Engineering Justification Paper

Control Room Replacement or Redesign

Version: Final

Date: December 2019

Classification: Highly Confidential

Reference: SGN IT – 005 ContRm EJPDec19

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2 Introduction

Gas Control undertakes a wide range of activities to support SGN's primary objective of delivering a safe and secure supply of gas to our customers. They actively monitor and control supplies of gas from the point at which it is taken from the National Transmission system right through to the lower pressure tiers.

This proposal needs to be reviewed in conjunction with the EJP – Telemetry Refresh (*SGN IT - 018 Telem EJPDec19*).

2.1 General Background

The Gas Control Application Suite is used by SGN's 24/7 dedicated Gas Control Centre to monitor, control and manage SGNs high and medium pressure gas networks. These systems include critical applications such as SCADA (Supervisory Control and Data Acquisition) which provides real time data from nearly 400 of our gas networks sites; Business Applications, Demand Management Suite and Forecaster that allows Gas Control to forecast and track the gas demand and gas quality within the network both within day and up to 7 days in advance; Supporting applications that contain vital information to manage faults and site works on the Gas Network including recording alarm and site setting information; Planning Tools that are used to provide both steady and transient state analysis of the network to support planning and emergency activities.

As well as the above our stakeholders have made it clear that keeping the gas flowing safely should be our greatest priority. Our gas control applications are critical to ensuring SGN can meet its licence obligations when it comes to monitoring and controlling the high-pressure gas network, forecasting gas demand and carrying out analysis of planned works. Investment is critical to ensure these applications remain appropriately supported to minimise any impact on public safety.

This paper outlines the capital investment required to ensure gas control application services, including infrastructure used to provide these services, undergo the necessary upgrades and enhancements to keep them in step with operational processes.

2.2 Site Specific Background

Gas control primary operations are based out of SGN offices in Security
The applications are also accessible to remote SGN users and support teams.
The applications are integrated with 3rd parties like Security .

3 Equipment Summary

A high-level view of the Gas Control application and interface landscape is provided below.

Figure 1: Services Landscape

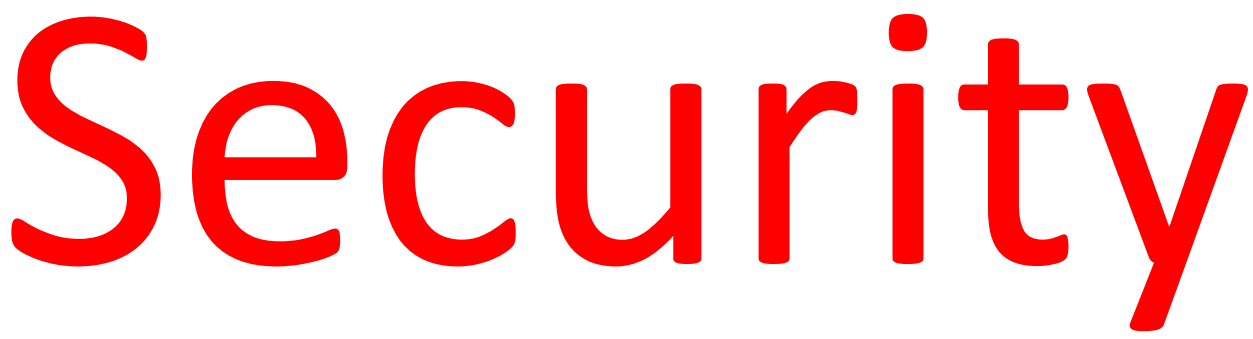


Table 1: Service Description

Service	Description	Key Statistics	Key risks
Telemetry	Telemetry system relays data from remote gas sites to the central SCADA system. VSAT, Dial Backup and Radio are the main important components of SGN Telemetry system.	Not shown in the landscape above as it is out of scope of this paper. Please see separate EJP – Telemetry Refresh	
Supervisory Control and Data Acquisition (SCADA)	Primarily used in the Control Room to monitor and manage the gas network, by controlling the remote sites.	Licenses: No. of WebX – 21 No. of ViewX – 48 No. of Client connections - 104 Servers:	1. High Memory utilisation (Memory Leak): ~ Slow performance experienced by all users. Failover is undertaken at a greater frequency than recommendation to ensure memory block is not higher than threshold

		No. of servers – 15 No. of client Workstations – 20 Workstations: Windows 10 –	~ Security has suggested to upgrade and perform diagnostics 2. Security ~ If new defects identified after 16 Mar 2020, Security will not provide the fix in Security build, as it is difficult to backport the issues found in builds that are not under active maintenance support. ~ SGN rely on workarounds for outstanding defects until fixed in the upgrade. 3. Last Hardware refresh was performed in Oct 2015 and is due for an upgrade in 2020.
Business Apps (BA) & Demand Management Suite	Security	App- Servers: 8 Database- Servers: 8	1. Last Hardware refresh was performed in Oct 2015 and is due for an upgrade in 2020 and 2025. 2. BA and DMS screen slow performance reported by business users can be overcome by redesigning the BA and DMS screens.
Forecaster	Security provided proprietary forecasting system. Used by the Control Room to forecast the gas demand during the day.	App- Licenses: 5 Servers: 5 Database- Servers: 5	1. Application is running on Security which will stop receiving security updates after 14Jan2020 and will reach end of support. 2. Last Hardware refresh was performed in Oct 2015 and is due for an upgrade in 2020 and 2025.

			3. Few application fixes from last few years are yet to be taken in new build from vendor.
Offtake Profile Forecaster (OPF) & Time to Fail (TTF)	Used in the Control Room to submit the OPN to UKT and for nominating volumes of gas with National Grid. The service uses Security	App (Application installed within BA server)- Licenses: 0 Servers: 6 Database- Licenses: 8 Servers: 6	1. Last Hardware refresh was performed in Oct 2015 and is due for an upgrade in 2020 and 2025.
Gas Network Simulator (GNMS) & Trainer	Used in the Control Room to simulate the distribution network, Forecast, demand and balance management and provides forecasting simulation services for Gas Control users. The service uses Security	App - Servers: 6 Client: 3 PLS dongle license Database (Database installed within SQL server used by OPF)- Licenses: Servers: 6	1. Last Hardware refresh was performed in Oct 2015 and is due for an upgrade in 2020 and 2025.
Lotus Notes Apps	Lotus Notes holds 23 applications which are used by the control room and support teams. Lotus notes contain multiple utility applications used in control room activities like log book, shift works, phonebook, shift handover, change request, etc. Security	Servers: 5	1. Application is running on Security which will stop receiving security updates after 14Jan2020 and will reach end of support. 2. Security 3. Last Hardware refresh was performed in Oct 2015 and is due for an upgrade in 2020 and 2025.
Interfaces	There are various Interfaces between different SGN GasControl applications and to manage that Filemover is used. Filemover is an application used to pick up and move files from one server to another using security protocols. This is broadly	Around 90 Internal and External Interfaces with a scan frequency of 1 minute or higher Servers: 4	Filemover is planned to be replaced with SGN's enterprise File transfer service based on Security SGN intend to complete this migration in the GD1 period but regular upgrades will be required

	used between various business applications for GasControl such as DNCS BA, Forecaster, GNMS, etc.		to meet support contract obligations
Workstations	RTGAS Workstations	Count: 22 (including 2 spare machines in Comms room) SCADA Client license: 20	Security
AD	RTGAS Domain controllers	Server hardware - 2 (covered in ESX)	Needs to be reviewed by 2020
SAN & 3PARS	SAN storage 3-PARS & SAN Switches - (Production and Pre-production)	3-PARS Count: -4 SAN switches: - 6	They are Security and 2015 refreshed ones so we need to review 2020 They are old but Security and 2013 refreshed ones so we need to review any time soon
ESX	ESX (Production and Pre-production)	Security	They are Security (Pre-production) so we need to review 2020 and 2025 Security
P-SERIES & LPARS	P-series Hardware used for multiple purposes including backups, schedulers and AIX virtual servers	Security	Hardware was reviewed in 2015 and need to be reviewed soon in 2020 Security
File shares	RTGAS File servers (VMs within ESX)- (Production and Pre-production)	Server - 4 (covered in ESX) Security	Follow hardware refresh cycle - 2020

Domain controllers	RTGAS domain controllers (VMs within ESX) (Production and Pre-production)	Server Hardware - 3 (covered in ESX)	Follow hardware refresh cycle - 2020
Load Balancers	Security Netscalers hosted on VMS on ESX)	Server Hardware - (covered in ESX) Security	Follow hardware refresh cycle - 2020
Citrix	RTGAS Citrix servers Production- (Existing On-premise) Production - 8 servers (2 store front and 6 VDAs) Pre-Production - 8 servers (2 store front and 6 VDAs)	Server Hardware - (covered in ESX) Security	Windows - 10/10/2023 Citrix 7.6 - 11/01/2026
Firewalls	SOMSA Cluster (Pre-Production and Production firewall)	Appliances – 4 units	Cisco hardware needs to be reviewed in 2020 Security
Screens	Wall Screens used by the control room to display dashboards	Count: 7	Wall screens with Windows 7 will reach end of life in Jan 2020.

4 Problem Statement

The Gas Control application and infrastructure estate is the bedrock of our bread-and-butter processes to ensure safe and reliable transport of gas. Investment in the maintenance of these services is perceived as 'keeping the lights on' kind of problem and is necessary to meet our license obligations.

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

The Network control applications and infrastructure are pre-dominantly based on commercial off-the-shelf (COTS) products. SGN require this investment for them to remain in a supported state and not reach their end of life prematurely. If this investment in regular upgrade and enhancements is not made, they will gradually reach an unsupported state, followed by catastrophic failures.

Below is a summary of the key risks which arise if there is a drop in the service standard:

Table 2: Risk of doing nothing

Risk Category	Risk description
Continuity of Supply	Failure to maintain our estate appropriately will result in development of faults which could lead to a loss of ability to monitor the gas network in real time. This could adversely

	impact reacting and meeting variable gas demand levels during a gas day.
Network Reliability	Failure to maintain our estate appropriately will result in a loss of ability to receive meaningful and timely alarms. The system reliability is directly proportional to the reliability of the gas network.
Network Capacity	Failure to maintain our estate appropriately will result in a loss of ability to manage the gas network effectively and breach our licence obligations.
Major Accident Prevention	Failure to maintain our estate appropriately will result in a loss or reduction in the ability of reacting to emergency events like gas escapes, weather events, etc.
Usability	The service will not remain aligned to the digitalisation trends and will no longer remain fit for purpose.
Security	The applications and infrastructure will no longer cope with the changing security requirements

What is the outcome that we want to achieve?

SGN is expected and aims to maintain its gas network including the underlying Information Technology and Operational technology systems through continued investment.

How will we understand if the spend has been successful?

Practical priorities will drive Network Control's digital investment:

i. Ensure **straightforward digital access** to Gas Control services and help engineers effectively manage our gas network and operations, monitored by tracking and ensuring the pre-defined service availability standards are met or exceeded. Example: SCADA Service availability target of 99.99%

ii. Ensure **systems and data are secure** through implementation of security, monitoring systems and staff education by meeting NIS directive and our duty as an Operator of Essential Services (OES)*

iii. Use intuitive **tools to capture, baseline, improve data** as a by-product of operations in ways that empower business and reduce the administrative burden, in line with Energy Data Taskforce (EDTF) recommendations for Digitalisation of Energy System*

iv. IT systems need to revolutionise, to make it a more satisfying **user experience** and ensure continued compliance with standards like EEMUA 191

v. Align asset technologies and capabilities with
   a. changing business demands and regulations
   b. changing technical capabilities e.g. Cloud, IIOT low power devices, AI/ML, etc.
   c. growth in the number of monitored sites and points

Ref: Business Plans guidance
https://www.ofgem.gov.uk/system/files/docs/2019/09/riio-2_business_plans_guidance_september_2019_-_published_0.pdf
Ref: Energy Data taskforce report
https://es.catapult.org.uk/news/energy-data-taskforce-report/

4.1 Narrative Real-Life Example of Problem

SGN maintains the Gas Control SCADA system which is used to monitor and control all SGN's high and medium pressure gas networks. Security

SCADA receives information from over 400 gas sites on SGN networks so that the shift teams can monitor and operate the system.

SGN's DNCS SCADA is based on Security

There had been 13 unplanned system failover events resulting in 113 minutes of system outage over a 5-month period on the Security . Poor operator performance was encountered on a regular basis and weekly reboots were required to mitigate further performance degradation.

The risks mitigated by completing the upgrade are below:

- SGN went out of support in February 2018 on the business critical SCADA systems used by Gas Control to manage the safe and secure supply of gas in our networks. We now have support for another year.
- Core code fixes are now available to SGN in the event of a system failure.

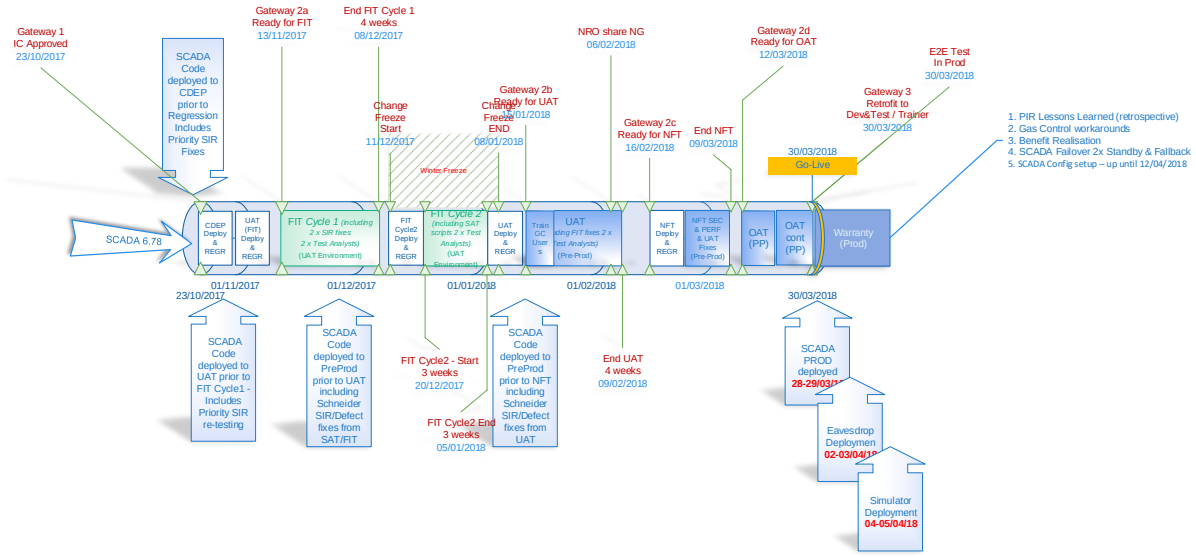
This project also facilitated building a new virtual server which has been used as a Code Deployment server. This allowed the existing Code Deployment server to be incorporated into the pre-production system. This has been vital to testing the performance problems previously encountered on version Security This new server (called Security was built, tested, passed OAT and has been accepted into support.

The upgrade was tested following standard testing methodology and involved Regression, Functional Integration Testing, User Acceptance testing, Non-functional testing and Operational acceptance testing across the Code deployment, UAT and pre-production environments. All test phases passed successfully. The project managed to remove 18 business defects and incorporated a new way of presenting the display to the operators resulting in the operators requiring to log-on to 75% less screens. The Simulator and Eavesdrop environments have also been upgraded to Security

There were 2 major defects that were evident version Security These were 69337 Action Replay and 71878 Slow Performance in DNCS SCADA, these have both resolved with this upgrade to Security

Although minor versions and security updates are considered BAU, the major releases include feature changes and sometimes significant changes to the underlying core engine. SGN as per its contract with Schneider Electric is expected to keep within 2 versions of the latest product released, like all the other customers.

Figure 2: SCADA Upgrade Timeline



Each such release requires SGN's support teams and business users to undertake rigorous tests before the upgrade is undertaken in production. Thus, SGN combine multiple releases and cycle a consolidated production release once every two years.

During the last upgrade of DNCS SCADA from Security , the following observations were made. Please note that the costs and effort expended for any enhancements included vary for each release and could be spread over the previous meeting.

Table 3: SCADA Upgrade Key Statistics

Number of Functional tests undertaken	217 Test Cases (7044 Test Steps)
Number of Non-functional tests undertaken	NFT – 35 Test Cases OAT – 47 Checks and Measures
Number of User Acceptance tests undertaken	155 Test Cases (4125 Test Steps)
Number of defects observed	18 SIR Defects raised Severity 1 – 0 defects Severity 2 – 3 defects Severity 3 – 3 defects Severity 4 – 11 defects
Overall Project duration from investment approval	6 months

The following table summarises the project's final resource assessment.

Table 4: SCADA Upgrade Resource Loading

Role	Design	Design	Build	Test	Implementation	Total Effort
Project Management	10	10	10	15	5	50 Days
SGN Technical External Resource		5	20	8	5	38 Days
Architect		2				2 days
Enzen SCADA Testing			20	90	3	113 Days
External SCADA Tester				59		59 Days
Test Manager	5	10	20	40	5	80 Days
Implementation Manager			2	5	4	11 Days
Desktop Support				1	2	3 Days
Enzen Release Resource			45	35	20	100 Days

4.2 Spend Boundaries

This paper only covers the capex costs associated with procuring, implementing and rolling out application upgrades and enhancements for SGN's Network Control operations. It does not cover any ongoing costs associated with maintaining these services through GD2. These ongoing costs are covered in our GD2 opex run costs.

This proposal needs to be reviewed in conjunction with the EJP – Telemetry Refresh (*SGN IT - 018 Telem EJPDec19*).

5 Probability of Failure

The Network control services are not built to fail to ensure continued 24x7 service. Each failure occurrence is dealt with as an emergency with resolutions targeted within minutes and hours, rather than days. This level of service has been expected, if not better, throughout the GD1 period and will be expected in the GD2 period as well.

5.1 Probability of Failure Data Assurance

For this paper, IT assets are assumed to have a relatively short life of 5 years*, unlike gas equipment. Although certain software product manufacturers require us to upgrade every 2 years for effectiveness of support or ensure the live instances of the software products are at the very least within 2 versions of the latest available product release.

The hardware equipment end of life is also recommended to be 5 years by most manufacturers like HP and Cisco. However, advise from the product vendors is incorporated on a case by case basis.

Ref: IT equipment life benchmark from a comparable Australian utility asset management plan
https://www.aer.gov.au/system/files/PWC%20-%2014.9P%20AMP%20SCADA%20and%20Communications%20-%2028%20February%202018.pdf

6 Consequence of Failure

Table 5: Impact of Failure

Failure Categories	Loss of Supply to Customers	Safety Impact of Failure	Environmental Impact
Catastrophic failure of all services or full or intermittent outages of SCADA for more than 2 hours	Security		

Security

Security

Business Apps (BA) & Demand Management Suite

Forecaster

Security

Offtake Profile Forecaster (OPF)
Time to Fail (TTF)
Gas Network Simulator (GNMS) & Trainer
Lotus Notes Apps

Security

Interfaces

7 Options Considered

The options outlined below are in line with our current refresh process which aims to ensure best value is achieved from all assets.

7.1 Option 1 – Maintain current systems – Capital spend on upgrades and enhancements to keep them fit-for-purpose, replace only upon End of Life

This option predicts investment will be required in GD2 commensurate with GD1. In GD1 period, 30 projects were delivered at a total expenditure of £11.5 m. This submission of £8m of predicted spend in GD2 is broadly in line with the expenditure seen in GD1 when the shorter time period of GD2 is considered. Major Projects that have been successfully delivered in the GD1 period included:

i) three SCADA system upgrades;
ii) refresh of the Gas Control IT infrastructure;
iii) application changes and replacements to accommodate changes to the start time of the Gas Day to align with European Union countries;
iv) provision of new applications to provide transient state analysis, of the Gas Network.

7.2 Option 2 – Pre-Emptively Replace – Capital purchase and deployment of replacement systems

This option is to replace all the existing Network Control Systems i.e. SCADA, Business Applications, Demand Management System, Forecaster and other supporting applications such as Log Book, Pipeline Studio & Manager with a new integrated suite of systems and applications that will address the future requirements of SGN's business.

This option predicts investment of Commercial Confident will be required, at a similar level to the implementation of systems into the new Gas Control Centre in 2011. The investment covered the creation of

i) a dedicated IT environment, separate from the corporate IT environment, to host the Gas Control Applications.
ii) creation of the dedicated infrastructure specialised applications (including SCADA, Business Applications, Demand Management System, Forecaster and other supporting applications) were bought and
iii) customised to meet the needs of the Gas Control Centre created in 2008.

The difference between Option 2 and Option 1 is that Option 1 looks at keeping the existing systems in support while this option (Option 2) looks at replacing the systems.

7.3 Option 3 – Baseline Option – Replace on Failure – Sweat the Asset

This option is the baseline option and proposes that faults are fixed or applications replaced when they fail. This option is not viable and has not been costed as it poses a risk to our Critical National Infrastructure and breaches our license obligation.

7.4 Options Technical Summary Table

Table 6: Options Technical Summary

Option	First Year of Spend	Final Year of Spend	Volume of Interventions	Equipment / Investment Design Life	Total Cost
Baseline	2025	2025	0	0	Commercial Confidentia
Control Room Refresh	2022	2026	12	5 years	
Full Control Room Replacement	2022	2026	1	8 years	

Please note the costs outlined in the Options Technical Summary Table are based on the following assumptions:

Baseline Assumptions:

- SGN manage its IT estate in line with the HSEs ALARP (as low as reasonably practicable) risk management principles. On that basis SGN have assumed a failure to invest in required upgrade, replacement or refresh activity for safety critical systems, would lead to catastrophic system failure as well as a lack of 3rd party support (based on support contracts, 3rd party roadmaps, architectural standards and internal policies, designed to ensure upgrade, replacement or refresh activity is carried out at the appropriate point in time to in order to prevent a non-recoverable functional, technical or security failure).
- SGN have assumed that a lack of investment combined with a lack of support would prevent the reinstatement of systems should they fail.
- SGN have assumed a catastrophic failure of safety critical systems and an inability to reinstate systems after failure would lead to an inability to respond to gas emergencies, an inability to know where our assets are and an inability to track performance and regulatory outputs.

- SGN have assumed an inability to respond to gas emergencies, an inability to know where our assets are and an inability to track performance and regulatory outputs would inevitably lead to a catastrophic incident e.g. explosion and loss of life (£17.73m). This assumption is supported by section 2 of the Health and Safety at work act which identifies scenarios that would result in loss of life.
- SGN have assumed an inability to respond to gas emergencies, an inability to know where our assets are and an inability to track performance and regulatory outputs would inevitably lead to an inability to operate. This would lead to a catastrophic breach of license conditions (up to £100m fine)
- SGN have assumed catastrophic failures in regard to loss of life (£17.73m), a breach of license conditions (up to £100m) will occur within 4 years of failing to adhere to support contracts, 3rd party roadmaps, architectural standards and internal policies designed to ensure upgrade, replacement or refresh activity is carried out at the appropriate point in time to in order to prevent a non-recoverable functional, technical or security failure.

Control Room Refresh Assumptions:

- Assumes a steady rollout, throughout GD2, across industry of Open Data Sharing and whole energy system approach - i.e. Ofgem and BEIS policy does not require accelerated delivery of open data and energy system approach.
- Assumes shared investment of establishment and operation Open Data Sharing service.
- Assumes "reasonable endeavours" for service elements: quality of data, frequency of service delivery, service SLA's etc.
- Assumes little or no requirement for specific technology solutions within SGN to support industry Open Data service, which are not aligned to our technology policies and roadmaps.
- Assumes no specific system changes to these applications are required to support new regulatory requirements - such as seen in the past for 'Gas Day Change'.
- Assumes no specific system changes to these applications are required to support new legislative requirements driven by Brexit.

7.5 Options Cost Summary Table

Table 7: Cost Summary

Option	Template	Cost Breakdown	Total Cost (£m)
Control Room Refresh	IT Capex	Resources Software Hardware Contingency	Commercial Confidentia
		Total	
Full Control Room Replacement	IT Capex	Resources Software Hardware Contingency	
		Total	

8 Business Case Outline and Discussion

This investment enables our Gas Control systems to remain operational. By performing the preferred option 1 i.e. incremental maintenance of the systems, we can ensure that our DNCS SCADA and dependent systems are operational, thus enabling us to monitor and control the >7 bar gas network. Without these systems, SGN would easily breach the UNC processes thus resulting in loss of license, and fatality.

8.1 Key Business Case Drivers Description

Table 8: Summary of Key Value Drivers

Option No.	Desc. of Option	Key Value Driver
1	Maintain current systems	Ability for SGN to support business processes Enables us to meet our outputs and license conditions Incremental change
2	Pre-emptively replace systems	Ability for SGN to support business processes Enables us to meet our outputs and license conditions Significant change to modernise services

Table 9: 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
Baseline	Do Nothing / Do minimum	N	Commercial Confidentiality					
1	Control Room Refresh **Absolute NPV**	Y						
2	Full Control Room Replacement **Absolute NPV**	N						
1	Control Room Refresh **NPV relative to Baseline**	Y						
2	Full Control Room Replacement **NPV Relative to Baseline**	N						

8.2 Business Case Summary

Table 10: Business Case Matrix

	Control Room Refresh	Full Control Room Replacement
Capex (£m)	Commercial Confidentiality	
Number of Interventions		
Carbon Savings ktCO2e (GD2)		
Carbon Savings ktCO2e /yr		
Carbon Emission Savings (30yr PV, £m)		
Other Environmental Savings (30yr PV, £m)		
Safety Benefits (30yr PV, £m)		
Other Benefits (30yr PV, £m)		
Direct Costs (30yr PV, £m)		
NPV (30yr PV, £m)		
High Carbon Scenario		
Carbon Emission Savings (30yr PV, £m)		
High Carbon NPV (30yr PV, £m)		

9 Preferred Option Scope and Project Plan

9.1 Preferred option

The preferred Option 1 is to maintain current systems – Capital spend on upgrades and enhancements to keep them fit-for-purpose, replace only upon End of Life. This is the lower risk, lower investment option.

9.2 Asset Health Spend Profile

The following works plan has been developed based on

i) the spend profile of GD1 period
ii) End of support dates published by the product vendors, like
a. Security

iii) Anticipated 5 years end of life of Workstation Hardware procured from HP
iv) Anticipated 5 years end of life of Local Area Network equipment procured from Cisco
v) Application upgrades based on current contracts with suppliers with minimum 2 year interventions with SCADA

Please note, SGN keep the roadmap of works updated every 6 months to ensure coherence with business objectives.

Figure 3: High Level Roadmap

Security .

Table 11: Spend Profile

Asset Health Spend Profile (£m)						
	2021/22	2022/23	2023/24	2024/25	2025/26	Post GD2
Control Room Refresh			Commercial Confidentiality			

9.3 Investment Risk Discussion

Table 12: Key Risks

Risk Description	Impact	Likelihood	Mitigation/Controls	Comments
Change in capital expenditure	Capex expenditure	<=20%	Thorough Project Management, design and testing, risk and issue management. Appropriate budget assigned for delivery considering lessons learnt from previous upgrades.	Impact of upgrade activity on ability to manage gas network impacting regulatory outputs.
Change in timelines	Capex expenditure	>40% & <=60%	Investment in technology roadmaps, ensuring early sight of any changes.	Changing technology trends including operating systems and applications impact the cost and timelines for delivery of the option.

Table 13: Sensitivity Analysis for Option 1 [Preferred Option] –

	Low	Mid	High
GD2 Capex (£m) Number of Interventions Carbon Savings ktCO2e (GD2) Carbon Savings ktCO2e /yr		Commercial Confidentiality	
Carbon Emission Savings (35yr PV, £m) Other Environmental Savings (35yr PV, £m) Safety Benefits (35yr PV, £m) Other Benefits (35yr PV, £m) Direct Costs (35yr PV, £m)			
NPV (35yr PV, £m)			

SGN IT believes the preferred option is to ensure our existing Gas Control applications, including the infrastructure used to provide these services, undergo the necessary upgrades and enhancements to keep them in support with the vendors.

For the purpose of sensitivity analysis, the following has been applied to the preferred option:

Low Case: SGN have applied a reduction of 10% CAPEX costs – this can be applied if SGN experience a low appetite for change within the business and/or there are fewer releases from the vendors than anticipated. In addition, an 80% reduction has been applied to both the Safety Benefits associated with the risk of a fatality and Other Benefits associated with the impact of a Breach of Licence Conditions.

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 50% on the CAPEX expenditure, as this is believed to be the potential cost increase to cover major deviations from a simple refresh/upgrade path. These deviations could include continued technology change, such as the introduction of AI/ML and deep learning and/or regulatory changes such as the cessation of clock change or reversion to 6am Gas Day commencement

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

Capitalisation 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, except for scenario 4, at the 20, 35 and 45 Year points, to demonstrate the effect of Capitalisation Rate on this value.

Table 14: Capitalisation Rate Sensitivity Results

Scenario	1	2 SGN	3	4
Capex (%)	65	41	100	0
Opex (%)	65	41	0	0
Repex (%)	100	100	100	0
Output				
NPV (20yr PV, £m)	101.17	98.63	104.87	
NPV (35yr PV, £m)	89.66	87.83	92.32	
NPV (45yr PV, £m)	83.90	82.61	85.78	
Payback	3.00	3.00	3.00	3.00

Appendix A - Acronyms

Acronym	Description
AD	Active Directory
AI/ML	Artificial Intelligence / Machine Learning
AIX	IBM Unix operating system
BA	Business Applications
BAU	Business as Usual
CBA	Cost Benefit Analysis
COTS	Commercial off the shelf products
DB	Database
DMS	Demand Management System
DNCS	Distribution Network Control System
Commercial Confidentiality	is an international accredited registrar and classification society headquartered in Høvik, Norway
EEMUA	Engineering Equipment and Materials Users Association
EJP	Engineering Justification Proposal
ESX	VMware ESXi is an enterprise-class, type-1 hypervisor developed by VMware for deploying and serving virtual computers
FWACV	Flow weighted average calorific value
GCS	Gas control system
GNMS	Gas Network management simulator
H&SE/HSE	Health and Safety Executive
HP	Hewlett-Packard was an American multinational information technology company headquartered in Palo Alto, California
IBM	International Business Machines Corporation is an American multinational information technology company headquartered in Armonk, New York
IIOT	Industrial Internet of Things
IT	Information Technology
LAN	Local Area Network
MFT	Managed File Transfer
MS SQL	Microsoft Structured Query Language
NEC	Network Emergency Coordinator
NFT	Non-Functional Testing
NG	National Grid
NIS	Network and Information Systems Directive
NPV	Net Present Value
NTS	National Transmission System
OAT	Operational Acceptance Testing
OES	Operator of Essential Services

OFGEM	The Office of Gas and Electricity Markets, supporting the Gas and Electricity Markets Authority, is the government regulator for the electricity and downstream natural gas markets in Great Britain
OPF	Offtake Profile Forecaster
OPN	Offtake Profile Notification
OS	Operating System
PARS / LPARS	Partition / Logical Partition - A logical partition is a subset of a computer's hardware resources, virtualized as a separate computer. In effect, a physical machine can be partitioned into multiple logical partitions, each hosting a separate instance of an operating system
PLS	Pipeline Studio
RTGAS	Real Time Gas network
SAN	Storage Area network
SCADA	Supervisory Control and Data Acquisition
SGN	Scotia Gas Networks
SIR	Schneider Electric Incident Reference number
SOMSA	System Operation managed services agreement
SQL	Structured query language
TSM	Tivoli Storage Manager
TTF	Time to Fail - application used during Gas Emergencies
TWS	Tivoli Work Scheduler software
UAT	User Acceptance testing
UK	United Kingdom
UKT	UK Transmission
UNC	The Uniform Network Code (UNC) is competitive gas industry's legal and contractual framework for the transportation and supply of gas. It has a common set of rules which ensure that competition can take place on equal terms
VPX	VPX is a worldwide standard for blade embedded computers and systems
VSAT	VSAT (Very Small Aperture Terminal) is a satellite communications system
XOSERVE	Xoserve is the Central Data Service Provider for Britain's gas market