a current from being impressed onto the pipeline leaving it unprotected against corrosion.
- The DC Bridge rectifier used to turn the output of the Variac into a ripple free DC constant. DC rectifier failure would prevent a current from being impressed onto the pipeline leaving it unprotected against corrosion.

However even though these are the components likely to fail, it's important to note that SGN do not see these component fail frequently and component failure is not the main driver/justification for this works.

The main driver for these works are to relocate the pole mounted transformer to allow for safe working conditions and to replace those TR units which although may still provide full operational functionality, they are not in a safe condition or environment to maintain or operate.

As a result of this. SGN will only be including <20% of the asset population for replacement or repair.

5.1 Probability of Failure Data Assurance

As stated previously, the driver for this programme of works is not due to excessive failures of components across the asset class.

SGN carry out annual inspection and test on all of their CPTR's, this regime is managed through SGN's maintenance management systems MAXIMO which schedules the following:

Table 2: Maintenance Regime

Location	Task	Frequency	Work Schedule Tag
Pipeline	RCD Functional Check	3 Monthly	E1144A - MAINT 11004 C1 - RCD Functional check (CP)
Pipeline	Full Inspection and Test	Annual	E1143A - MAINT 11023 - Full inspection & test (CP)
Operational Site	RCD Functional Check	6 Monthly	E1143A - MAINT 11023 - Full inspection & test (CP)
Operational Site	Inspection and Functional	Annual	E0002A - Maint 11 Inspection & Functional check
Operational Site	Full Inspection and Test	2 Yearly	E0001A - Maint 11 Full inspection & test

These inspection and testing work orders allow for the facilitating of identification of CPTR's requiring integrity related replacements.

As part of this schedule, the majority of failures of components are related to failure of RCD's, these are generally repaired/replaced at point of discovery. This work programme is for these remaining CPTR's which are mounted on poles which is not a condition/failure driver.

6 Consequence of Failure

The negative impact the T/R failure will cause is that pipework will fall below the minimum protection criteria laid out in SGN Policy Document SGN/PM/ECP/2 - Management Procedure for Cathodic Protection of Buried Steel Systems. The failure of the T/R unit will mean SGN pipelines technicians would not be able to carry out the walking surveys of the pipelines. This includes OLI/4 surveys that are required to conform with the PSSR Regulations (2000).

Loss of Supply to Customers

Loss of cathodic protection would not lead to immediate loss of supply to the customer, however with continued rate of degradation to the integrity of the pipeline within cathodic protection could have the potential to result in gas escapes/explosions which would result in the loss of gas supply to the customer, however it's highly unlikely.

Safety Impact of Failure

Prolonged failure of cathodic protection could result in the potential (impressed current) of the pipework to fall to its natural level which will promote accelerated corrosion of the pipeline, thus causing damage to the pipeline and shortening its lifespan.

The main driver of this work stream is to ensure the electrical safety to SGN employees who must operate and maintain these assets as well as those members of the public/livestock who may be in close proximity to the CPTR units located outside of SGN operational sites.

Environmental Impact

Loss of cathodic protection in the long run could result in increased gas escaped into the atmosphere. However, this would require no cathodic protection on the pipeline over a significant time period.

Natural gas (Mostly methane) is a powerful greenhouse gas which is a significant contributor to climate change, as a large gas supplier SGN are determined to keep gas leaks to a minimum in order to reduce greenhouse gas emissions and avoid damage to vegetation and livestock.

7 Options Considered

Replace on Failure

The issues with replacing the T/R units only upon failure are as follows:

- The risks to the public, livestock and SGN maintenance operatives from the aged enclosures and installation locations will still be present until the unit fails.
- The deterioration of the enclosure designed to ensure the electrical safety of the TR installation would continue until a failure occurs and it is replaced.
- In the event of failure there will be a lead time on obtaining the TR units leaving the pipeline unprotected for this period.
- Increased costs relating to materials purchase for a single unit replacement.
- Increased design, approval and appraisal costs incurred by single requirement needs.
- Potential non-compliance with the PSSR Regulations 2000 until replacement.
- Potential non-compliance with the Electricity at Works Regulations 1989 until replacement.
- Potential non-compliance with the Electrical Equipment (Safety) Regulations 1994 until replacement.
- Potential non-compliance with the Pipelines Safety Regulations 1996 until replacement.
- Prolonged periods without CP protection on the pipework causing corrosion.

- Costly excavations, network diversions and pressure restrictions along the network to repair corrosion damaged pipelines.

Repair on Failure
The issues surrounding repairing the T/Rs in the event of failure are as follows:

- The older Mapel TR's are no longer supported so component changes to repair is not possible.
- The repairs to be made to the pole mounted T/Rs would expose SGN operatives to the risks of Working at Heights whilst having the ladder or scaffold set on uneven grounds. The work required to access the components involves disconnecting heavy instrument plate from its electrical supply and unbolting it from its surround. This enables the operative to lower the instrument plate to the ground to facilitate the repair. The reverse process is undertaken to reinstate the repaired T/R back into its enclosure. This brings the added risk of manual handling whilst working at height. However as stated previously the scope here would be to relocate to ground level as the main driver here to mitigate these risks.
- The older style TR's are housed in concrete kiosk have no facility for data logging meaning the faults often go undetected until either detected via a pipeline walk or through a quarterly visit by an electrical technician. This can lead to the pipeline not being protected against corrosion for prolonged periods of time.

Pre-emptively replace
Pre-emptively replacing the T/Rs has the following benefits:

- Eliminates the risk attached to the worst of the affected TR's. By enabling the movement of the pole mounted TR's to ground level to reduce the human factors hazards, risks to public and livestock.
- Replace the obsolete Mapel type TR's with a modern supported unit for the best cost options.
- Maintains pipeline protection levels and network integrity continuously.
- Cheaper materials costs for bulk ordering of equipment under replacement project.
- Once only generic design approval and appraisal costs as part of replacement project.

Pre-emptively Repair
The issues surrounding pre-emptively repairing the T/Rs are:

- No spares available for the older Mapel TR's.
- Unable to pre-emptively detect component failures.
- Faults undetected between quarterly maintenance visits leaving the pipeline with no CP protection.
- Human factors, risk to public a livestock will remain.
- No improvement to enclosure condition or relocation carried out.

Do Nothing
The issues surrounding the do-nothing approach are:

- Non-compliance with the PSSR Regulations 2000.
- Non-compliance with the Electricity at Works Regulations 1989.
- Non-compliance with the Electrical Equipment (Safety) Regulations 1994.
- Non-compliance with the Pipelines Safety Regulations 1996.
- Prolonged periods without CP protection on the pipework causing corrosion.
- Increased risk to the public, livestock and SGN technicians through failing enclosures and electrical safety issues.

- Costly excavations, network diversions and pressure restrictions along the network to repair corrosion damaged pipelines

7.1 Replace on Failure Option Summary

The technical detail of the option i.e. capacity, system rating, availability etc.
This option is to replace the existing TR's as and when they fail. This would be a complete replacement of the TR unit, including the housings, internal components and if required the civils base, but not any 'pipelines' related assets such as earth ground beds.

This option would mean there would be increased downtime of cathodic protection on the pipeline until design, materials and installation could be carried out.

The basis for the cost estimate/unit cost
The costs for this option have been derived from similar project works carried out in the GD1 price control period. The example used was a one-off ad-hoc project due to asset failure (Project – GM5 high pressure gas pipeline TGSH1170). This cost leads to a unit cost of £23,743 per unit.

Additionally, there is an ongoing cost of the carried risk associated fatalities, non-fatal incident and loss of supply due to only replacing these assets as/when they fail. These are summarized in the table below:

Table 3: Associated Risk Cost

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	£225,000.00
Non-serious "nuisance" / odour incident	1	£50,000	0.01	45	£22,500.00
Total/site					£248,963.63
Total for Scotland	**15**				**£3,734,454.45**
Total for South	**40**				**£9,958,545.20**

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. However, there is already a regime in place of inspections and an asset population has already been identified – primarily pole mounted TR's.

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
Some of the costs in previous projects include for additional costs for electrical distribution networks (DNO's) for new electrical supplied – it is assumed that as these are replacements they already have an electrical supply. It is also assumed additional costs for land/wayleaves will not be required for the majority of sites.

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 cost reductions based on economies of scale savings.

7.2 Pre-emptively Replace Option Summary

The technical detail of the option i.e. capacity, system rating, availability etc.
This option is to proactively replace the existing TR's which are pole mounted and those known to have integrity/condition issues which are predicted to require replacement in the GD2 period. This would be a complete replacement of the TR unit, including the housings, internal components and if required the civils base, but not any 'pipelines' related assets such as earth ground beds.

As this is a planned programme of works, downtime will be minimal as equipment will be pre-designed and pre-constructed off site, and contingency plans will be put in place to reduce downtime of CP on the pipeline.

The basis for the cost estimate/unit cost
The costs for this option have been derived from similar project works carried out in the GD1 price control period. The example used was a one-off ad-hoc project due to asset failure (Project – GM5 high pressure gas pipeline TGSH1170). This cost leads to a unit cost of £23,743 per unit, however there have been some cost assumptions made, which reduce the cost for this option to £13,233 per unit.

The perceived benefits of the option
This option would result in reduced downtime but also represent the most cost-effective option as design and material costs will be reduced but also allow for the management of labour to be carried out in such a manner to reduce on site install and commissioning costs and achieve preferred contract rates as the work would be sustained over a period of time.

Delivery timescales
Provided that the proactive work such as tenders, advance purchase and build of materials and model designs are in place, site works could be a period of a week and records another week. This is greatly reduced to the alternative of ad-hoc replacements on failure.

Key assumptions made
It is assumed that model designs can be achieved for the asset portfolio and materials would be purchased at a discount due to larger volume purchases.

Any other items that differentiate the option from the others considered
Costs vary a mentioned earlier.

7.3 Options Technical Summary Table

Table 4: Options Technical Summary

Option	First Year of Spend	Final Year of Spend	Volume of Interventions	Equipment / Investment Design Life	Total Cost
Scotland LDZ					
Replace on Failure	2022	2026	15	25 Years	0.34
Pre-emptively Replace	2022	2026	15	25 Years	0.25
South of England LDZ's					
Replace on Failure	2022	2026	40	25 Years	0.91
Pre-emptively Replace	2022	2026	40	25 Years	0.67

7.4 Options Cost Summary Table

Table 5: Cost Summary

Option	Cost Breakdown	Total Cost (£m)
Pre-emptively Replace	Surveyor & legal fees to be met by SGN and legal fees for new easement rights. £1,200 Installation costs – external contractor £2,500 Paul Wright Construction to provide civils works £2,000 Kiosk & TR unit provided by Solutech ltd £3,150 UKPN Costs (cost from the electrical distribution network operator (DNO)) £1,500 In house electric design £100 CP design approval and appraisal £100 External Project Management £1,500 10% Contingency for site variations 1,205	Total Sites Scotland:15 South of England: 40 Total Capex Scotland: £0.25m (Gross) Total Capex South of England: £0.67m (Gross)
Replace on Failure	Surveyor & legal fees to be met by SGN and legal fees for new easement rights. £1,380 Farmer payments £605 Paul Wright Construction to provide civils works £7,000 Kiosk & TR unit provided by Solutech ltd £3,415 UKPN Costs (cost from the electrical distribution network operator (DNO)) £1,500 In house electric design £600 CP design approval and appraisal £3,500	Total Sites Scotland:15 South of England: 40 Total Capex Scotland: £0.34m (Gross) Total Capex South of England: £0.91m (Gross)

8 Business Case Outline and Discussion

A pre-emptive replacement program is considered the most cost effective and optimum solution to ensure continued compliance with the previously mentioned regulations (Ensuring the networks integrity and reducing the risks to SGN operatives, public and livestock).

8.1 Key Business Case Drivers Description

Table 6: Summary of Key Value Drivers

Option No.	Desc. of Option	Key Value Driver
1	Replace on Failure	Potential for reduction of workload in GD2 as no programme of works in place – replacement will be only when failure occurs. This is the least cost-effective option and could result in non-compliance with current regulations.
2	Repair on Failure	Not a viable option
3	Pre-emptively Replace	This option is the most cost effective, and it ensures that SGN will not be operating with potential non-compliances with current legislations. It also ensures that there will be minimal downtime between projects.
4	Pre-emptively Repair	Not a viable option
5	Do Nothing	Minimum requirement is option 1

Table 7: 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	Replace on Failure	N	-0.34	-1.12	-0.63	-0.66	-0.68	-0.99
1	Pre-emptively Replace Absolute NPV	Y	-0.25	-0.33	-0.17	-0.19	-0.21	-0.27
1	Pre-emptively Replace NPV relative to Baseline	Y	-0.25	-0.33	0.46	0.47	0.48	0.72
South of England LDZ's								
Baseline	Replace on Failure	N	-0.91	-3.01	-1.73	-1.80	-1.85	-2.69
1	Pre-emptively Replace Absolute NPV	Y	-0.67	-0.88	-0.48	-0.53	-0.57	-0.75
1	Pre-emptively Replace NPV relative to Baseline	Y	-0.67	-0.88	1.25	1.27	1.28	1.94

8.2 Business Case Summary

This project is driven by the potential for electrical safety risks to SGN employees, the public and livestock caused by the deteriorating of SGN's CPTR units on operational gas sites and non-operational locations such as farms/fields. This is also to relocate pole mounted TR units to ground level to mitigate the issues with working at heights and manual handling requirements.

This project will also ensure reduced downtime of impressed current on the pipeline between the replacement of CPTR units.

Table 8: Business Case Matrix

	Pre-emptively Replace	Pre-emptively Replace
	Scotland	South of England
GD2 Capex (£m)	0.25	0.67
Number of Interventions	15.00	40.00
Carbon Savings ktCO2e (GD2)	0.00	0.00
Carbon Savings ktCO2e /yr	0.00	0.00
Carbon Emission Savings (35yr PV, £m)	0.00	0.00
Other Environmental Savings (35yr PV, £m)	0.00	0.00
Safety Benefits (35yr PV, £m)	0.68	1.81
Other Benefits (35yr PV, £m)	0.00	0.00
Direct Costs (35yr PV, £m)	0.11	0.30
NPV (35yr PV, £m)	0.79	2.11
High Carbon Scenario		
Carbon Emission Savings (35yr PV, £m)	0.00	0.00
High Carbon NPV (35yr PV, £m)	0.79	2.11

9 Preferred Option Scope and Project Plan

9.1 Preferred option – Pre-emptively Replace

The preferred option for SGN is the Pre-emptive replacement program of 55 TR's replaced throughout the pricing period. Focusing on the pole mounted, Mapel installations and those that pose a risk to SGN operatives carrying out maintenance tasks or those that pose a risk to the public or livestock.

By carrying out pre-emptive replacements of the TR installations the individual cost of the installations will be lessened by the added discounts available from the manufacturers for buying multiple units. This coupled with the additional benefit of utilising model designs, approval and appraisal costs as a generic project design adds to the cost saving.

The GRP kiosk is the preferred installation method for the replacement of the TR's. The GRP kiosks are substantially stronger due to their construction material and method. They are built to withstand the long-term effect of the elements. The kiosks will be located at ground level in order to comply with ECP/2 Regulation 4.12.3 which states "All equipment should be accessible from ground level and housed in lockable enclosures to prevent interference by or hazard to livestock and unauthorised persons".

This will minimise both the risk posed to SGN operatives during maintenance from working at heights whilst reducing the additional maintenance costs incurred of hiring access equipment and the need for two man working reducing the operational costs of maintaining the TR's.

The improved electrical distribution system layout installed to the BS 7671 18th Edition Wiring regulations coupled with the improved electrical design includes the added benefit of a heater within the kiosk. The heater is used to minimise condensation and in turn will protect the TR and extend the life of the asset.

The electrical system within the kiosk also has provisions for the installation of a remote data logger if required. Remote monitoring allows detection of a mains fail or component failure within the TR. This in turn means that any pipeline protection problem will be addressed swiftly and nullifies the possibility of a pipeline lying unprotected for a length of time between quarterly maintenance visits.

The primary option focused on the pre-emptive replacement of stand-alone T/R installations. Replacement costs are estimated at £13,233 per installation.

9.2 Asset Health Spend Profile

Table 9: Preferred Option Spend Profile

Asset Health Spend Profile (£m)					
Pre-emptively replace	2021/22	2022/23	2023/24	2024/25	2025/26
Scotland LDZ	0.05	0.05	0.05	0.05	0.05
South of England LDZ	0.14	0.13	0.13	0.13	0.14

9.3 Investment Risk Discussion

Risk Matrix

Table 10: Risk Register

Risk Description	Impact	Likelihood	Mitigation/Controls
Budget	Over Spend	>20% & <=40%	SGN have not accounted for those TR's which may be damaged due to lightning strikes and the resulting electrical surges. SGN have had a history of TR units being damaged due to lightning strikes. To mitigate this, SGN will risk rank the TR units, and potentially asset swap if another TR unit is damaged as part of a lightning strike
Budget	Over Spend	<=20%	Network have not built in any risk/contingency costs for this works. However being a programme of works, this allows for slight flex on project scope/volume etc if there are any issues with unpredicted cost increases.

CAPEX Sensitivity

Table 11: Sensitivity Analysis

	Scotland LDZ			South of England LDZ's		
	Low	Mid	High	Low	Mid	High
GD2 Capex (£m)	0.21	0.25	0.30	0.57	0.67	0.80
Number of Interventions	15	15	15	40	40	40
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)	0.7	0.7	0.7	1.8	1.8	1.8
Other Benefits (35yr PV, £m)	0.0	0.0	0.0	0.0	0.0	0.0
Direct Costs (35yr PV, £m)	0.1	0.1	0.1	0.3	0.3	0.4
NPV (35yr PV, £m)	0.8	0.8	0.8	2.1	2.1	2.2

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 15% CAPEX costs – this can be applied if SGN achieve greater than expected discounts on material purchase and also if greater efficiencies can be achieved in projects delivery that haven't already been fed into the costs – this would be process improvements and streamlining working practices to reduce mobilisation time on site.

This reduction also considers any cost savings which may be as a result of no wayleaves or power supply agreements being required or no drafting on legal agreement or procumbent of additional land.

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, as this is believed to be the potential cost increase if SGN do not go to tender and achieve best possible market prices. This could also be impacted by political changes which may impact on resource availability or material costs. This increase in cost also allows for any issues in obtaining generic designs for the full volume of works or SGN not being able to delivery these projects efficiently due to internal processes which would increase contract labour costs. This also includes for increased legal/wayleave costs which may be incurred on specific sites.

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 12: 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)	0.47	0.48	0.47	
NPV (35yr PV, £m)	0.79	0.79	0.78	
NPV (45yr PV, £m)	0.79	0.80	0.79	
Payback	0.00	0.00	0.00	0.00

Table 13: 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)	1.27	1.28	1.25	
NPV (35yr PV, £m)	2.10	2.11	2.08	
NPV (45yr PV, £m)	2.12	2.13	2.12	
Payback	0.00	0.00	0.00	0.00

Appendix A - Cost Breakdown

Network E&I requested costs for this package of works from Major Construction Projects department.

The costs which were used we for a similar project. Project Number TGSH1170 – cathodic protection scheme to protect GM5 high pressure pipeline. The costs for this project are broken down below:

Table 14: Cost for GM5 Pipeline Project

Item	Cost
Medway council surveyor & legal fees to be met by SGN and legal fees for new easement rights.	£1,380
Consideration payment to the farmer for crop loss	£250
Paul Wright Construction to provide civils works	£11,300
Kiosk & TR unit provided by Solutech ltd	£3,415
UKPN Costs (cost from the electrical distribution network operator (DNO))	£3,090
In house electric design	£600
CP design approval and appraisal	£3,708
Total	£23,743

It was concluded by Network E&I that the costs for this project were too high, as the scope of works of this engineering justification paper excludes ground beds and the associated civils works and that there would be a minimal requirement for DNO works. It is also thought that farmer fees are normally higher for these kinds of works.

Based on this, Network E&I have estimated that a on off TR replacement would cost following:

Table 15: Network E&I Estimate for Ad-Hoc Replacement TR

Item	Cost
Surveyor & legal fees to be met by SGN and legal fees for new easement rights.	£1,380
Farmer payments	£605
Paul Wright Construction to provide civils works	£7,000
Kiosk & TR unit provided by Solutech ltd	£3,415
UKPN Costs (cost from the electrical distribution network operator (DNO))	£1,500
In house electric design	£600
CP design approval and appraisal	£3,500
Total	£18,000

For a project which forms a part of a packaged programmes of works, SGN policy and procedures allow for a standard design to be produced, and to be used across multiple projects of the same scope. The below costs are again an estimate, but discounts have been put in for design and procurement costs to better reflect the true cost of a project which has been through a competitive tender.

Table 16: Estimate for packaged project costs

Item	Cost
Surveyor & legal fees to be met by SGN and legal fees for new easement rights.	£1,200
Installation costs – external contractor	£2,500
Paul Wright Construction to provide civils works	£2,000
Kiosk & TR unit provided by Solutech ltd	£3,150
UKPN Costs (cost from the electrical distribution network operator (DNO))	£1,500
In house electric design	£100
CP design approval and appraisal	£100
External Project Management	£1,500
10% Contingency for site variations	1,205
Total	£13,255

Appendix B - Acronyms

Acronym	Description
CP	Cathodic Protection
T/R	Transformer Rectifier
AC	Alternating Current
DC	Direct Current
CIP	Close Interval Protection
RCD	Residual Current Device
GRP	Glass Reinforced Plastic