Engineering Justification Paper

Renewable Energy

Final Version

Date: December 2019

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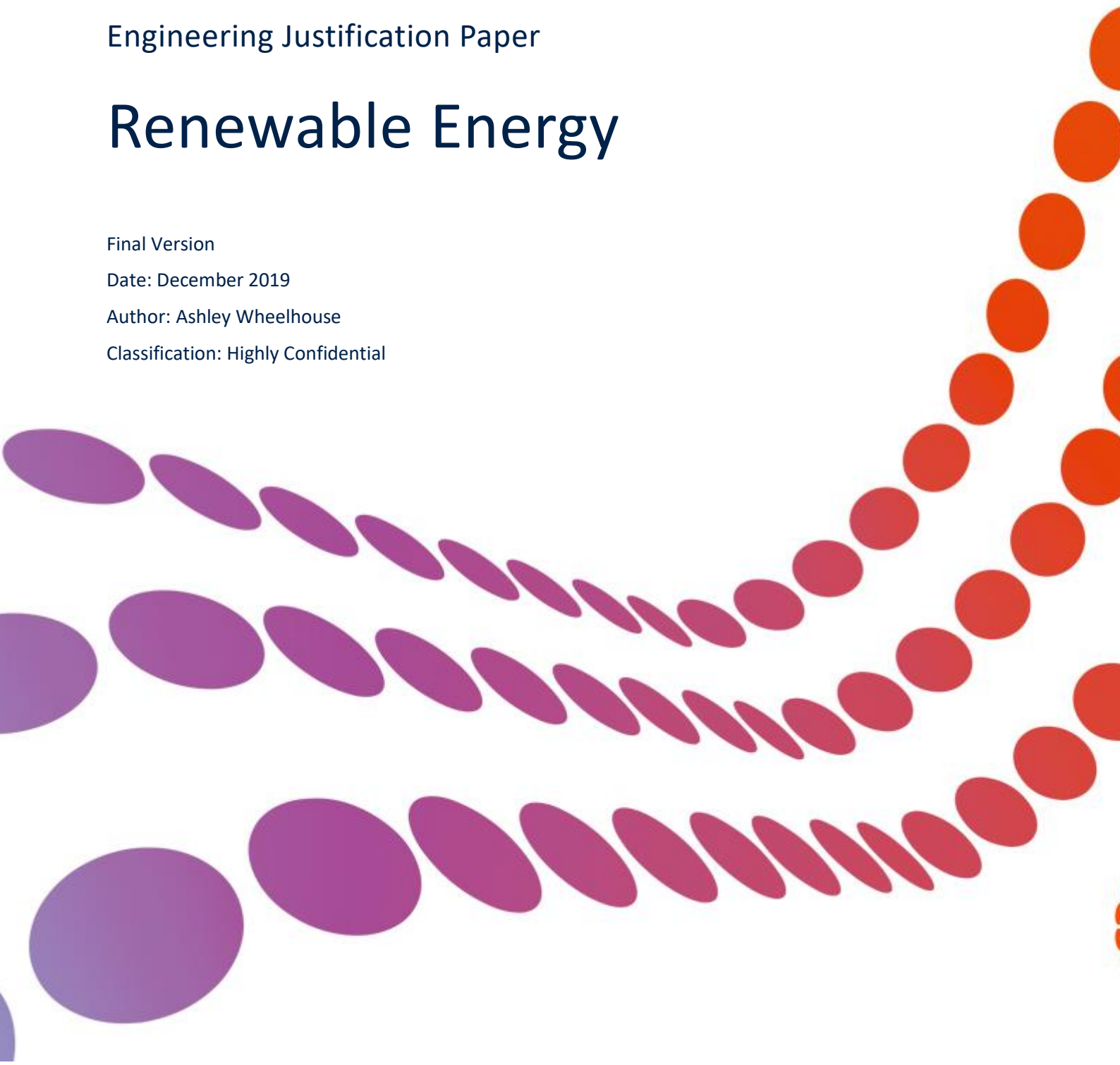
Classification: Highly Confidential



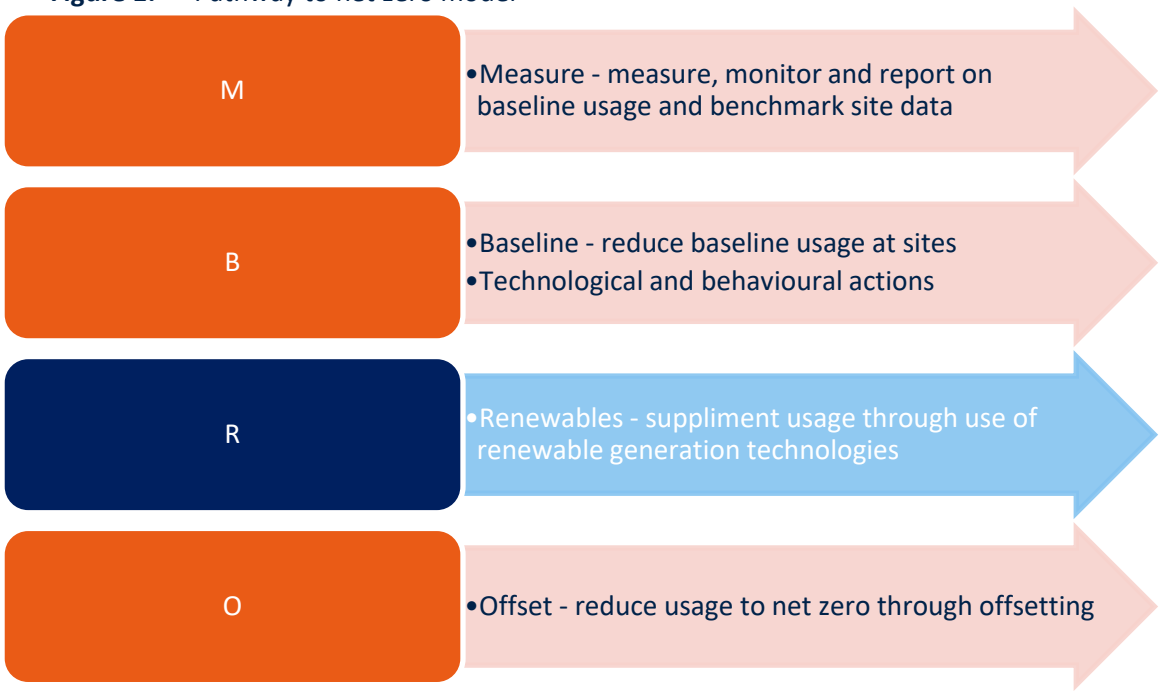
1. Table of Contents

2 Introduction

This paper seeks to justify the renewables phase from the programme of energy management and utility saving projects, in support of our Environmental Action Plan (EAP) goals.

To support deliver of these goals, we will be creating a "pathway to net zero" for each of our occupied premises. The basis of the pathway will follow a four-step process for each building as highlighted in **Figure 1** below.

Figure 1: Pathway to net zero model



The above pathway model highlights four key action areas to focus on in order to achieve significant savings. These action areas have been summarised below: -

Measure
Install equipment to measure and monitor baseline usage per area. Report on usage against a baseline in order to identify and target reductions.

Baseline
Identify both technological and behavioural opportunities to reduce energy usage at a site. Industry data suggests that the two highest consumers of energy in non-domestic buildings are heating (41%) and lighting (23%). Another property paper seeks funding to target reductions against each by installing networked BMS technology into our main buildings to monitor and control systems and reduce usage – see **SGN Prop 004 Energy Management and Utility Reduction EJP and CBA**. It also seeks to implement interface control to existing Heating, Ventilation and Air Conditioning (HVAC) systems and a rolling programme to install new LED lighting and BMS control interfaces to our main offices. Behavioural change campaigns linked to our EAP will also be undertaken in GD2 to target baseline usage reduction.

Renewables
Once baseline usage is as low as possible, supplement usage by the introduction of renewable generation technologies to supplement the site consumption (This paper covers this step).

Offsetting
Additional carbon offsetting must then be considered to achieve net zero.

By installing renewable technology at our occupied sites, we can make a significant and cost-effective contribution in reducing SGNs Business Carbon Footprint, which will (together with energy management and utility reduction initiatives) bring about a 68% reduction in comparison to financial year 2018/19 and provides an ambitious move towards net zero in 2045.

3 Equipment Summary

At present, the SGN estate only has one renewable technology (Solar Photovoltaic) installation to harvest savings from our environment.

The site is located in Southern network at our Walton Park office in Cosham.

A 49.9KW system was installed and commissioned in July 2012 with an annual generation capacity of 39,864 KWh as part of a site refurbishment project. The system is made up of 204 Suntech 245W panels located on the warehouse roof elevation. This system at full capacity supplements 2.5% of the total site energy usage through renewable technology.

4 Problem Statement

Why are we doing this work and what happens if we do nothing?
The introduction of renewable energy to the SGN Estate shall bring about operational cost savings to our office accommodation and ensure we are heading in a positive direction to achieving net zero carbon naturality.

Failure to implement interventions through renewable technology shall mean that costs savings cannot be realised, and the company carbon neutral vision cannot be achieved. Therefore, operational costs shall continue at current levels.

What is the outcome we want to achieve?
We aim to make costs savings to our real estate operational expenditure on utilities. To achieve this, we seek investment to improve the technological infrastructure to drive down usage. The installation of the renewable energy technology can be used to reduce our ongoing energy costs and carbon footprint.

How will we understand if the spend has been successful?
The occupied sites will continue to operate at business as usual standards while reducing the reliance on energy from utilities. This will be recordable and has been predicted by the carbon offset measure using DEFRA conversion.

4.1 Narrative Real-Life Example of Problem

The total electrical energy consumption for financial year 2018/19 was 6,013,465KWh which is expected to continue at current levels in GD2.

Models provided by Carbon Trust have suggested that a reduction of 56.4% in building utilities by 2030/31 is required to meet net zero targets. This will not be achievable without technological interventions through energy management and renewables - see **Appendix A.**

The following example is based on a costed proposal from RA Group for a renewable energy installation at Axis House, Edinburgh which suggests an intervention of Solar PV technology only could save up to 11.5% of carbon emissions.

Axis House – Edinburgh, Scotland

- Current annual electricity consumption – 469,662 KWh
- Utility costs (based on £0.16/KWh) - £75.15k
- CO2 generated (DEFRA conversion factor @0.2556 Kg CO2e) – 120 tonnes CO2

Installation of large site direct Solar PV array: -

- Axis House net internal area – 2432m2
- Install space @18% of NIA – 440m2
- Array size @0.165 of install space – 72.6KW system
- Install cost (based on £1,073/Kw) - £77.9k
- Generation @1000KWh/KW – 72,000KWh
- Performance factor @75% of generation – 54,000KWh
- Cost reduction (based on £0.16/KWh) - £8.65k
- Carbon reduction (DEFRA conversion) – 18.8 tonnes of CO2
- **Projected site carbon emissions reduction – 11.5%**

4.2 Spend Boundaries

The focus of this paper is to highlight a programme fund to explore renewable opportunities at our occupied sites.

Projected avoided costs focus on direct utility reduction and cost of carbon avoidance in support of the proposed EAP.

Approximate costs for install have been modelled on a costed real-life example – see **Appendix B**. Based on the modelled example, we are proposing a "use it or lose it" mechanism for installation at the identified sites.

Unknown installation and planning variables mean that the programme risk is sufficient to justify the use of the uncertainty mechanism.

What is in Scope?

This programme proposes the installation of appropriate renewable energy technologies to directly supplement and reduce utility use and subsequent carbon emissions, which include the purchase of equipment, project and planning fees, installation/modifications and maintenance.

What is out of Scope?

The programme does not cover repairs, upgrades or replacements to plant and infrastructure which are not linked to the installation of such technologies above.

5 Probability of Failure

Without renewable technology intervention we are unable to influence the required reductions in utility usage and carbon emissions. This would result in a failure to meet our targets stated in the EAP – **Appendix 003**.

5.1 Probability of Failure Data Assurance

Our assumption is that utility usage would continue at the current levels benchmarked from our financial year 2018/19 data.

6 Consequence of Failure

There are currently limited renewable assets installed across our sites, should the 'do nothing' option be adopted, the consequence of not having a pathway to a carbon neutral property portfolio would lead to utility use remaining at current levels as well as: -

- Failure to meet business carbon footprint reductions, science-based targets and net zero emissions
- Increasing costs from grid electricity and battery supply
- Increasing operational and fuel costs
- Supply issues for lithium batteries as resource scarcity increases
- Increase in hazardous waste disposal costs for lithium batteries
- Potential issues with grid reliability as pressure on the grid rises
- Fall in reputation as customers and stakeholders see other companies achieving net zero and increase in renewable energy and SGN falling short

It would also result in a failure to achieve the stated goals and ambitions laid out in the EAP.

7 Options Considered

All options being considered are for new assets. The only intervention mode that is relevant is **Build new** (installation of new assets). All other intervention are not considered in this paper.

The options considered within the **SGN Prop 003 Renewable Energy CBA** are: -

1. Do nothing
2. Installation of new Solar PV
3. Installation of Wind Turbines

The renewable energy equipment to be installed as part of this programme is broken into two areas, these are: -

1. Photovoltaic Cells
2. DC-AC Inverters

Photovoltaic Cells

There are three main types of solar PV panel technologies available. These are: -

- Monocrystalline (most efficient and most expensive)
- Polycrystalline (mid-efficiency and mid-price)
- Thin film solar cells (lowest efficiency and lowest priced. Also, most flexible)

There are several advantages to using solar PV panels. Some of the main ones are listed here: -

- They can provide clean, green, energy for up to 50 years
- They have an incredibly long lifespan – projected at 35 years in this proposal
- They can cover around 60% of energy needs, on average, at this time
- They are incredibly efficient in the summer
- They continue to generate energy even on a cloudy day
- They won't freeze over during the winter months
- They can supplement the energy requirements of commercial office environments

An example of PV Panels is displayed in **Figure 2** below: -

Figure 2: Example PV panels

DC-AC Invertors

A range of transformer-less three-phase inverters for PV systems of every size are available on the market be it standard installations to irregularly shaped or multi-oriented roofs – **see Figure 3**.

Standard interfaces to the internet via WLAN or Ethernet and the ease of integration of third-party components and BMS systems. Furthermore, metering interface permit dynamic feed-in management and a clear visualisation of the consumption overview.

Additionally, the use of Optimisers may be necessary for an installation to overcome shading effects whereby arrays are switched over as the sun moves from east to west.

Figure 3: Example DC-AC invertors

We have 44 occupied sites across our Property estate. We intend to carry out Solar PV installations at these occupied sites (depending on viability results from pre-installation site surveys). Sites are categorised as either Small, Medium or Large according to following square meterage – **see Table 1.**

Table 1: Occupied site size categorisation

Type of site	Site Size	No of sites
Large	>=2250m2	5
Medium	<=2249m2	9
Small	<=400m2	30

The list of occupied sites and net internal areas, to which this programme applies, is outlined in **Appendix C.**

Programme costs have been generated from SPONs price book data and check prices for a representative sample from a quoted sample install from R&A Group and baseline desktop data from our consultants COGEO. The saving reduction has been generated from the following metrics: -

- Install space @ 18% of NIA
- Array capacity at factor of 0.165 of Install space
- Install cost at £1,073/Kw (generated from consultant and sample quote)
- Annual generation capacity 1000Kwh/Kw
- Performance factor (Assumed conservative factor) 75% of generation capacity

Direct purchase, installation and operation of the assets is deemed preferable over Energy Saving Company (ESCO) model due to the reduced risk of third-party ownership as well as receiving the greatest financial benefit on the CBA.

7.2 Do nothing (baseline)

The option of doing nothing shall expose SGN to an inability to reduce our carbon footprint as energy will continue to be consumed at current levels. The consequence of not having a pathway to Net Zero approach shall affect our corporate and environmental responsibility which could be very damaging to our business and customers. This option is also not in line with our customer and stakeholder environmental expectations.

7.3 Solar PV

Installation of Solar PV was considered as a renewable energy intervention to directly reduce our carbon footprint through supplementing a proportion of the baseline energy consumption with renewable energy. This will also yield cost reductions through direct utility costs and indirect cost of carbon tax. It is also in line with our customer and stakeholder expectations of high ambition in relation to our EAP goals. A summary of Solar PV installation options considered is detailed in **Table 2** below.

Table 2: Installation options

Options	**No of sites**	**Total KW system**
Installation of Solar PV at large sites located across Southern England, Scotland and Glenmavis.	5	723,750
Installation of Solar PV at large and medium sized sites located across Southern England, Scotland and Glenmavis.	14	912,750
Installation of Solar PV at large, medium and small sites located across Southern England, Scotland and Glenmavis.	44	1,025,250

NOTE: The programme proposes the increase the existing PV capacity at Walton Park (large site).

The perceived benefits of this renewable option is the avoided costs detailed in **Table 3** below.

Table 3: Avoided costs

Cost Area	**Description**	**Perceived Value £m**
Utility cost reduction PV installs	Utility saving projections through installation of effective PV systems. Based annual generation of 75% of 1000/KW capacity @ £0.16/KWh	0.820
Carbon cost reduction PV installs	Cost of carbon reduction based on projected direct KWh generation from PV install. DEFRA conversion factor applied. Cost of non-traded carbon taken from CBA template – fixed time series data 2019 price.	0.094

The high-level advantages of solar PV are: -

- PV panels provide clean – green energy. During electricity generation with PV panels there is no harmful greenhouse gas emissions thus solar PV is environmentally friendly
- Solar energy is energy supplied by nature – it is thus free and abundant

- Solar energy can be made available almost anywhere there is sunlight
- Solar energy is especially appropriate for smart energy networks with Distributed Power Generation – DPG is indeed the next generation power network structure
- Solar panel costs are currently on a fast-reducing track and is expected to continue reducing, consequently solar PV panels are economically viable and environmentally sustainable
- Operating and maintenance costs for PV panels are low, almost negligible, compared to costs of other renewable energy systems
- PV panels have no mechanical moving parts, except in cases of sun-tracking mechanical bases consequently, they have far less breakages or require less maintenance than other renewable energy systems (e.g. wind turbines)
- PV panels are totally silent, consequently, they are a perfect solution for urban areas and residential applications
- PV panels provide an effective solution to energy demand peaks

7.4 Wind energy

We also considered wind energy, either through direct installation on our own sites or through the provision of a PPA. Both were discarded at this moment in time due to: -

- Challenges in obtaining planning permission for wind turbines onshore
- Greater financial benefit of solar PV vs wind energy installation
- Our electricity consumption is relatively low, only corresponding to approximately the output of two standard sized wind turbines. We have spoken to experts in this area and the challenges currently outweigh the benefits in seeking to provide a PPA for such a small number of turbines as the PPA market in the UK is still immature

Options that were not considered within CBA are: -

- Refurbish
- Rebuild

7.5 Options Technical Summary Table

A technical summary of all options is detailed in **Table 4** below.

Table 4: Technical summary

Option	First Year of Spend	Final Year of Spend	Volume of Interventions	Equipment / Investment Design Life	Total Cost £m
Do Nothing (baseline)	2022	2022	0	36 years	5.01
Installation of Solar PV at large sites and Glenmavis	2022	2026	6	36 years	5.63
Installation of Solar PV at large and medium sites and Glenmavis	2022	2026	15	36 years	5.81
Installation of Solar PV at large, medium and small sites and Glenmavis	2022	2026	45	36 years	5.96

NOTE: The total costs shown are absolute costs relative to the baseline.

7.6 Options Cost Summary Table

A cost summary table that provides a breakdown of the costs for each option is detailed in **Table 5** below. Each option has allowed for equipment, civils and engineering costs. **Table 6** provides an annual cost breakdown for GD2.

Table 5: Cost summary

Option	Cost Breakdown £m	Total Cost £m
Do nothing	Utility spend at current levels • Large @ 3,654,707 KW/h x 16p per KW/h per annum • Medium @ 811,969 KW/h x 16p per KW/h per annum • Small @ 1,546,789 KW/h x 16p per KW/h per annum • Glenmavis @ 243,153 KW/h x 16p per KW/h per annum	5.01
Installation of Solar PV at large sites and Glenmavis	• Large - 0.79 • Glenmavis – 0.35 • Maintenance – 0.02	1.16
Installation of Solar PV at large and medium sites and Glenmavis	• Large – 0.79 • Medium – 0.30 • Glenmavis – 0.35 • Maintenance – 0.04	1.48
Installation of Solar PV at large, medium and small sites and Glenmavis	• Large – 0.79 • Medium – 0.30 • Small – 0.18 • Glenmavis – 0.35 • Maintenance – 0.09	1.71

Table 6: GD2 cost breakdown

Options	2021/22 £m	2022/23 £m	2023/24 £m	2024/25 £m	2025/26 £m	GD2 Total £m
Do Nothing – baseline	1.00	1.00	1.00	1.00	1.01	5.01
Installation of Solar PV at large sites and Glenmavis	0.75	0.40	0.00	0.00	0.01	1.16
Installation of Solar PV at large and medium sites and Glenmavis	0.90	0.55	0.01	0.01	0.01	1.48
Installation of Solar PV at large, medium and small sites and Glenmavis	0.99	0.65	0.02	0.02	0.03	1.71

8 Business Case Outline and Discussion

Our consultants have clearly stated the need to reduce utility consumption across our property portfolio in order to facilitate the required reduction levels to achieve our EAP goals. Therefore, the do-nothing option is deemed not acceptable.

Following a number of consultative workshops facilitated by our Health, Safety and Environment team, the pathway to net zero model was produced for SGN. This model highlighted the introduction of appropriate renewable technologies as an essential requirement to achieve the meaningful reductions stated in our science-based targets and EAP.

A desktop study of renewable opportunities was carried out which reviewed a number of options taking into consideration our estate, installation viability and costs against generation capacity.

Solar PV and Wind Turbine technologies were deemed the most economically and technologically advantageous options. These options were then selected for further investigation.

Costed examples were provided by third party consultants/installers where it was deemed that wind turbines represented too high a risk due to planning, geographical and installation constraints at our sites.

A number of costed examples were provided for sample sites, the outputs of which were used in the cost model and CBA for Solar PV. All Solar PV options considered returned a positive NPV, however the preferred option to install at large, medium, small sites and Glenmavis was the only option that return sufficient reductions to meet our EAP targets.

8.1 Key Business Case Drivers Description

A summary of key business drivers for all **Build New** options are set out below in **Table 7**. **Table 8** provides a detailed summary of the CBA results.

Table 7: Key business drivers

Option	Description of Option	Key Business Case Drivers
1	Do nothing - baseline	• Accept as-is and continue to pay the utility bills for the estate • Failure to meet EAP targets
2	Installation of Solar PV at large sites and Glenmavis	• Reduced electricity usage and resulting carbon footprint • Increased self-sufficiency and reduced reliance on grid electricity • Direct and indirect cost reductions through cost of utility reduction and carbon tax • Heightened public awareness of SGN's commitment to sustainability • Reductions through generation for this option are not sufficient to meet our EAP targets
2	Installation of Solar PV at large and medium sites and Glenmavis	• Reduced electricity usage and resulting carbon footprint • Increased self-sufficiency and reduced reliance on grid electricity • Direct and indirect cost reductions through cost of utility reduction and carbon tax • Heightened public awareness of SGN's commitment to sustainability • Reductions through generation for this option are not sufficient to meet our EAP targets

2	Installation of Solar PV at large, medium and small sites and Glenmavis	• Reduced electricity usage and resulting carbon footprint • Increased self-sufficiency and reduced reliance on grid electricity • Direct and indirect cost reductions through cost of utility reduction and carbon tax • Heightened public awareness of SGN's commitment to sustainability • Reductions through generation for this option are sufficient to meet our EAP targets
3	Installation of Wind Turbines	• Reduced electricity usage and resulting carbon footprint • Increased self-sufficiency and reduced reliance on grid electricity • Direct and indirect cost reductions through cost of utility reduction and carbon tax • Heightened public awareness of SGN's commitment to sustainability • Geographical locations of proposed installation sites not deemed favourable for optimum generation. • Planning risks considered too high.

Table 8: Summary of CBA results

NPVs based on Payback Periods								
Option No.	Description of Option	Preferred Option (Y/N)	Total Forecast Expenditure £m	Total NPV £m	2030 £m	2035 £m	2040 £m	2050 £m
Baseline	Do Nothing / Do minimum	N	-5.01	-29.81	-6.56	-10.16	-13.66	-19.97
1	Option 1 Absolute NPV	N	-5.63	-27.95	-6.75	-10.04	-13.21	-18.88
2	Option 2 Absolute NPV	N	-5.81	-27.54	-6.82	-10.04	-13.13	-18.65
3	Option 3 Absolute NPV	Y	-5.96	-27.57	-6.91	-10.13	-13.21	-18.70
1	Option 1 NPV relative to Baseline	N	-5.63	-27.95	-0.19	0.12	0.45	1.09
2	Option 2 NPV Relative to Baseline	N	-5.81	-27.54	-0.26	0.12	0.53	1.32
3	Option 3 NPV Relative to Baseline	Y	-5.96	-27.57	-0.35	0.04	0.45	1.27

8.2 Business Case Summary

A summary table with the selected headline business case metrics is provided in **Table 9** to enable a high-level comparison of the options.

Table 9: Business case metrics

	Installation of Solar PV at large sites and Glenmavis	**Installation of Solar PV at large, medium sites and Glenmavis**	**Installation of Solar PV at large, medium and small sites and Glenmavis**
GD2 Capex (£m)	1.16	1.48	1.71
Number of Interventions	6	15	45
Carbon Savings ktCO2e (GD2)	925.0	1166.5	1310.3
Carbon Savings ktCO2e /yr	185.0	233.3	262.1
Carbon Emission Savings (35yr PV, £m)	0.00	0.00	0.0
Other Environmental Savings (35yr PV, £m)	0.51	0.64	0.72
Safety Benefits (35yr PV, £m)	0.00	0.00	0.0
Other Benefits (35yr PV, £m)	0.00	0.00	0.0
Direct Costs (35yr PV, £m)	0.93	1.11	1.0
NPV (35yr PV, £m)	1.44	1.75	1.7
High Carbon Scenario			
Carbon Emission Savings (35yr PV, £m)	0.00	0.00	0.0
High Carbon NPV (35yr PV, £m)	1.44	1.75	1.7

9 Preferred Option Scope and Project Plan

9.1 Preferred Options

The preferred GD2 option is installation of Solar PV at large, medium, small sites and Glenmavis. The total capital intervention costs of this option is **£1.71m**.

9.2 Asset Health Spend Profile

The spend profile for GD2 is detailed in **Table 10** below. The costs are gross including efficiencies.

Table 10: GD2 spend profile

Asset Health Spend Profile						
Preferred option	2021/22 £m	2022/23 £m	2023/24 £m	2024/25 £m	2025/26 £m	Post GD2 £m
Installation of Solar PV at large, medium and small sites and Glenmavis	0.99	0.65	0.02	0.02	0.03	40.03

9.3 Investment Risk Discussion – The Uncertainty Mechanism

We are proposing to use Ofgem's criteria to account for uncertainty by using their 'use it or lose it' mechanism in GD2. Our justification for this is as follows: -

What is the issue/risk that the proposed mechanism addresses?

The uncertainty around renewables is whether the sites identified will in practice be appropriate for deploying Solar PV onto them or whether there is are structural or planning considerations that will limit the practical deployment.

Where does the ownership of risk lie in relation to the uncertainty?

There is no risk to the customer as the risk lies with the installer as the model in the paper assumes favourable installation conditions at all sites. The programme proposes a pre-installation survey at installers cost to determine if an install is feasible. Should the installation not be feasible the associated costs of install would not be incurred by the customer.

Materiality of issue

As detailed throughout this paper estimated costs have been provided in respect of the funding required to install renewables at all sites. In addition to implementing the project, funding will also be required to maintain and monitor success of enhancement measures implemented.

Frequency and probability of issue over the price control period

Failure to implement the proposed programme of works is highly likely to fail to deliver the stated EAP targets.

What is the proposed mechanism?

We are proposing the use of the "use it or lose it" mechanism to provide funding of **£1.71m** (based on the costed model in this paper) to install renewables (Solar PV) at all sites, following on from a pre-installation survey.

Upon completion of these surveys, we will understand the costs and conditions involved to implement projects that are identified as feasible, any remaining funding will be return to customers.

What are the justifications for the mechanism?
The mechanism will allow us to better understand how many of the sites we have identified are actually feasible to install Solar PV.

What are the drawbacks of the proposed mechanism?
There is an element of uncertainty in the number of sites where Solar PV projects are feasible due to the risk identified. However, it is estimated that some sort of project will be able to be undertaken on almost all sites. The size of installation and generation capacity have been based on a costed example at Axis House, Scotland, the actual site conditions may defer from assumptions made in the model.

Can the drawbacks be reduced?
There is little way to understand the renewables profile across the sites without undertaking pre-installation surveys for each site. The proposed mechanism reduces risk to the consumer by returning any unused portion of the proposed funding to them.

Explanation of how on balance, the mechanism delivers value for money while protecting the ability to finance efficient delivery.
The adoption of the mechanism is focused predominantly at delivering value for money. It ensures that funding is available to undertake renewable projects where they have been demonstrated as being feasible to implement and also allows for any surplus funding to be returned.

Treatment in Business Plan Data Templates (BPDTs)
The costs have been included in the **3.05 (Other Capex)** Section of the BPDT.

9.4 Results of CBA

The results from the CBA are detailed in **Tables 11-14** below.

Table 11: Risk matrix

Risk Description	Impact	Likelihood	Mitigation / Controls
Roof structures not able to support install	Medium	>20% & <=40%	Each install undertake at standalone project. Full structural assessments to be undertaken as part of project scoping. Roof strengthening mitigation to be applied if appropriate.
Available roof space to install sized array	Medium	<=20%	Conservative metric used based on quoted example of a large site.
Failure to deliver programme resulting in insufficient reductions and failure to achieve EAP targets	Medium	>80% & <=100%	Site assessment for each site prior to install. Programme delivered by the uncertainty mechanism. Maximum PV array size per site to minimise risk.

Table 12: Capex sensitivity

	Low	Mid	High
GD2 Capex (£m)	1.29	1.71	2.57
Number of Interventions	45.00	45.00	45.00
Carbon Savings ktCO2e (GD2)	1310.27	1310.27	1310.27
Carbon Savings ktCO2e /yr	262.05	262.05	262.05
Carbon Emission Savings (35yr PV, £m)	0.00	0.00	0.00
Other Environmental Savings (35yr PV, £m)	1.37	0.72	-2.25
Safety Benefits (35yr PV, £m)	0.00	0.00	0.00
Other Benefits (35yr PV, £m)	0.00	0.00	0.00
Direct Costs (35yr PV, £m)	4.28	1.01	-12.59
NPV (35yr PV, £m)	5.65	1.73	-14.84

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.

Table 13: Sensitivity assumptions

Spend Area	Scenario	Justification
Capex	High	Assumed 50% increase in costs and materials
	Mid	No change on original baseline.
	Low	Assumed 25% decrease in costs and materials
Opex	High	Assumed 50% increase in costs and materials
	Mid	No change on original baseline.
	Low	Assumed 25% decrease in costs and materials
Environmental Cost	High	Assumed 50% increase in utility and carbon costs
	Mid	No change on original baseline.
	Low	Assumed 25% decrease in utility and carbon costs

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 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)	0.39	0.54	0.17	
NPV (35yr PV, £m)	1.58	1.73	1.36	
NPV (45yr PV, £m)	1.94	2.00	1.86	
Payback	13.00	12.00	16.00	11.00

10 List of Acronyms and Reference Documentation

10.1 Acronyms

Acronym	Description
PPM	Planned preventative maintenance
RRM	Routine reactive maintenance
HVAC	Heating, ventilation, air conditioning
CIBSE	Chartered institute of building service engineers
CBA	Cost benefit analysis
BCM	Business continuity management
EAP	Environmental Action Plan
BMS	Building Management System
LED	Light Emitting Diode
LUX	Unit of measure for light levels
PIR	Passive Infrared
AC	Air Conditioning
KWh	Kilowatt Hour – unit of measure for electricity
DEFRA	Department for Environment, Food and Rural Affairs
CO2	Carbon Dioxide Emissions
PV	Photovoltaic
DC	Direct Current
AC	Alternating Current
WLAN	Wireless Local Area Network
NIA	Net Internal Area
PPA	Power Purchase Agreement

10.2 Reference Documentation

Acronym	Description
CIBSE Guides (Guide M)	Management Engineering and Management
SPONS	Architects and Builders Price Book 144th Edition (2019)
SPONS	Mechanical and Electrical Services Price Book 50th Edition (2019)
RICS	BCIS Building Maintenance Price Book 39th Edition (2019)
BSRIA BG1 / 2008	Illustrated Guide to Renewable Technologies
Desktop data	Information on Renewables rules of thumb COGEO (2019)

Appendix A - Carbon Trust Emission Reductions

Summary emission reductions – location based

Emission source		2020/21	2030/31	2050/51
Shrinkage		-10.0%	-36.7%	-68.7%
Buildings		-14.5%	-56.4%	-92.6%
Light vehicles (cars)	WTW	-8.0%	-34.2%	-68.9%
Commercial vehicles (vans)	WTW	-4.8%	-16.4%	-34.1%

Appendix B - Sample install from R&A Group

R&A Renewable Energy Ltd
22 Clydesdale Street
Hamilton, ML3 0DA
Tel: 01698 200300 Fax: 01698 200244

Date: 17/06/2019
Quotation Reference: RARE-E1411

UVDB Empowered by Achilles

QUOTATION

Customer

Company: SGN
Address: 10 Axis House
City: Edinburgh
Post Code: EH28 8TG

Project Details

Title: PV System Installation
Description: Install 49.8Kw and 23Kw PV array onto Flat Roof

Item	Description	Unit	Qty	Unit Cost £	Total £
1	Roof No1 49.8Kw PV Array				
1.1	Supply and install low Ballast system roof kit at agreed locations	Sum	1	£ 10,204.25	£ 10,204.25
1.2	Supply and install containment	Sum	1	£ 1,100.00	£ 1,100.00
1.3	Supply and install 265w polycrystalline panels onto low ballast roof kit	Nr	188	£ 142.25	£ 26,743.00
1.4	Supply and install DC isolators at agreed location	Nr	10	£ 90.00	£ 900.00
1.5	Supply and install 6mm solar cable from PV panels to DC isolators and from DC isolators to inverters	mts	2000	£ 3.20	£ 6,400.00
1.6	Supply and install TP&N Distribution Board C/W with 125A main incomer at agreed location	Nr	1	£ 550.00	£ 550.00
1.7	Supply and install TP MCBs	Nr	3	£ 121.33	£ 363.99
1.8	Supply and AC isolators at agreed locations	Nr	3	£ 90.00	£ 270.00
1.9	Supply and install rubber cable from DB to AC isolators	mts	30	£ 30.43	£ 913.00
1.10	Carry out all terminations	Sum	1	£ 1,232.00	£ 1,232.00
1.11	Carry out all testing and commissioning	Sum	1	£ 616.00	£ 616.00
1.12	Allow for O&M	Sum	1	£ 960.00	£ 960.00
1.13	Allow for MEWP	Sum	1	£ 1,100.00	£ 1,100.00
					£ 51,352.24
2	Roof No2 23Kw PV Array				
2.1	Supply and install low Ballast system roof kit at agreed locations	Sum	1	£ 4,712.80	£ 4,712.80
2.2	Supply and install containment	Sum	1	£ 508.03	£ 508.03
2.3	Supply and install 265w polycrystalline panels onto low ballast roof kit	Nr	87	£ 142.25	£ 12,375.75
2.4	Supply and install DC isolators at agreed location	Nr	6	£ 90.00	£ 540.00
2.5	Supply and install 6mm solar cable from PV panels to DC isolators and from DC isolators to inverters	mts	1200	£ 3.20	£ 3,840.00
2.6	Supply and install TP&N Distribution Board C/W with 125A main incomer at agreed location	Nr	1	£ 550.00	£ 550.00
2.7	Supply and install TP MCBs	Nr	2	£ 121.33	£ 242.66
2.8	Supply and AC isolators at agreed locations	Nr	2	£ 90.00	£ 180.00
2.9	Supply and install rubber cable from DB to AC isolators	mts	20	£ 30.43	£ 608.60
2.10	Carry out all terminations	Sum	1	£ 579.47	£ 579.47
2.11	Carry out all testing and commissioning	Sum	1	£ 616.00	£ 616.00
2.12	Allow for O&M	Sum	1	£ 960.00	£ 960.00
2.13	Allow for MEWP	Sum	1	£ 1,100.00	£ 1,100.00
					£ 26,813.31
				TOTAL	£ 78,138.55

Appendix C - Occupied Sites List

List of Occupied Sites		
Site	Size in m2	Site Size Level
Walton Park	10,450	Large Sites
Ashford	4,038	Large Sites
Horley	3,046	Large Sites
St Mary Cray	2,513	Large Sites
Edinburgh	2,432	Large Sites
Epsom	1,956	Medium Sites
Aldershot	632	Medium Sites
Provan	2,018	Medium Sites
Paisley	1,020	Medium Sites
Glasgow	717	Medium Sites
Segensworth	795	Medium Sites
Bramshill	411	Medium Sites
Burgess Hill	553	Medium Sites
Redhill	431	Medium Sites
Dumfries	267	Small Sites
Horsham	357	Small Sites
Dunfermline	359	Small Sites
Gillingham	388	Small Sites
Oban	146	Small Sites
Thurso	144	Small Sites
Wick	143	Small Sites
Reading	144	Small Sites
Stornoway	93	Small Sites
Inverness	131	Small Sites
Basingstoke	102	Small Sites
Bexhill	31	Small Sites
Campbeltown	353	Small Sites
Galashiels	172	Small Sites
Incholm	171	Small Sites
Kilmarnock	375	Small Sites
Broadstairs	256	Small Sites
Braishfield	45	Small Sites
Milton Keynes	179	Small Sites
Whyteleaf	124	Small Sites
Croydon TN	63	Small Sites

Chichester	31	Small Sites
Dorking	90	Small Sites
Kennington DI	72	Small Sites
Farningham	130	Small Sites
Hardwick	51	Small Sites
Marsh Gibbon	53	Small Sites
Coatbridge	399	Small Sites
Shorne	108	Small Sites
Tatsfield	70	Small Sites