Project Code/Version No:

Gas Network Innovation Competition Full Submission Pro-forma

Section 1: Project Summary

1.1 Project Title: Low Carbon Gas Preheating

1.2 Funding Licensee: Northern Gas Networks Limited

1.3 Project Summary: The transition to a low carbon energy sector in the UK presents Gas Distribution Networks (GDNs) with a number of challenges, including reducing the Business Carbon Footprint (BCF) of operating gas networks. The requirement for GDNs to preheat gas at pressure reduction stations (PRS) to avoid freezing the outlet pipework and ensure continuity of supply is a significant contributor to our BCF. GDN's preheating requirement is currently delivered using aging Water Bath Heaters (WBH) or more modern Boiler Package technologies (BH). However, there are several key issues that GDNs currently face when appraising investment options for preheating technology. Firstly, the whole life costs and in particular the carbon impact of currently available technologies is not understood. Secondly, there has been limited research or development in this area resulting in no financially viable alternative to existing technologies. And finally, the current shrinkage arrangements provide no incentive to target reductions in BCF associated with preheating.

The Low Carbon Gas Preheating (LCGP) seeks to address these issues directly. The project will install two 'alternative' preheating technologies across six NGN sites of differing scale - three Thermo Catalytic Systems (HotCat) and three Low Pressure Steam Systems (LP Steam). Smart metering technology will be installed on each of the six sites to provide data required to calculate and publish the system efficiency of each site and each technology. Additionally, smart metering technology will be installed separately on six sites that employ existing technologies. System efficiencies will be calculated and published for direct comparison.

The project has four key objectives:

- To significantly accelerate the development of alternative technologies and increase the level of competition in the preheating technology market.
- To provide necessary data to allow networks to optimise investment decisions, including reducing the BCF of preheating.
- To provide robust data to assess the accuracy of current estimates of GDNs 'Own Use Gas' within the current Shrinakge Gas estimates.
- To reduce whole life costs of preheating installations and provide direct benefit to customers as lower charges and improved environmental performance.

1.4 Funding

1.4.2 NIC Funding Request (£k): 4,842.8

1.4.3 Network Licensee Contribution (£k): 765.1

1.4.4 External Funding - excluding from NIC/LCNF (£k): 0

1.4.5 Total Project cost (£k): 6,331.5

RIIO NIC NETWORK INNOVATION COMPETITION

Project Code/Version No:

Gas Network Innovation Competition Full Submission Pro-forma

Section 1: Project Summary continued

1.5 Cross industry ventures: If your Project is one part of a wider cross industry venture please complete the following section. A cross industry venture consists of two or more Projects which are interlinked with one Project requesting funding from the Gas Network Innovation Competition (NIC) and the other Project(s) applying for funding from the Electricity NIC and/or Low Carbon Networks (LCN) Fund.

1.5.1 Funding requested from the LCN Fund or Electricity NIC (£k, please state which other competition):

1.5.2 Please confirm if the Gas NIC Project could proceed in absence of funding being awarded for the LCN Fund or Electricity NIC Project:

☐ **YES – the Project would proceed in the absence of funding for the interlinked Project**

☒ **NO – the Project would not proceed in the absence of funding for the interlinked Project**

1.6 List of Project Partners, External Funders and Project Supporters:

Proheat Systems Limited
9 Devonshire Square
London EC2M 4YF
Stefan Romocki, Managing Director

Bruest Catalytic Heaters
Division of Catalytic Industrial Group, Inc.
713 N. 20th Street P.O. Box 827
Independence, KS 67301
Virgil J. Macaluso, President

1.7 Timescale

1.7.1 Project Start Date:	**1.7.2 Project End Date:**
January 2014	December 2017

1.8 Project Manager Contact Details

1.8.1 Contact Name & Job Title:	**1.8.3 Contact Address:**
Dan Sadler - Head of Investment Planning & Major Projects	Northern Gas Networks 1100 Century Way Thorpe Park Business Park Leeds LS15 8TU
1.8.2 Email & Telephone Number: dsadler@northerngas.co.uk 0113 397 5381 / 07584 391 466	

Gas Network Innovation Competition Full Submission Pro-forma

Section 2: Project Description

This section should be between 8 and 10 pages.

2.1 Aims & Objectives

The transition to a low carbon energy sector in the UK presents Gas Distribution Networks (GDNs) with a number of challenges, including reducing the Business Carbon Footprint (BCF) of operating gas networks. The requirement for GDNs to preheat gas at pressure reduction stations (PRS) to avoid freezing the outlet pipework and ensure continuity of supply is a significant contributor to our BCF.

Heat must be applied at PRS to avoid freezing the outlet pipework and ensure continuity of supply. Preheating on gas PRS is required to mitigate the effects of gas temperature loss when the pressure is reduced (the Joules-Thompson effect). Within NGN we currently have 93 Waterbath Heaters (WBH) and 44 Boiler Houses (BH) which are used for preheating gas. The consequences of failure to preheat gas at a PRS can be significant and include:

- **Loss of Supply -** Freezing of the outlet pipework can lead to a potential loss of gas to the down stream system through freezing of control pilots.
- **Environmental damage -** Frost heave results from ice build up around buried pipelines. If left the consequences can become catastrophic not only damaging the site but also pavements, roads and other third party land which the pipeline passes under.
- **Safety –** If the PRS is close enough to the Low Pressure (LP) system, cold gas may enter the network affecting the physical characteristics of different pipe materials. E.g. cast and ductile iron becomes more brittle at lower temperatures resulting in greater potential leakage of gas from the network.

The Problem

WBHs are a mature technology with limited provision to suit the modern requirements of efficiency and environmental performance. There are limited options for replacement of these WBH units, which will currently be by the use of a BH and heat exchanger (HX). BH are believed to give better performance and efficiency savings, utilising modern burner management systems and controls. However, the scale of NGN activities means that, even with more efficient BH solutions, preheating accounts for a significant portion of NGN Business Carbon Footprint (BCF).

The key challenges that gas networks currently face are:

- ***Data*** - The system efficiency of current or alternative preheating technologies is not understood. There is no reliable data on the efficiency or carbon emissions of current or alternative preheating technologies in a live operating environment. As a result investment decisions on replacement preheating assets can be considered sub-optimal as they can only consider a small number of the relevant factors due to lack of data.
- ***Technology*** - There are limited proven technical options to provide preheating requirements in the UK. There has been minimal technological development / assessment of alternative preheating equipment in the UK over the past 20 years.
- ***Operational*** - At present operational decisions are sub-optimal with respect to carbon emissions due to the lack of information and understanding. Without accurate information on carbon emissions and system efficiencies we cannot seek to maximise the benefit of any operational flexibility that may exist within the network.
- ***Commercial*** – Currently the supply side of this market is dominated by 1

technology and 1 supplier with little incentive for competition. Reasons for this include; Unit cost of alternative technologies and current 'Shrinkage Gas' incentive mechanisms.

- ***RIIO-GD1 Requirements*** - NGN has a requirement to replace/upgrade circa 45 preheating installations over the RIIO-GD1 period. This is likely to be followed by a requirement for a similar investment programme in RIIO-GD2. Before we commit to this significant investment programme, in assets with long economic lives, it is important that NGN have access to tangible data allowing the network to make optimised investment decisions.

To address these challenges, the proposed project has four key aims & objectives:

- Assess the potential for alternative technologies to meet preheating requirements across a range of heating system sizes and operating site parameters.
- Provide an independent and accurate model for assessing the efficiency of preheating systems across the UK based on reducing BCF and whole life costs.
- Increase the technological options available to gas transporters for the replacement of preheating assets and increase the supply side of this market.
- Provide quantified data on system efficiency of both alternative and existing technologies that can provide the industry with information that will allow more informed investment decisions and a more efficient operation of the network.

The Method & Trials

NGN has been considering the potential for the use of alternative low carbon technologies to provide preheating over a number of years. In 2012 we carried out a desktop research study into the availability and applicability of technologies that had the potential to be deployed to provide preheating. This study allowed us to exclude a number of approaches which did not meet our specified criteria and focus more directly on those that showed the greatest potential. This allowed us to focus the scope of this NIC project, reducing costs and accelerating the overall timescales.

The project will generate and test solutions directly on NGN's network. To achieve this, there will be 3 key elements:

- **Existing Technologies:** a broad range of representative sites with either WBHs or BHs will be selected based on site configuration, heat load requirement, and operational functionality. Monitoring equipment will be installed, including smart metering, flue gas monitors, and additional pressure / temperature / flow sensors as required. The monitoring equipment will capture all energy inputs as well as all energy outputs. This will include all energy input subsequently lost to the gas stream through overheating or to atmosphere. This will explore the assumptions that underpin current assessment methodologies.

- **Alternative Technologies:** Installation of 3 Thermo Catalytic Systems (HotCats) and 3 Low Pressure Steam Systems (LP Steam) to representative sites. The same monitoring equipment will be installed as used on existing technologies, including smart metering and flue gas monitors where appropriate. As described for existing technologies, all energy inputs as well as outputs including losses will be captured.

- **Knowledge Dissemination** – Real time release of operating and system efficiency data of the existing and alternative technologies included within the project. The

project will include the development of a dedicated website that will provide access to relevant data on a real time basis. Internet based access to these results will allow any UK preheating project to consider this data in making investment and / or product development decisions.

To ensure that the data collected and analysed can be rolled out across NGN's sites and utilised by other networks, site selection will be critical to the success of this project. The calculated results, with respect to system efficiency and carbon emissions, need to be applicable to any other site across the network and across the country if they are to prove ultimately useful.

As such we will select sites based on the following criteria:

- Preheating requirements can range from circa 90kW to 2.5MW. 3 sites for each technology (HotCat / LP Steam / BH / WBH) will be selected as a representative sample. 1x small site (less than 200kW), 1x medium site (201kW to 799kW), 1x large site (above 800kW) will be selected which will provide comparable results that can be interpolated and extrapolated robustly.
- In addition to the heating load, when selecting sites NGN will consider the different flow characteristics of the gas stream to give a range of operating conditions across the test results.
- Preheating sites will be selected where we have assessed that by using alternative and innovative techniques to control the gas flows throughout the network, we can increase the flow rate through the site with anticipated increased system efficiency whilst simultaneously reducing the heating load of a less efficient site.
- Where existing preheating systems are being replaced with alternative technology we will cross reference the fault data from our asset data to achieve best value for money by replacing assets already in need of upgrade.

Solution

A successful project will provide a robust methodology and assessment process which will change networks' investment strategies for the preheating process. This will include 2 alternative technologies that have demonstrated effectively the potential to meet preheating requirements and their suitability for a range of conditions by reducing whole life costs, reducing BCF and designing heating systems that minimise thermal losses. The learning from this project will give benefit to the management and investment decision making processes for all GDNs at every site requiring preheating. Additionally, a significant benefit will be the provision of quantifiable data allowing an evaluation of the current estimates of own use gas within the currenty shrinkage gas estimates.

2.2 Technical Description of Project

The scope of the project is summarised overleaf:

Project Description continued

In Scope
• Design, procure and installation of three LP Steam preheating systems at a large, medium and small pressure reduction station. • Design, procure and installation of three HotCats at a large, medium and small pressure reduction station. • Design, procure and installation of smart meters and measuring equipment to verify the system efficiency and carbon footprint of each alternative installation. • Installation of smart meters and measuring equipment to verify the system efficiency of existing WBHs and BHs at a large, medium and small pressure reduction station. • Procure hardware for Website to enable knowledge sharing. • Develop and publish relevant preheating information on the website. • Develop software to calculate energy information required by the website.
Out of Scope
• Installation and verification of preheating system efficiency for those systems that have already been 'ruled out' as part of the NGN feasibility study. • Installation of any other preheating systems that were not identified in the preheating study and which are not entirely focused on preheating – for example biomethane heat recapture, turbo expanders etc. • Any other associated site upgrades other than those specifically relating to the preheating system.

The four separate technologies that will form the basis of the project are explained below:

Water Bath Heaters (WBH)

WBHs are commonly found on NGN's existing sites. They currently provide heating to approximately 50% of the sites where preheating is required. They are usually between 30 and 40 years old. Burner capacity can range between 210kW up to 2,330kW per WBH.

Operation of the units is simple as the burners are usually either 'on' or 'off'. Variances occur where some WBHs have 2 or 3 burners and some burners have 'high' and 'low' fire. WBHs are usually installed in pairs with one WBH capable of providing sufficient energy to

heat the peak load of the gas stream. Gas flow usually passes through both WBHs simultaneously. The burners are controlled by the monitoring of the downstream gas temperature. As gas passes through both WBHs simultaneously, the first WBH fires at a set point slightly higher than that of the second WBH. By controlling in this way, should a problem occur with one burner, the other will automatically pick up the load. However, if both WBHs are regularly firing due to the requirements of the peak demand, energy is lost as thermal energy to atmosphere (kW) and to the gas stream by overheating it above 0°C (kW).

Gas Fired Boiler Houses (BH)

Since the early 1990's, when a preheating system has been replaced, BHs have been installed on sites. To date BHs have been the preferred method for preheating. Sites with BHs around 5 years old and older have floor mounted gas fired boilers. Newer installations are usually provided with more efficient multiple (modular) wall mounted condensing gas fired boilers. Each gas stream requires one Heat Exchanger (HX). Pipework from the BH can serve more than one HX as required. The total energy able to be produced by the BH is sized to serve the peak demand of the gas stream with some redundancy to allow for plant failures or planned maintenance.

The system efficiency of this method of preheating should not be assessed by looking at the efficiency of the boilers in isolation. To date, no study has been published to demonstrate the system efficiency of BH's used in preheating gas. As such, losses of heat to atmosphere through pipework and HXs, and losses due to the system providing heat to the gas stream unnecessarily must be assumed. No study has been provided into the excess energy used when overheating the gas stream. Additionally, the total electrical load, is not considered when calculating the boiler efficiency.

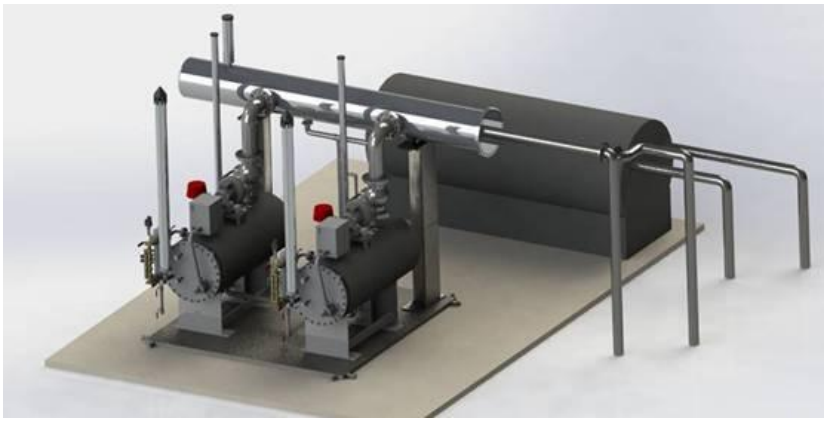
Thermo Catalytic Systems (HotCat) – Bruest

The system is based on gas fired catalytic heaters. These provide radiant heat which is collected by the gas pipeline within the unit. This system can be installed as a direct replacement of an existing WBH with the added benefit that only 1 suitably sized HotCat would be required to replace 2 existing WBHs.

HotCat's are made up of several zones each containing 2 catalytic heaters. Each zone can be controlled independently. Bruest state in their literature that the efficiency of their system is 70%. However, this figure does not include electricity consumption. Before the gas supply is provided to each heater, the catalyst needs to be preheated to 232°C by an electrical preheating element. Once achieved, the electrical supply is disconnected and gas combusts to provide all of the required heat.

Low Pressure Steam - Proheat

This system uses low pressure steam to heat the gas stream and can be installed as a direct replacement of an existing WBH with the added benefit that only 1 system would be required to replace 2 existing WBHs due to the modular nature of the design.



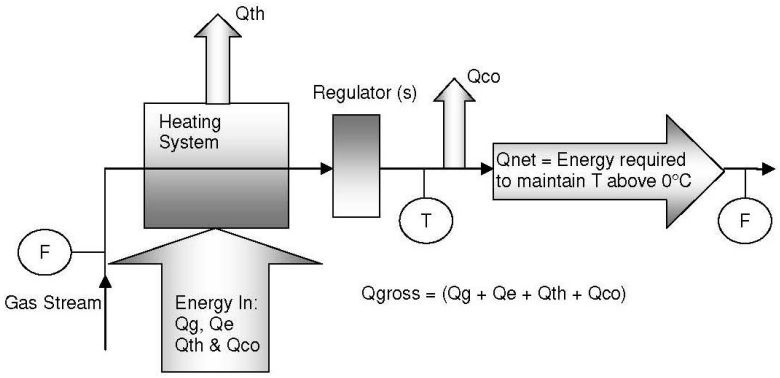
The system is based on gas burners heating a water-glycol mix until it becomes steam. By creating a vacuum containing the system fluid, the steam is created at around 42°C, this is a significantly lower temperature steam produced from water at atmospheric pressure. Once this steam condenses on the cold gas stream pipe it gives off an enormous amount of energy compared with the energy potentially given up by a liquid at the same temperature. This then allows the system to contain considerably less fluid than it would if a liquid was the heat transfer medium resulting in reduced thermal losses.

Calculation of System Efficiency

The NGN preheating study undertaken in 2012, identified a standard method of calculating system efficiency across different technologies.

This method will be utilised throughout this project to ensure comparable, meaningful data

is produced. This is summarised below:



System efficiency, η, is defined by: $\eta\ (\%) = \frac{Qnet}{Qgross}$

Where: $Qgross = Qg + Qe + Qth + Qco$

Therefore: $\eta\ (\%) = \frac{Qnet}{Qg+Qe+Qth+Qco}$

- Qnet = Energy required by the gas stream in the form of heat (kW) to ensure that the downstream gas temperature is 0°C after the pressure cut
- Qgross = Energy required to produce Qnet (kW)
- Qg = Gas energy input to the heating system to achieve Qnet (kW)
- Qe = Electrical energy input to the heating system including electrical loads of any pumps / boilers / controls etc (kW)
- Qth = Energy inputted to the heating system but subsequently lost as thermal energy to atmosphere (kW)
- Qco = Energy inputted to the heating system but subsequently lost to the gas stream by overheating it above 0°C (kW)

In order to calculate system efficiency we need to determine or obtain the same information from each site regardless of the preheating technology installed as follows:

- Qnet is a theoretical value and can be calculated for any given hour by looking at the hourly readings of pressure, temperature and flow rate for that site. By knowing the flow rate, the inlet gas stream temperature, the target outlet temperature and the pressure reduction across the site, Qnet can be calculated. Although the data would effectively be a snap shot of conditions at a point in time within any given hour, we feel that this can be used as a figure to represent the conditions within that hour and subsequently can be multiplied by 1 (hour) to give a value in terms of kilowatt hours.
- Qgross can be determined by metering the amount of gas and electricity being used by the heating system. By installing smart meters on the electrical and gas supplies serving the preheating system, real time consumption information can be obtained remotely and used to calculate the carbon equivalent for each system.
- Qco will be calculated by looking at the outlet temperature of the gas stream after the pressure reduction and comparing it with the target outlet temperature (0°C). The difference between target and actual temperatures (i.e. when the actual gas

temperature is above 0°C) can be said to be wasted energy.

- Qth will be determined by deduction as heat lost to atmosphere is not directly measurable.

2.3 Description of Design Trials

To obtain a representative cross section of information which can then be related to any other gas preheating site in the country, we propose to monitor 12 sites in total as part of this proposal. These sites will be of a variety of sizes with 1 of 4 technologies being studied on each site. We will calculate the same data for 4 different technologies on 3 'small' sites, 3 'medium' sites and 3 'large' sites.

For the purpose of this bid, we will determine the size of the site based on the theoretical heating demand of the gas stream (Qnet). By selecting sites on this basis we will ensure that we select a suitable range of sites to generate information useful to all other networks. The results will be comparable and therefore should any other network wish to use the information to decide which heating system would suit their requirements they will be able to do so from the information that we generate. We will define the site's size as follows:

Small	Qnet less than 200kW
Medium	Qnet between 201kW and 799kW
Large	Qnet greater than 800kW

By carefully selecting the sites to monitor or upgrade we can increase the system efficiency of one site whilst also reducing the BCF of another and hence obtain two or more quantifiable carbon savings from one installation. This will be achieved by increasing / decreasing throughput at the most efficient / inefficient sites respectively via our system control department. This can only occur where we currently have more than one site feeding into the same network. Without the understanding of efficiency / emissions generated through this project, the potential to look holistically at the way preheating affects the network's BCF is not understood.

By training the system control staff operating the network to understand the potential carbon savings possible by utilising the most efficient sites for preheating, we can reduce the overall BCF of the network by strategically installing the most efficient preheating systems. Without the learning provided from collecting and comparing the information across a wide selection of heating sizes and technologies this innovation would not be possible.

The information will be pulled together through a website for all 12 sites where it can be compared. All data will be processed to calculate the respective efficiency / emissions with results being represented in an easy to understand tabular format.

Data collection for existing sites

Each preheating site within NGN's network has a remote telemetry unit (RTU) where signals are collected for pressure sensors, temperature sensors, flow sensors and fault signals. These remote signals are then automatically reported back to NGN's system control department.

Without affecting the information currently sent to system control, we will procure and install equipment to repeat the relevant information and issue data directly to a remote

server. From here the website will have software designed into it to calculate all values as required to produce the information on the front page table. Should it be identified that particular sensors / monitors, such as gas stream flow monitors, are not currently installed on site, then these will be procured and installed as part of this project.

Planned preventative maintenance procedures for both WBHs and BHs will be uploaded to the website in addition to engineer's reports following any unplanned maintenance visit. From this information regular maintenance summary reports will be produced to enable the whole life costs to be determined more accurately.

Data collection for new sites

Based on recommendations in NGN's study into alternative preheating technologies published in April 2013, there are 2 alternative technologies available to the UK market, Low Pressure Steam (LP Steam), and Gas Catalytic Heating (HotCat). Recommendations from the study suggested that these will both deliver the following benefits:

- Reduce lifecycle costs
- Reduce reactive and planned maintenance costs
- Increase preheater system efficiency therefore reducing carbon emissions
- Increase reliability therefore reduce the risk of service interruption to customers

By calculating all values required to populate the website, we aim to prove or disprove the anticipated benefits as suggested in the study. In the same way that we are planning to obtain information from sites with existing technology installed, for the sites selected to have alternative technology installed we will collect the same information and transmit this to the website for comparison.

Published Data

One of the main objectives of the project is to develop a web-based central monitoring station sharing the following live information:

Site Name	**Preheating Technology**	**Qnet (kW)**	**Gas Flow (SCMH)**	**Carbon Emissions (kg CO_2e/ hr)**	**Carbon Emissions (kg CO_2e year to date)**	**System Efficiency (%)**
Site a	WBH	Small	XX	XX	XX	XX
Site b	WBH	Med	XX	XX	XX	XX
Site c	WBH	Large	XX	XX	XX	XX
Site d	BH	Small	XX	XX	XX	XX
Site e	BH	Med	XX	XX	XX	XX
Site f	BH	Large	XX	XX	XX	XX
Site g	LP Steam	Small	XX	XX	XX	XX
Site h	LP Steam	Med	XX	XX	XX	XX
Site i	LP Steam	Large	XX	XX	XX	XX
Site j	HotCat	Small	XX	XX	XX	XX
Site k	HotCat	Med	XX	XX	XX	XX
Site l	HotCat	Large	XX	XX	XX	XX

Further relevant information could then be provided by clicking on the table to show information including:

- Site schematic diagrams showing location of pressure / temperature sensors / flow measuring devices
- Preheater layout / schematic drawings
- Planned maintenance procedures
- Reactive maintenance logs / fault logs
- Calculation details for System efficiency

This information would be required to calculate accurate whole life costs of a preheating installation. From this published evidence, the industry would be able to make informed investment decisions safe in the knowledge that their choice of preheating system has been proven to be of the greatest possible value in terms of whole life costs and carbon emissions.

Once we are able to share the above information we will have successfully demonstrated that the following tasks have been completed:

- Site selection
- Design of preheating systems utilising alternative technologies
- Installation of monitoring equipment to existing sites
- Installation of alternative equipment to selected sites
- Completion of all commissioning at each site including any trouble shooting associated with alternative technologies / monitoring equipment
- Setting up the central monitoring station
- Sharing the information from the monitoring station via the internet to provide knowledge to other network licensees and to Ofgem

Once up and running we will need to deliver training to our own personnel responsible for operating the network to allow them to understand how to operate the network in the most carbon efficient manner.

2.4 Changes since Initial Screening Process

The scope of the proposed project has been amended slightly since being submitted as part of the Initial Screening Process. Through internal challenges and reviews we have added IT and training costs to assist with knowledge dissemination, added costs to retrospectively remove redundant equipment once proved that the alternative technologies are successful, and have increased the costs provided by NGN for the installation of equipment. We have removed the costs proposed for 'Emerging Technologies' following review of the Preheating feasibility study recommendations.

Section 3: Project Business Case

This section should be between 3 and 6 pages.

3.1 Background

The business case for this project is based upon four key aims & objectives:

- Assess the potential for alternative technologies to meet preheating requirements across a range of heating system sizes and operating site parameters.
- Provide an independent and accurate model for assessing the efficiency of preheating systems across the UK based on reducing business carbon footprint (BCF) and whole life costs.
- Increase the technological options available to gas transporters for the replacement of preheating assets and increase the supply side of this market.
- Provide quantified data on system efficiency of both alternative and existing technologies that can provide the industry with information that will allow more informed investment decisions and a more efficient operation of the network.

These aims and objectives are essential to address the problems NGN and other GDNs face in accessing accurate data on system efficiencies and a narrow base of preheating technologies that have not been developed to modern requirements of efficiency, environmental performance and low whole life costs.

3.2 NGN's existing Preheating Investment Requirement

Within the NGN network we currently have 93 Waterbath Heaters (WBH) and 44 Boiler houses (BH) which are used for preheating gas as defined under the requirements of the IGEM standard IGE/TD/13. Within the RIIO-GD1 period NGN has a requirement to replace and/or upgrade 32 WBHs, 26 BHs and to install 3 preheating systems on existing sites. This equates to preheating upgrades on circa 45 sites. The majority of NGN's WBH are showing signs of deterioration and are at, or are moving towards, the end of their economic lives. As a result NGN's current preheating investment program is expected to carry on into the next price control review.

Should this bid be unsuccessful, investment decisions on preheating assets will be made with little or no research. This will result in sub-optimal investment decisions which cannot consider BCF associated with both alternative and existing technologies and will be limited in the number of technology options and technology providers available. Without the research NGN cannot be certain that the decisions made will be best value for money for our customers in the longer term.

Preliminary Research Results

In 2012 NGN undertook a preheating technology feasibility study. The objective of this study was to undertake a desktop assessment of all preheating options currently on the market ultimately producing a recommendation for the top performing systems to be put forward for this project. As a result of the study two technologies were recommended - Low Pressure Steam (by Proheat) and HotCat (by Bruest). The report concluded that currently there are no other alternative options that can provide the heating flexibility whilst meeting

the health and safety requirement required on a gas transmission site (Above 7 Bar).

3.3 Customer Benefits

It is anticipated that customers will benefit from the proposed project and solution through reductions in overall investment and operating costs within RIIO-GD1. They will share directly in these reductions via lower gas distribution transportation charges. This impact is expected to be matched in RIIO-GD2 as information from this project and experience during RIIO-GD1 will lead to lower investment and operating cost allowances for preheating assets.

Through the capture of energy usage data on each of the heating systems NGN will be able to verify the system efficiency equation which was developed as part of the preheating feasibility study (See Section 2). This will remove anecdotal information from suppliers and will provide the UK gas industry a definitive guide to the most carbon efficient heating systems across a range of site sizes and operating conditions. Ultimately this will allow networks and designers to make fully informed decisions on the optimal heating solution for each site in terms of BCF.

In addition, the successful implementation of this project will allow GDNs and Ofgem to evaluate the accuracy of current estimates of 'Own Use Gas', within the Shrinkage Gas arrangements. Currently gas consumed by GDNs at preheating sites is not metred but based on a fixed percentage of total network throughput. The project would allow the consideration of improvements on the accuracy of this figure.

The profile for the delivery of these benefits is summarised below:

- *Short term (one to three years)* **-** As with all new technologies there will be a short term increase in the unit cost associated with the design and installation of new gas preheating systems. These increases in costs will result from the additional research and development costs of each bespoke unit. After this initial investment NGN believes that these alternative technologies will become much more competitive on a unit cost comparison with existing technologies and will ultimately be a viable option for the UK gas industry. The overall installation costs of different systems will be understood including civil, mechanical, electrical and instrumentation works supporting future investment decisions.

  The environmental performance of each asset will be well understood and will begin to inform investment decisions that include accurate data on BCF across the remainder of RIIO-GD1.

- *Medium (three to six years)* **-** Currently the UK gas industry is almost totally dependent on one supplier of preheating systems, BHs from Pottertons. This project should allow alternative technologies to gain a foothold in the UK gas market and will create much needed competition. Not only will this allow different suppliers into the market but it will also drive down existing costs of favoured technology.

Reductions in BCF from alternative technologies will begin to be delivered from within NGN's large RIIO-GD1 investment programme in preheating assets when compared to business as usual (base case).

- *Long Term (six years and above)* **-** Once the project has gathered the statistical information to verify the system efficiency of all types of viable preheating, a cost benefit analysis will be produced. This will be shared across the UK gas industry to allow all gas preheating to be optimally designed. Ultimately this will result in a reduction in BCF and operating costs from the ongoing strategic change of the UK gas industry's heating asset population.

  Most of the UK's WBH systems are 30 to 40 years old and will be replaced in this and coming price control periods. It is generally accepted that installing new WBHs is not a preferable option as they are inefficient and limited in supply. BHs, unlike WBHs, currently have an estimated asset life of between 15 and 20 years. The alternative technologies are estimated to have an asset life closer to that of WBH resulting in a reduction in whole life cost and therefore a reduction in customer bills.

  BHs are complex in design with multiple failure modes. They also require expensive specialist maintenance which typically is not covered in the competencies of network industrial staff. The alternative heating systems have simpler designs and can be maintained by network technicians reducing ongoing maintenance costs by removing specialist maintenance contracts.

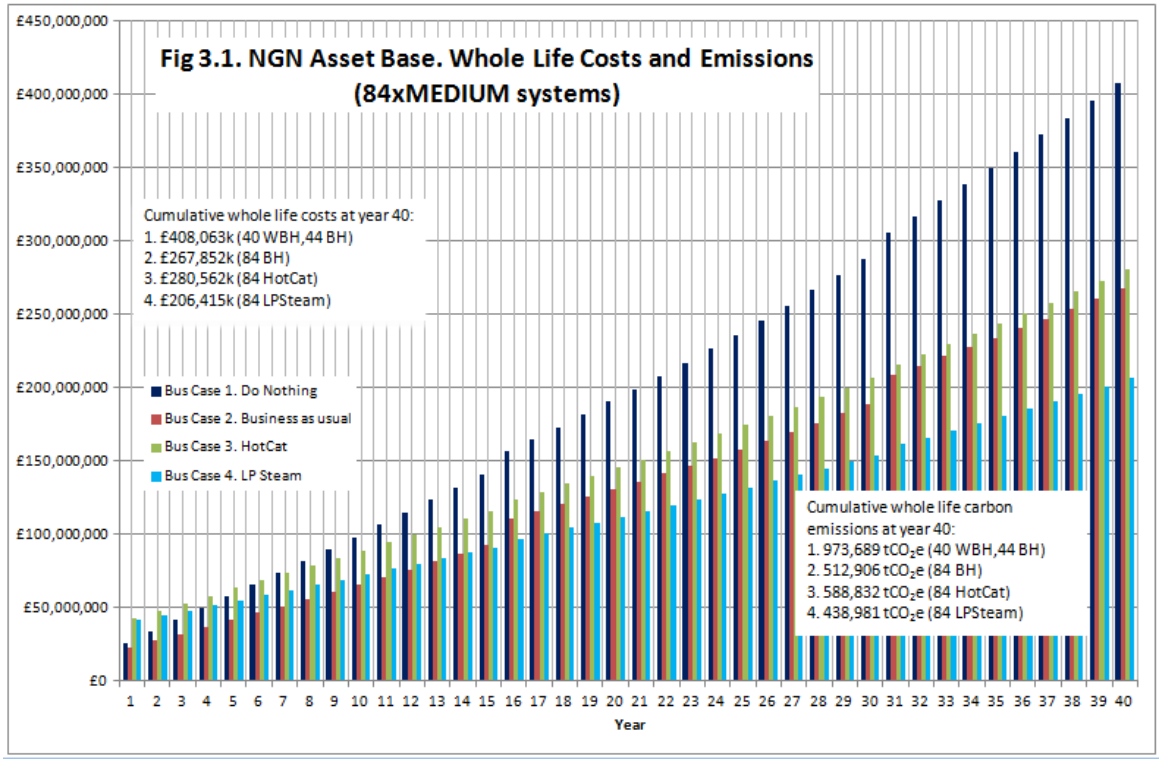
a. Financial & Carbon Benefits from NGN's Activities

By beginning this project within the first year of RIIO, NGN aims to be able to optimise its existing preheating programme within RIIO-GD1. Ultimately this project will allow NGN to invest in the correct preheating replacement strategy taking into account all variables of a cost benefit analysis with accurate data and a level playing field for unit cost comparison.

Business as usual for the gas industry is to upgrade WBHs or to replace them with BHs. This project aims to challenge this solution by delivering research and development results that allow companies to assess if whole life cost and BCF savings can be delivered using alternative technologies.

As part of this business case, NGN have made some conservative engineering assumptions on potential costs and BCF savings associated with alternative technologies. More details of these calculations can be found in Section 4. Extrapolating the potential results of a medium sized site to represent all of NGN's preheating assets (84 existing preheating sites) could result in an annual carbon saving of between 1,850 to 13,400 tCO_2e/year. This is the equivalent of around 825 to 6,000 cars less on the road per year (see section 4 for the assumptions for this calculation). The financial benefits could be between circa £1.5m to £5m per year.

Figure 3.1 overleaf shows the potential financial benefits in graphical format.



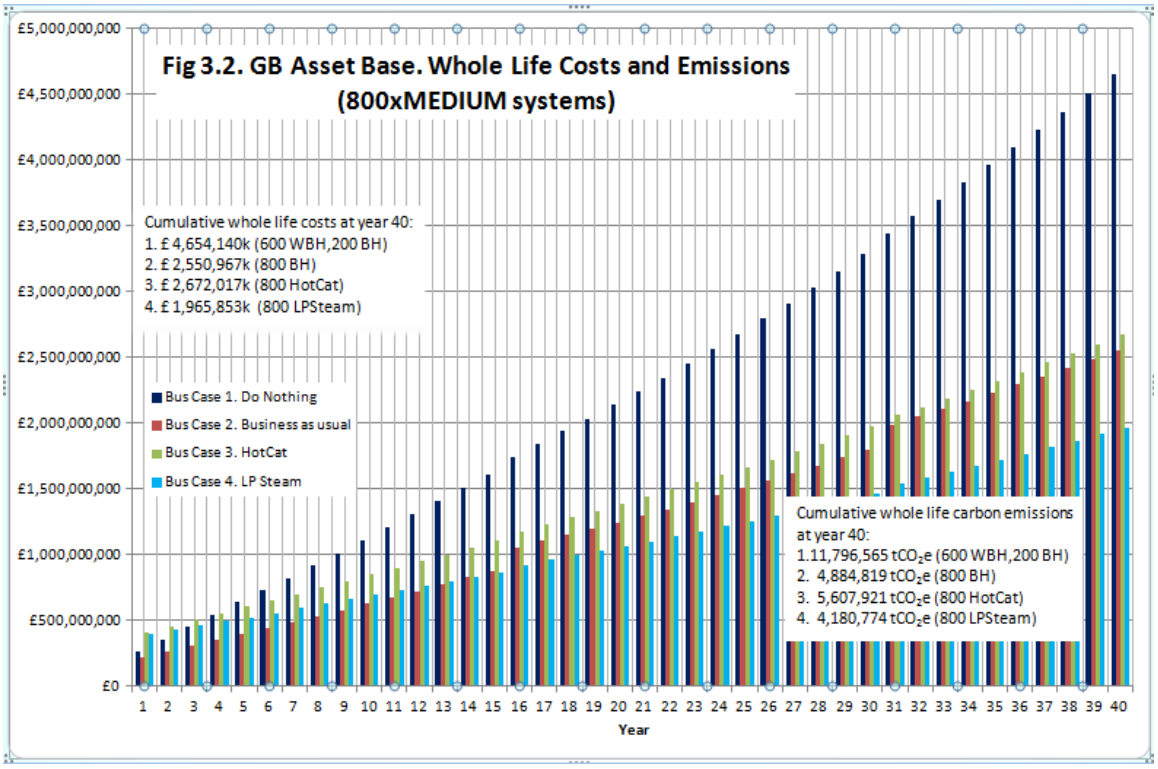
Over a 40 year period, NGN's customers could see a cost benefit between circa £60m and £200m (including carbon savings valued at DECC's central estimate of Non-traded cost of carbon). With an overall reduction in BCF between 74m to 535m tCO_2e (33,000 to 240,000 cars).

b. Financial & Carbon Benefits from UK Gas Industry Activities

The findings of this project will be shared with the UK gas industry via a real time data capture website. This will allow all other gas networks, and the wider preheating industry, to see the performance of these technologies on a real time basis. In addition to the website NGN will host site visits and conferences delivered via the project team. Ultimately this project will have a significant impact on the UK gas industry's preheating asset population.

NGN understands there to be in the region of 800 waterbath heaters (WBH) and 200 BHs in the UK gas distribution networks. Almost all WBH are over 30 years old and BHs generally have a 15 to 20 year economic life. The success of this project will influence the UK gas industry preheating upgrades for the next 30 to 40 years and could significantly reduce the BCF of the industry.

Figure 3.2 overleaf shows the potential benefits of this scenario to the UK gas industry.



Over a 40 year period, UK gas customers could see cost benefit between circa £585m and £2,700m (including carbon savings valued at DECC's central estimate of Non-traded cost of carbon). With an overall reduction in BCF between 700,000 and 7.6m tCO_2e (8,000 to 85,000 less cars on the road per year)

3.3 Project Financial Analysis

As detailed above, NGN have successfully completed a desktop study into alternative sources of preheating. This was funded in 2012/13 through the Innovation Funding Incentive (IFI). As a result of this study NGN have already undertaken substantial amounts of stakeholder engagement with potential partners for this NIC project. The total costs from this NIC bid are summarised below. The NIC Spreadsheet is contained in Appendix A with a further breakdown available in Appendix C:

Funding Source	Funding Level/ Contribution
NIC Funding	£4,916,592.37
Northern Gas Networks Contribution	£1,414,932.63
Project Partners (Pro Heat / Bruest)	£0

a. NIC Project Costs

- **Site Works:** Items 1 to 6 in the table overleaf will cover the design and procurement of all alternative heating systems and associated materials. Items 7 & 8 will cover the design, procurement and installation of all measuring equipment for alternative and existing heating systems.

Cost associated with the installation of the alternative preheating systems will be provided by NGN. Costs associated with the retrospective removal of redundant equipment that has been operated in tandem with the alternative preheating systems will also be provided by NGN. This is required to ensure the alternative preheating systems can be validated as fit for task before removal of the old equipment, effectively providing a short term back up should NGN encounter any initial problems.

- **Information Technology:** The key communication tool for this project will be a publicly available website providing real time up to date information on all the sites being monitored by the project.

  On installation of the alternative preheating systems duplicated alarms and monitoring equipment will need to be installed and connected to our system control department.

- **Project Management:** NGN does not have the capacity or specialist skill sets in house to manage this project. The project team will be lead by Adam Sadler, a Chartered Building Services Engineer (author of NGN's preheating feasibility report) supported by a Quantity Surveyor, Project Engineer and Project Supervisor. The project will report through the NGN Major Projects department. Please see the project organogram, Appendix B.

Section 4: Evaluation Criteria

This section should be between 8 and 10 pages.

4.1 How does the project accelerate the development of a low carbon energy sector and / or delivers environmental benefits whilst having the potential to deliver net financial benefits to future and / or existing customers

Technologies currently employed to provide gas preheating requirements have seen little technological development and have not focussed on delivery of requirements of efficiency and environmental performance. The scale of preheating requirements both within NGN's network and nationally means that preheating accounts for a significant portion of the Business Carbon Footprint (BCF) of operating gas distribution networks. Additionally, the system efficiency of existing gas preheating systems is not understood. Without both accurate information on system efficiency and incentive mechanisms that ensure GDNs face the true costs of gas used for preheating, investment appraisal of preheating technologies cannot be considered to be optimal.

The Low Carbon Gas Preheating (LCGP) project is aimed at quickly and aggressively proving the feasibility of two specific low carbon alternative technologies. If successful, we will take a significant step towards introducing greater competition into the market and stimulate further development of these specific and other technologies capable of providing low carbon gas preheating.

Additionally, the proposal to provide an accurate assessment of the system efficiency of current Water Bath Heater (WBH) and Boiler House (BH) technologies, will provide the industry with data required to evaluate the accuracy of current estimates of GDN's own gas use associated with gas preheating. This ensures that GDNs face directly the true cost of operating these assets and allow greater optimisation of preheating asset investment decisions.

i. The Carbon Plan The energy used in the preheating of gas would fall within the 'Industry' section of the Carbon Plan as the process can be considered to be an 'industrial heating process'. Specifically, this project sits within the savings identified as 'Energy, process and material efficiency' which the government predicts emissions will fall by 12% by 2030 compared with 2008 levels. Due to the lack of previous study into the gas used by preheating processes, and the low level of understanding within the industry, there are significant potential emission savings possible by applying the learning from this project.

An initial calculation suggests that having 6 preheating sites with alternative preheating systems installed, compared with the same 6 sites having traditional preheating systems installed, could result in an annual carbon saving of around 50%. Given the scale of gas preheating assets in the UK this could provide a significant contribution to the targets set out within the carbon plan. We have not considered fuel switching as mentioned in the Carbon Plan as our feasibility study considered the currently available options and concluded that none were suitable for an industrial heating process at the scale required by this project at this stage.

An initial assessment has been made of the potential financial and environmental benefits of the two alternative technologies when compared to current technologies across the 6 sites

proposed in this study. These results are set out in figure 4.1 below:

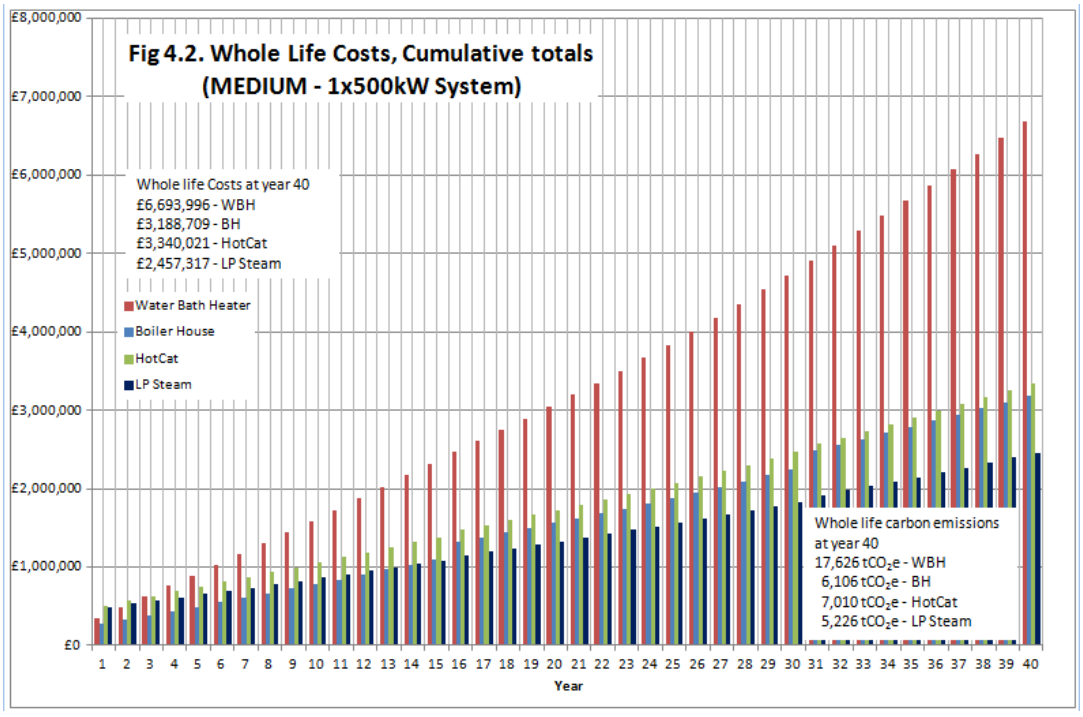
Figure 4.1:

	Business Case	Lifecycle Costs. Cumulative Cost at Year 40 (£000,000's)				Carbon Emissions. Cumulative total at Year 40 (,000 tCO_2e)			
		S	M	L	Total	S	M	L	Total
WBH	Business as usual	[redacted]							
BH									
HotCat	Alternative technology								
LP Steam									
Total Difference									

The table shows that to replace the business as usual costs for 6 sites with alternative technologies for 6 sites would deliver:

- Lifecycle Cost Savings. A net reduction in the lifetime costs of operation of £14.97m over 40 years.
- Carbon Emission Savings. A net reduction in carbon emissions of 41,400 tCO_2e over 40 years (1,035 tCO_2e per year). This is the equivalent carbon saving of having 462 cars less on the roads per year for 40 years (based on an annual mileage of 10,000 and a 'typical' emissions rate of 140g/km)

Details of the 'Medium' site are shown graphically in Figure 4.2 below. These have been extrapolated to give financial savings for NGN's entire asset base and the UK's entire asset base later in this section.



Assumptions made to calculate the values are:

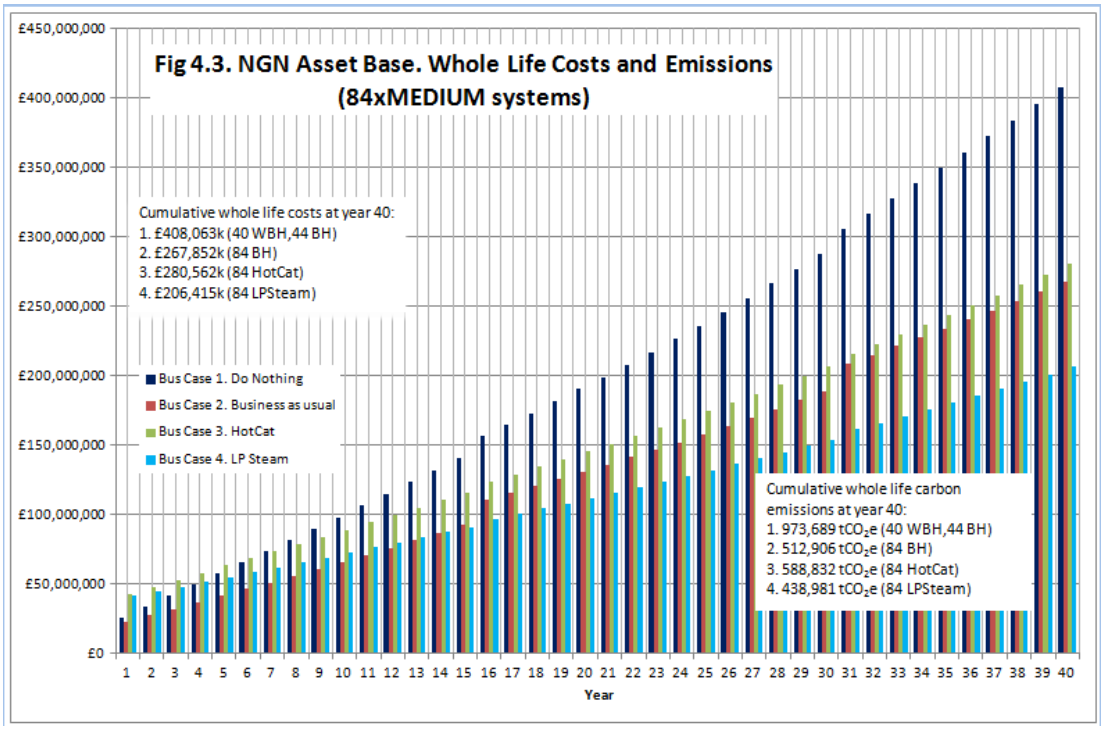
- Gas costs at 4.5p/kWh;
- Electricity costs at 13.3p/kWh;
- Climate Change Levy charged on electricity used at 0.524p/kWh
- Costs associated with attending to faults; sub-contracted maintenance (where required). Fault data increases with age.
- Additional fuel cost associated with efficiency.
- Capital costs for equipment have been based on figures used in Section 3 with upgrade costs added at year 16 and 31
- System efficiency of each technology (assumed); WBH 25%, BH 75%, HotCat 65%, LP Steam 85%.
- Heating is required for 1,200 hours per year at each site.
- Costs of carbon have been considered in line with guidance from DECC (£/tonne, non-traded price, central case).

4.2 Provides Value For Money to Gas Customers

Business as usual for the gas industry is to upgrade WBHs or to replace them with BHs. This project aims to challenge this solution by delivering research and development results that allow companies to assess if whole life cost and BCF savings can be delivered by using alternative technologies.

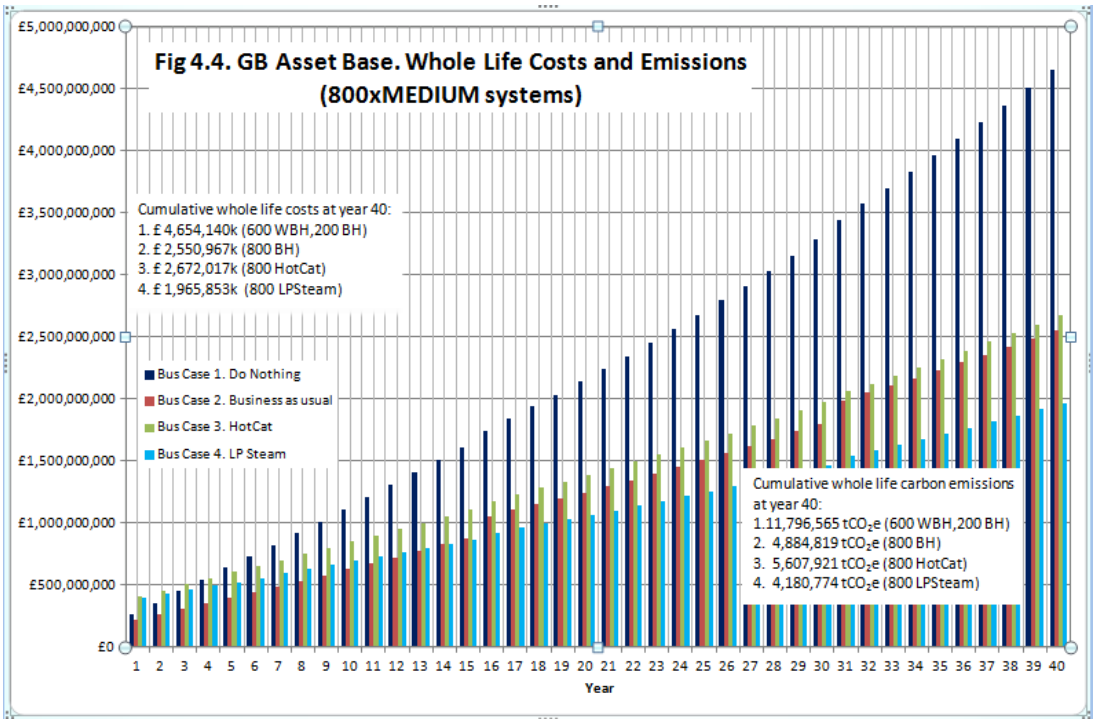
Extrapolating the potential results of a medium sized site to represent all of NGN's preheating assets (84 existing preheating sites) could result in an annual carbon saving of between 1,850 and 13,400 tCO_2e/year. This is the equivalent of around 825 to 6,000 cars less on the road per year (see section 4 for the assumptions for this calculation). The financial benefits could be between circa £1.5m to £5m per year.

Figure 4.3 overleaf shows the potential financial benefits in graphical format.



Over a 40 year period, NGN's customers could see a cost benefit between circa £60m and £200m with an overall reduction in BCF between 74m to 535m tCO_2e (33,000 to 240,000 cars in total).

Should this replacement strategy be developed across the UK the potential benefits in terms of whole life costs and BCF can be seen in Figure 4.4 below.



Evaluation Criteria continued

Over a 40 year period, UK gas customers could see cost benefit between circa £585m and £2,700m with an overall reduction in BCF between 700,000 and 7.6m tCO_2e (8,000 to 85,000 less cars on the road per year).

These scenarios demonstrate that this project could deliver significant benefits in terms of reducing BCF and financial risk.

Additionally, throughout the development of this project and in the bid preparation NGN have sought to ensure that the project is delivering good value for money for gas customers:

- ***Efficient Project Cost***s – All large investment projects within NGN are managed and delivered via the Major Projects Team that employs an Integrated Management Systems (IMS) that is integrated with the ISO9001 quality system. This project will be delivered and managed using this system will ensure that the project is managed efficiently taking into account all relevant legislation, appropriate commercial strategies and quality management. Additionally, the project will be delivered using NGN's approved framework partners for design and delivery. These partners have been identified and selected through a competitive tender and procurement process. To ensure that framework partners meet the requirements of NGN, these partners are regularly reviewed and performance evaluated.
- ***Initial Feasibility Study*** – In 2012 we carried out a desktop research study into the availability and applicability of technologies that had the potential to be deployed to provide preheating. This study allowed us to exclude a number of approaches which did not meet our specified criteria and focus more directly on those that showed the greatest potential – decreasing the potential scope of this project, reducing costs and accelerating the overall timescales.
- ***Inclusion of Existing Technologies*** **–** The inclusion of existing technologies within the project for only a small additional marginal cost provides significant additional value to the project. This will provide complete efficiency data on all preheating assets, existing and alternative, that can be used effectively when making investment decisions and potentially improving the accuracy of shrinkage gas calculations – even if the two alternative technologies are unsuccessful.
- ***Minimising Project Scale*** **–** this project benefits from potential economies of scale and scope in providing a good representative sample size to ensure that results can be meaningful and knowledge shared effectively across GDNs. We have worked hard to identify the minimum size of project that can deliver these benefits. This has been achieved by specifying very tightly the criteria for site and technology selection that is a good sample of representative sites across the industry. We believe that we have proposed the minimum number of sites to provide sufficient information for meaningful extrapolation.
- ***Project Partners*** **–** The initial feasibility study and development work in this area has allowed us to form a good working relationship with our proposed partners. This has assisted the project team in producing a robust business plan in terms of cost and timescales. These arrangements have resulted in both project partners making commitment to the project in terms of resource and technology development at zero

cost to the project.

4.3 Generates knowledge that can be shared amongst all relevant network licensees

The LCGP Project will generate data, knowledge and learning across a number of key areas which will be of critical importance for facilitating the further development and deployment of alternative technologies for preheating.

System Efficiency Data **-** The project will deliver standardised system efficiency data across four separate technologies and importantly across a range of different sites. This approach will allow other GDNs to directly assess the application of this data when considering investments in replacement of their own preheating assets.

Technical Knowledge – Deploying alternative preheating technologies on a large scale will generate significant knowledge and learning around design, planning, installation, and commissioning of these assets. The project is expected to generate new approaches to asset management and the assessment of replacement, upgrade and reconditioning requirements of these new assets.

Operational Knowledge - Experience of the maintenance requirements and procedures for new types and categories of assets will help accelerate the development of these assets and reduce the costs of operation for other GDNs. Additionally, any learning associated with how the wider system can be operated and configured to minimise operating costs and maximise the carbon benefits can be delivered directly to other GDNs.

Commercial Knowledge – The project will deliver learning on the commercial challenges associated with bringing new and alternative technologies to the market and any funding gaps that may exist when compared to existing technologies. It is anticipated that this knowledge will be of use directly to other GDNs but will also act as a stimulus to the wider market and the development and adaptation of other technologies that have the potential to deliver preheating requirements.

Regulatory Knowledge – NGN is forecasting a requirement to replace circa 45 Preheating installations during RIIO-GD1 and a similar number during RIIO-GD2. This project, if successful, will allow NGN to deliver greater benefit for customers during RIIO-GD1 but also ensure that NGN and Ofgem have the relevant information to ensure that any investment programme for RIIO-GD2 is optimised based on the learning from this project.

Additionally, the data generated by the project will allow a detailed evaluation of the estimates of GDN's own use gas, specifically for preheating. This project will allow NGN to consider any necessary changes to this calculation that will provide greater accuracy and improved incentives for GDNs to optimise their investments.

Further Independent and Collaborative work with GDNs – Standardising the method for calculating the system efficiency of current and alternative technologies creates a benchmark for the industry. This will lead to significant opportunities for future projects, both independent and collaborative, to build directly upon this project and continue to

develop the market for low carbon preheating technologies.

The project will employ a range of methods for disseminating the data, knowledge and learning. A knowledge and dissemination strategy will be developed to include a wide range of approaches.

One such approach will be the development of a purpose built website. The website will contain all relevant information associated with the 12 sites selected in relation to preheating. This information will be useful for any other network licensee wishing to optimise a preheating investment decision. Vital information, which has never been produced before will be uploaded for alternative and existing technologies including;

- Overall system efficiencies
- Carbon emissions
- Gas usage
- Electricity consumption
- Number, level type and description of faults
- Site drawings and designs
- Whole life costs
- Construction, installation and commissioning learning
- Maintenance experiences
- Asset Management of new assets

Data will be ready for use by other networks to give them suitable levels of information to be able to make the optimum investment decisions into their preheating asset strategy. Our outline programme shows that the first set of data published on the website will be associated with the existing technologies. This will be followed by the data collection from the sites where the alternative technologies are installed.

4.4 Is innovative (i.e. not business as usual) and has an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness

WBHs and BHs both have a long and proven history of providing the preheating requirements of the GDNs. As such they present a low risk means to deliver necessary replacement and upgrade of aging, poor performing assets.

With little or no technological research or development into alternative sources of gas preheating, installation of alternative technologies and approaches would provide a number of significant and inter-related risks:

- ***Commercial*** – The costs of the two alternative technologies within the project are, at present, prohibitive when compared to existing technologies. Their ability to deliver the BCF savings anticipated is also uncertain at this point. The business case needs to be proven with support from NIC. Without this we do not believe that any network has sufficient information to know that it is making the optimum decision when deciding its preheating asset replacement strategy. This project is based around proving commercial benefits, proving the technical superiority of alternative

equipment, and proving that a network can successfully manage its BCF associated with preheating if the correct information is provided.

- ***Technical*** – The ability of the alternative technologies to deliver the preheating requirements over a range of scenarios is uncertain. Both technologies require significant further research and development to apply effectively to the UK gas preheating market.
- ***Operational*** – Technically we anticipate that less faults occur with alternative technologies in comparison with existing technologies. However, if this is proven not to be the case then NGN may have to carry out retrospective works to the sites selected to reduce fault levels.
- ***Regulatory*** – The ability of the alternative preheating technologies within the project to provide the heating requirements is unproven. This combined with the significantly higher unit cost of these technologies when compared to exiting technologies measn that they cannot be considered as genuine alternatives as they pose a significant risk to NGN achieveing its required Asset Health outputs and associated expenditure allowances under RIIO-GD1.

These risks combined would be significant barriers to NGN delivering the necessary research and development required under a business as usual scenario. The high degree of uncertainty that these alternative technologies currently present means it would not be feasible to invest whilst guaranteeing the delivery of NGN's required outputs under RIIO-GD1.

The NIC funding mechanism allows us to fund directly an area that has received little investment whilst addressing these key risks. However, for this project in particular, it also allows us to increase the scale to deliver results on a more aggressive timescale than would otherwise be the case under smaller funding arrangements. This will help accelerate the development of these technologies and potentially begin delivering benefits within the RIIO-GD1 period.

4.5 Involvement of other partners and external funding

The LCGP project was developed using a very structured approach. The initial small-scale feasibility research study carried out in 2012 and funded under the Innovation Funding Initiative (IFI) helped evaluate alternative technologies and their potential to deliver low carbon gas preheating. The two alternative technologies proposed in this project were identified as part of this initial research.

Our two main partners who have committed to support this project are Proheat and Bruest. Both of these partners have previously technically supported the preheating feasibility study. They provide in depth and technical knowledge of the alternative technologies and are willing to develop their products to suit the UK gas industry and to optimise their own system's efficiency.

Both partners are committed to the project at director level as they both see the UK market in need of development due to the reliance on mainly only one technology and one supplier for the previous 15 to 20 years. We have included signed letters from Directors of both

companies in the appendices to show evidence of each company's commitment to the project.

Bruest produce the 'HotCat' which is a unit containing gas catalytic heaters mounted adjacent to the gas stream to heat the pipe wall / gas through radiant heat.

Bruest are committed to work with NGN in considering modifications to design including;

- Utilising additional tubes within the HotCat unit to increase the surface area where radiant heat can be focussed.
- Build a unit where each catalytic heater has a high and low fire operation. This will reduce the amount of electrical preheating required per unit by controlling each heater in a different way. Ultimately this reduces the carbon footprint drastically as the emissions associated with electricity consumption are 3 times higher than those associated with gas consumption.

In themselves these are both innovative product development ideas. As part of this bid they form part of the bigger scheme of proving technologies, efficiencies and ultimately, lifecycle costs.

Proheat - build boilers (evaporators) / condensers which use low pressure steam to heat the gas stream.

Proheat are committed to developing their product to suit the needs of the gas industry. In doing so they are planning to develop by looking into;

- How multiple electrical panels can be combined into one, therefore giving the option to skid-mount all components to allow factory testing therefore not only reducing capital costs but also reducing site commissioning time and anticipated problems.
- How multiple evaporators and condensers can be configured to allow all components to be skid mounted.
- How medium & large sites can be served by burners of different sizes to optimise efficiency.

4.6 Relevance and timing

The RIIO-GD1 period presents NGN with a requirement to replace/upgrade circa 45 sites with WBH / BHs over the eight year period. Prior to commencing such a significant investment programme that would deliver asset solutions with long economic lives we were keen to ensure that we would be making the correct investment decisions that addressed our short, medium and long term challenges.

The three year project provides a significant period of five years for NGN to assimilate the findings into its preheating investment programme and begin to deliver significant benefits for customers over the period to 2020/21. Any positive findings from the project could also feed into the RIIO-GD1 mid-period review in 2016/17. This is a clear benefit of the longer eight year price control period under RIIO and the innovation framework complementing each other to deliver early benefits for customers.

Evaluation Criteria continued

Other GDNs who have identified requirements to invest in preheating assets over the period will also be in a position to benefit from the project within the RIIO-GD1 period. The size of NGN's and other GDN's investment in this area over RIIO-GD1 has significant potential to improve the commercial feasibility of alternative technologies leading up to the next price control period.

The outcome from the project could also have a significant impact on the investment plans for GDNs in RIIO-GD2. The benefits that flow directly from the project and from NGN's investment programme over RIIO will give GDNs and Ofgem a greater insight into the options available for the provision of preheating, the associated benefits of alternative technologies and the likely costs.

Finally, the timing of the project early in RIIO-GD1 provides the opportunity to follow this up with further projects examining the potential of other technologies and allow time for manufacturers to bring new products to market following this initial stimulus.

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Section 5: Knowledge dissemination

This section should be between 3 and 5 pages.

☐ Please cross the box if the Network Licensee does not intend to conform to the default IPR requirements.

5.1 Role of Data, Knowledge and Learning Dissemination

Effective knowledge dissemination is central to the project achieving its aims and objectives. One of the key barriers to the effective investment appraisal of preheating solutions has been in part the paucity of high quality data and knowledge on the performance and whole life costing of existing and alternative preheating technologies.

The project will provide significant and extensive opportunities for GDNs, manufacturers and other energy and heat intensive industrial users to evaluate the potential for alternative heat sources. Additionally the project will generate data, knowledge and learning that will allow Ofgem to evaluate effectively both the investment options for preheating replacement and upgrades during RIIO-GD2 and incentive mechanisms relating to BCF and Own Use Gas by GDNs.

5.2 Categories of Data, Knowledge and Learning

There are several key categories that will be derived from the project from a variety of sources:

- **Technical Knowledge** – There are several areas of technical knowledge that it will be important to disseminate and share effectively including Design, Installation, Commissioning and Asset Management.
- **Operational Knowledge** – Knowledge relating to the planned maintenance schedules and requirements along with any fault reports and unplanned maintenance and repair requirements. Additionally any safety related issues with alternative technologies.
- **System Efficiency Data** – The performance of the preheating installations included against a wide range of measures will be critical to the success of the project. This will include system efficiencies calculated in accordance with the methodology described above.
- **Network Operation** – The knowledge gained from assessment of the ability to change the operation of the system taking into account system efficiency data at particular offtakes and PRS to deliver further reductions in BCF.

5.3 Key Responsibilities for Knowledge Dissemination and Learning

Partners within the project will have a role and contribute to the dissemination of knowledge and learning from the project. However, the Project Team will be responsible for delivering the Data, Knowledge and Learning Strategy developed at the start of the project. This strategy will develop a set of overarching aims and objectives for the project and identify the necessary workstreams with a responsible owner and an associated project plan and timetable for each.

The dissemination of knowledge and learning internally within NGN will be coordinated via

the Project Team in conjunction with NGN's Academy. NGN's Academy, is the route by which all training and development is delivered across NGN, including for key contractors and direct service providers. This process will ensure that all learning is disseminated in a controlled manner and effectively delivered into business as usual processes.

5.3 Primary Stakeholders of Project Data, Knowledge and Learning

The project will have a core target audience who will primarily be interested in the outcomes and knowledge generated;

- Other Gas Distribution Networks
- National Grid Transmission
- Ofgem
- The Energy Networks Association
- The Institute of Gas Engineers & Managers (IGEM)
- Industrial Heating Installation Developers and Manufacturers
- NGN Staff
- NGN Contractors and Direct Service Providers
- SBGI
- Energy & Utilities Alliance
- Academic Institutions

5.4 Methods Of Dissemination

The wide range of stakeholders in the output from the project dictates that our dissemination strategy must include a diverse range of methods that should be adaptable to the requirements of each particular audience.

- Project Website: NGN will create an easily accessible website linked directly from its home page and will form the hub of all its disseminated knowledge. It will provide stakeholders with access to site details, progress reports, photo & video gallery and lessons learnt in a live environment.
- Conferences & Seminars:
    - Attendance at the NIC annual conference to update on progress and lessons learnt.
    - Providing a report on key project findings address to meet wider utility needs focusing on the socio-technical aspects of the project.
    - IGEM Annual Engineering Update Conference to share analysis of the data and update engineering community.
- Network & Local Events; Site visits and presentations given to interested stakeholders including GDNs, Yorkshire Gas Association and North East & Yorkshire IGEM and extended to other local IGEM sections based on specific requirements.
- Publications; Specific areas for wider communications including gas and utility industry journals and periodicals to ensure maximum coverage of the benefits of the whole project and some of the key lessons learnt
- Technical;
    - Website including technical design drawings, site layouts, equipment data,

commissioning certification and other useful technical information.
    - IGEM technical standards to ensure the data captured, results of analysis and technical reports are incorporated in future industry standards. Technical reports will also be produced and shared via appropriate groups within the gas sector.
- Video, Podcasts, Social Media; To increase the dissemination to a wider audience NGN will consider the use of video updates on You Tube, use our social media mechanisms (LinkedIn) to put out overviews of the project to other stakeholders.

5.5 Intellectual Property Rights (IPR)

This project will conform to the NIC default IPR arrangements and a memorandum of understanding will be signed with all vendors and each project partner. To avoid any doubt, data produced via the smart metering, results of system performance and reports on system performance will be freely distributed. Lessons learnt and network performance outcomes will be shared with other GDNs free and non-[redacted]

The development of the two alternative technologies by Bruest and Proheat independently are currently commercially available products and will continue to be available via the open market following the end of the project including any developments introduced as part of the project.

Gas Network Innovation Competition Full Submission Pro-forma

Knowledge dissemination continued

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Knowledge dissemination continued

Section 6: Project Readiness

This section should be between 5 and 8 pages.

Requested level of protection require against cost over-runs (%): 11.4

Requested level of protection against Direct Benefits that they wish to apply for (%): N/A (This bid does not show any direct benefits)

6.1 Evidence of why the Project can start in a timely manner

NGN have spent time already considering exactly how this project will be managed, how the data will be shared, and the QA procedures that the project will be subject to. The following paragraphs detail some of these considerations to demonstrate how we feel that the project can commence in a timely manner.

The project would be run through the Major Projects Team and be subject to the integrated management system (IMS) in place within this team. The team's IMS is integrated with the ISO9001 quality system. It sets out the processes and procedures to follow for the implementation of a project through both the design and delivery phases.

Setting up of framework agreements

NGN have been through a procurement process, at the start of the RIIO period that will assist with the design and delivery of projects within the Major Projects Team. The LCGP project will be implemented utilising the approved framework partners.

There are 2 frameworks, design and delivery, specifically related to Major Projects that put in place suitably qualified companies who have met the evaluation criteria.

To ensure that the framework partners continually meet the requirements of NGN they are regularly reviewed. The process employs a 360 degree review of the project where the partners and NGN review each other. From this review process partners are ranked.

Preparation

A feasibility study providing information for this project has already been completed. During the preparation of the RIIO submission to Ofgem, NGN investigated alternative and renewable options available for preheating. After careful consideration NGN commissioned a Chartered Building Services Engineer to carry out an independent feasibility study to look at all types of heating systems from the traditional technologies, through to the alternative technologies, and including renewables such as heat pumps and solar thermal power. More detail of the study is given within Section 2 of this submission.

The study considered the overall system efficiency, not just the individual preheater efficiency. The efficiency calculations, within the report, took in to account losses not previously considered including:

- Thermal losses (Qth)

- Control losses (Qco)
- Energy in (electrical (Qe) and gas (Qg))

The outcome of the study highlighted that there are more efficient, low carbon preheating options, which could be employed within the gas industry. One major challenge that this bid aims to overcome is to encourage the uptake of alternative technology within a very conservative industry.

In anticipation of the award of the NIC, NGN have commenced with the design for the preheating on small sites. The cost for installing alternative technology, on sites with medium and large heating loads, would be prohibitive in comparison to conventional preheating. As such, as a business, NGN cannot justify these costs noting the associated risks.

When selecting which sites should be chosen for the site trials we have considered that the following criteria will be reviewed:

- Whether the site is representative of a typical small, medium or large site within NGN / the UK (to ensure that the knowledge generated is relevant to other networks)
- Whether the site is due an upgrade on the preheating system
- The amount of space available on site
- The electric power available on site
- Cost analysis for each of the available options
- The size of preheating requirement (Qnet, in kW)
- The criticality of the site within the NGN network
- The telemetry available
- The back-up power on site

Sites to assess the existing technologies will be selected from the existing stock of preheating assets within the network. To obtain the data required, the 6 sites selected will be fitted with smart meters for both gas and electricity consumption. All other data would be repeated from the remote telemetry unit already on site to the remote server hosting the website.

Project Programming

For all projects within NGN, cost loaded programmes are prepared in Primavera P6. Please see Appendix G for details of our programme relating to the LCGP project.

The programmes are initially created by the project leader and developed as the project progresses and more information becomes available. This includes incorporating both the designers and delivery framework partners' input based on their proposal for conducting the design and construction respectively.

The project programmes are cost loaded, initially based on experience and outline enquiries. As mentioned previously, the design and delivery phases of the project are tendered out to the framework partners to determine the most economical costs as well as

reviewing their ability, through execution statements.

The Plan identifies four Workstreams in addition to the mobilisation and close down phases as described below:

1. Web design. Setting up data collection and website. This will include setting up the website to allow other interested parties, within the gas industry, to view the data.
2. Existing Sites Phase. Installing smart metering across the 6 WBH and BH sites**.**
3. Medium and Large Sites Design and Build. The full design and construction of the 4 medium and large sites LP Steam and HotCat.
4. Trials and data collection. The data collection will start as soon as the first 6 sites for the WBHs and BHs have had their monitoring equipment installed. As each of the other sites come on line the data will start to be collected and compared.

6.2 Evidence of how the costs and benefits have been estimated (this can be supplemented in the appendices)

The costs identified in the business case are supported further in Appendix C.

Charts and tables used to calculate the anticipated financial benefits are contained in Appendix F. Information relates to the anticipated 6 sites that this project is proposing to upgrade, as well as the potential benefits of rolling out the project principals across NGN's preheating asset base followed by doing the same across the UK's asset base.

These tables make a number of assumptions which ultimately the LCGP project will actually prove. Assumptions have been detailed in section 4.

6.3 Evidence of the measures a Network Licensee will employ to minimise the possibility of cost overruns or shortfalls in Direct Benefits

As detailed above, this project will be subject to the IMS employed within the Major Projects team. This management system will ensure that processes involving commercial, design, planning, risk and management personnel will follow set and approved guidance. Problems arising will be regularly monitored and managed throughout this project to be sure that the project is delivered on time, safely, and within budget.

At the start of a project that involves commercial and project risk, a risk & opportunities workshop is held with all interested parties. The meeting follows a set format, which addresses all of the internal and external influences that could affect the cost and delivery of the project. The output of the risk review workshop is a risk factor which has been added to the project costings and programme.

The objective of the Risk & Opportunity workshop is to create a Risk & Opportunity register which lists the significant costs and schedule risks that may have an impact on the successful delivery of the project as well as identifying possible cost and schedule saving opportunities.

Specifically to this project, the list of risks and opportunities created and reviewed included:

- Design / procurement cost uncertainty (all sizes of alternative technology sites)
- Installation of monitoring equipment on sites with existing technology
- Development of the website
- Project Management
- Installation cost uncertainty (alternative technology sites)
- Retrospective removal of redundant equipment (alternative technology sites)

Individual costs have been discussed relating to the minimum, most likely and maximum cost outcomes for each particular risk and opportunity. In addition to the cost spread that could result from any specific risk or opportunity, the range of delays that could result were also discussed and recorded. As with the cost impact, these ranges of delay have then been attached to the task or tasks that would be affected by each risk or opportunity. The probability of a risk / opportunity materialising has been based on a scale between 0% and 100%. These values, both cost and schedule impact and the probability, can be seen in more detail in Appendix E. All costs identified in this workshop have been incorporated into the business plan.

6.4 A verification of all information included in the proposal (the processes a Network Licensee has in place to ensure the accuracy of information can be detailed in the appendices)

Figures contained in Appendix F were produced internally by NGN's Major Projects team. These figures have been used throughout this document to produce the business cases for this project in addition to being extrapolated to calculate the potential benefits to NGN's asset base as a whole and then to calculate the same for the UK's asset base as a whole.

To verify that the figures were correct we have employed a specialist Chartered Building Services Engineer through our framework to check and to challenge them. Whilst the feedback that we received from the specialist was that the assumptions do have a significant influence on the whole life costs made (e.g. the system efficiency of each of the existing / alternative technologies), it was thought that all other values represented accurate current costs and that the methodology was robust.

Regular internal meetings have been held within NGN in the preparation of this bid to ensure that the objectives proposed are achievable. Appendix H contains our 'EXP01' form signed by 4 senior managers to demonstrate that the bid has the full backing NGN. More on the EXP01 form is explained below.

Project progress review/governance

Once the project is live, there are two elements to governance within NGN which the project will be subject to. The first element is for the design and construction through the GL5/G17 process. The second is the internal commercial governance in terms of price and programme.

For internal commercial governance the different phases of the project are tendered,

through the framework partners, as detailed above. Before a contract is awarded the expenditure and scope of work will be approved by the investment steering group (ISG). The group is made up of NGN board and management. This group has already reviewed this project, evidence is contained within Appendix H in the form of the EXP01 which forms part of the IMS requirements. The signatures on this form also demonstrate the project readiness and support of senior staff within NGN.

Once the NIC is awarded, monthly reviews with the Head of Investment and Major Projects will begin. The reviews address progress against programme and costs against the cost loaded programme.

The NGN/PM/G/17 procedure provides a framework for the management and control of new works or modifications on gas systems. The management procedure encompasses all disciplines (mechanical, electrical, cathodic protection, instrumentation & control, safety and software). The procedure puts gates in place that must be achieved prior to moving on to the next stage. The most significant stage is the approval of the design where it is appraised by independent engineers. These design approver and appraisers are preapproved for the knowledge and experience by a competent design authority.

To close the project a report will be produced and published in line with the information contained within Section 9.

6.5 How the Project plan would still deliver learning in the event that the take up of low carbon technologies and renewable energy in the Trial area is lower than anticipated in the Full Submission.

We have considered that that by obtaining data from 12 sites (3 different sized sites for 4 different technologies), that if the uptake of the low carbon technology is lower than expected, then we will have still collected valuable data to prove the efficiencies of existing and alternative technologies which can be extrapolated to demonstrate to any network the potential benefits / pitfalls of a range of preheating equipment.

This data then ensures that our original objectives to develop alternative technologies, increase the level of competition within the industry, provide robust data to allow informed challenge of the shrinkage model, and to provide whole life cost data of a range of assets, will be achieved.

The project will not only allow a comparison of each of the different types of site (small, medium and large) for each of the different types of preheating technology, but it will also be able to validate the performance and efficiency claims of the manufacturers whether the uptake of the alternative technologies are increased or not.

Deliver Learning

The following are aspects of the project will be compared for the learning outcomes:

- Energy efficiency (% and carbon emissions)
- Project installation costs

- Planned and reactive maintenance costs

The main aspect for delivering learning will be through the bespoke website. More detail about the website is given in section 5.

All of the information and test data would be available for parties to share. This data would include the Approved and Appraised G17s.

Other aspects for learning will be the use of conferences and seminars where various aspects of the project will be presented and discussed. To add to the availability across the industry these could also be web based. Again the information will be added to the website.

6.6 The processes in place to identify circumstances where the most appropriate course of action will be to suspend the Project, pending permission from Ofgem that it can be halted.

Due to the amount of preparation and research already carried out prior to the submission date, coupled with the security of being managed by the Major Projects team subject to the IMS system, we believe that there would be very few instances where a project would be suspended. The rare occasions would be:

- Where the new heater installation could cause an interruption of supply during the winter period
- Failure of the heater to meet its desired minimum requirement during commissioning and performance testing

Should a problem such as this occur with one of the proposed technologies, our proposal would be to stop the installation of that particular technology only. This would change the scope of the project but the outcomes of providing the industry with robust data for the other systems (including existing technologies) would still provide benefits to the industry as discussed throughout this document.

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Project Readiness continued

Gas Network Innovation Competition Full Submission Pro-forma

Project Readiness continued

Project Code/Version No:

Gas Network Innovation Competition Full Submission Pro-forma

Section 7: Regulatory issues

This section should be between 1 and 3 pages.

☐ Please cross the box if the Project may require any derogations, consents or changes to the regulatory arrangements.

7.1 Regulatory Impact

It is not considered that the project will require any derogation, licence consent or licence exemption. Consequently, there are no regulatory hurdles to the project commencing or completing on the desired timescales.

7.2 Long-Term Regulatory Impact

The data, knowledge and learning derived from the project will have the potential to influence key elements of the regulatory framework for GDNs going forward. Two such areas include:

- Own Use Gas calculations within the estimation of Shrinkage Gas volumes and the associated Ofgem Baselines and Incentive arrangements; and
- Identifying benchmark values for considering the funding levels necessary to deliver preheating investment programmes in future price controls.

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Regulatory issues continued

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Regulatory issues continued

Section 8: Customer impacts

This section should be between 2 and 4 pages.

8.1 Direct Customer Impacts

The project will not have a direct impact on customer's premises nor is it planned to cause any interruption to supplies. The project does not require any customer disconnections or interruptions during installation or operation of new equipment.

Safety and security of supply will have the highest priority throughout the whole of this project with existing safety precautions being maintained or improved during every operational change or engineering operation.

8.2 Risk of Interruption

Whilst there is always a small risk of unplanned customer interruptions when alternative technologies or processes are introduced on the network due to unforeseen circumstances, the risk of such an occurrence happening is extremely low and we believe that the non routine procedures adopted by the network will reduce this risk to as low as reasonably practicable.

Whenever new equipment is installed there is a risk of faults occurring during the initial commissioning stages. As such, before any commissioning takes place, controls and monitoring will be put in place to ensure risks to the network are reduced to as near as possible to base method risks. NGN will take the opportunity, where it is prudent to do so, to increase monitoring during initial stages.

At each site identified within the project that will have alternative technology installed the risk of interruption to supply will be managed, where practical, by the retention of existing technology which has the capability to provide appropriate preheating backup if required.

During the project, network flows and quantities through various regulators will be effectively managed to minimise the need for preheating or to increase the effectiveness of the process. Again, we believe our safety measures, system control operations and expert knowledge will ensure that the risk to customers is maintained to existing levels. As part of our risk register and management of the process this risk will be constantly and consistently managed.

8.3 Stakeholders in the trial area

It is considered that the risks associated with alternative technologies will be managed to ensure that they are no greater than exist under business as usual processes. Consequently we do not see any requirement for alterations to our existing stakeholder strategy in this area.

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Customer impacts continued

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Customer impacts continued

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Customer impacts continued

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Section 9: Successful Delivery Reward Criteria

This section should be between 2 and 5 pages.

9.1 Preheating Site Selection

Each of the 12 sites is selected based on the identified criteria to ensure that the sites represent a good sample of preheating sites and operating characteristics. Ensuring that project results are both scalable and can be replicated across other sites and networks by March 2014:

- Publication of site evaluation criteria.
- Publication of preheating site evaluation results and details of analysis undertaken.
- Publication of sites identified for inclusion in project.

9.2 Preheating Site & Technology Design

Completion of the detailed designs of smart metering, HotCat and LP Steam technologies at each of the selected sites:

- Smart Metering to install alongside existing technology – June 2014
- HotCat and LP Steam Small Site Design – January 2014
- HotCat & LP Steam Medium and Large Site Design - December 2014

9.3 Technology Build & Installation

All hardware, including metering technology, telemetry, HotCat and LP Steam preheating assets installed and commissioned on each of the selected sites by December 2015:

- Smart metering, monitoring & telemetry equipment to be installed to existing WBH & BH sites – December 2014
- HotCat, smart metering, monitoring & telemetry equipment installed to selected sites December 2015
- HotCat, smart metering, monitoring & telemetry equipment installed to selected sites December 2015

9.4 Successful trialling and demonstration of alternative preheating technologies

The knowledge, learning and understanding gathered from the trialling of the two alternative preheating technologies will be captured and shared within the project timescales. This will include:

- Designs published alongside knowledge and learning and disseminated via project website – December 2014
- Knowledge and learning associated with the installation and commissioning of alternative technologies published and shared via project website – January 2016

- Technical data relating to the operational performance of preheating technologies – ongoing to December 2017.
- Asset performance including planned and reactive maintenance requirements – ongoing to December 2017.

9.5 Successful estimation of system efficiencies of existing preheating technologies

The system efficiency of existing technologies will be monitored continuously over the period from installation to the end of the project.

- System efficiency data calculated in accordance with efficiency calculation specified within the project (as set out in Section 2). Information to be provided 2 months post installation of smart metering and monitoring technology at each site.
- System efficiency data published to the project website via a live feed and available for download – December 2015 (all sites won't be installed and commissioned until 2015 see 9.3).

9.6 Knowledge, Learning & Dissemination Strategy

Deliver project website, accessible by all interested parties and able to receive and publish data on system efficiency for all selected sites:

- Website Procured – March 2014
- Website development completed to deliver reporting of system efficiencies, knowledge and learning sharing – December 2014.
- Capability for data and information to be downloaded from website – December 2014 (for Small site builds and existing technologies)

Capability for data and information to be downloaded from website – December 2015 for all sites NGN participation in the Annual NIC Fund Conferences with Low Carbon Gas Preheating project information in 2014, 2015 & 2016.

9.7 Project Evaluation & Final Project Report

Produce a detailed final report to close down the project which will include project findings, knowledge and learning generated and clear recommendations on the system efficiencies of existing and alternative technologies. The report will clearly set out recommendations on the potential for alternative technologies to provide the preheating requirements at sites of different scales of heat output and operating conditions.

The report will also evaluate the benefit of a longer term monitoring study of sites and technologies included within project. – December 2017.

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Successful Delivery Reward Criteria continued

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Successful Delivery Reward Criteria continued

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Successful Delivery Reward Criteria continued

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Section 10: List of Appendices

Appendix A: **Low Carbon Gas Preheating Project NIC Spreadsheet**

Appendix B: **Project Organogram**

Appendix C: **Financial Justification**

Appendix D: **Project Partners – Letters of Support**

- Bruest
- Proheat

Appendix E: **Project Risk Summary Report**

Appendix F: **Tables and Charts**

Appendix G: **Project Plan**

Appendix H: **EXP 01 – Expenditure Approval form**

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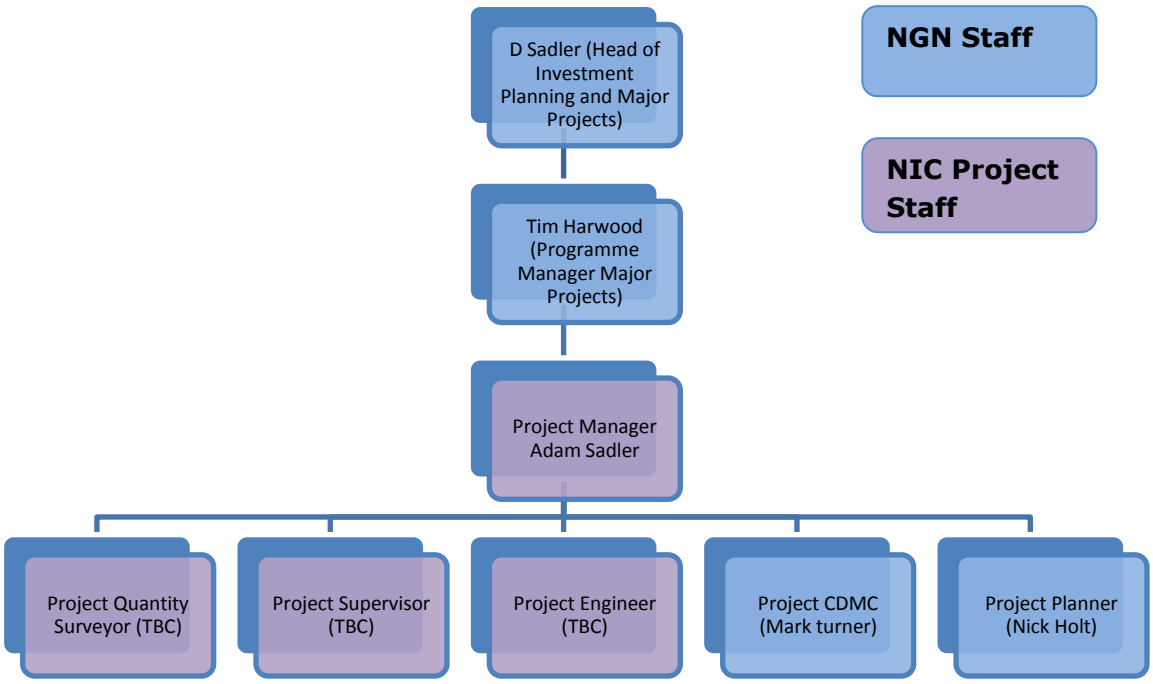
Appendix B: Project Organogram

Project Team Organogram

The project team will be reportable to the Major Projects department and will consist of a mix of NGN staff and NIC specific individuals.



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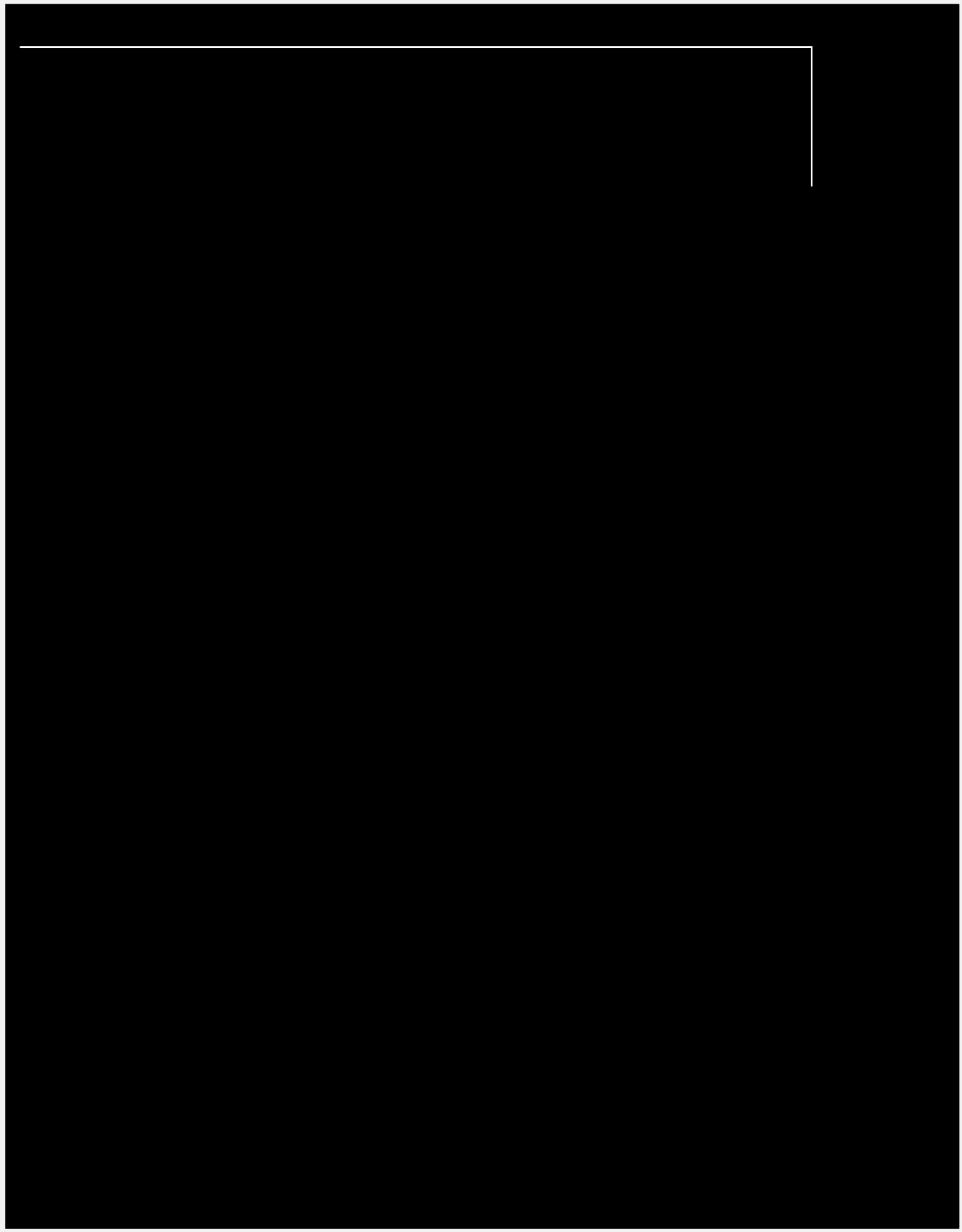
Appendix C: Financial Justification



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[redacted]

BRUEST CATALYTIC HEATERS
Division of Catalytic Industrial Group, Inc.

20th and Sycamore • P.O. Box 827, Independence, Kansas 67301
(620) 331-0750 • (800) 835-0557 • FAX: (620) 331-3402
email: bruest@cat-group.com
website: bruestcatalyticheaters.com

August 5, 2013

FAO Northern Gas Networks

Re: Network Innovation Competition 2013

Dears Sirs / Madam,

We thank you for your invitation for Bruest Catalytic Heaters to work alongside Northern Gas Networks in the above competition.

We fully support the main project objective to prove the actual system efficiency of a range of our gas preheating equipment with respect to gas use, electricity use and all associated losses of energy.

Please accept this letter as confirmation that we are delighted to be partnering with you as a supplier of 3 items of pre-heating equipment. We acknowledge that the live data you collect will be published on a website with a view to sharing all knowledge gained from the project with the rest of the UK gas industry.

We are aware that value for money is vital if you are to be successful in obtaining funding for this project, and whilst we cannot provide the equipment free of charge, we acknowledge that we aim ultimately to benefit as a company from our involvement. As such, we confirm that our prices will be commercially reasonable and we will assist with all reasonable development costs of the equipment that may arise throughout the design, installation and monitoring phases.

Yours Sincerely,

Virgil Macaluso
President
Bruest Catalytic Heaters

Bruest Flameless Catalytic Heaters • FM & CSA Approved For Class 1 • Div. 1 & 2 • Group D Areas

ProHeat SYSTEMS

FAO Northern Gas Networks

August 2, 2013

Dears Sirs / Madam,

Re: Network Innovation Competition 2013

We thank you for your invitation for ProHeat to work alongside Northern Gas Networks in the above mentioned competition. As a company dedicated to accountability for performance, we fully support the project objective to prove actual system efficiency using a range of gas preheating duties with respect to fuel use, electricity use and quantification of any other non-productive energy losses. Please accept this letter as confirmation that our team is delighted to be partnering with Northern Gas Networks as a supplier of three preheating systems. We acknowledge that the live data collected will be published on a website with a view to maximize sharing of knowledge gained from the project with the rest of the UK gas industry.

We are conscious that value for money is vital if Northern is to be successful in obtaining funding for this project, and whilst ProHeat cannot provide the equipment free of charge, we acknowledge that our goal to deliver more robust and efficient preheating solutions is ultimately aligned with meeting unmet needs of Northern and the UK gas industry. We feel strongly that benchmarking provides a basis of accountability which in turn ensures better value for preheater investment. As such, we confirm that our prices will be commercially reasonable and that ProHeat will assist the project with a contribution of resources including access to our pilot facilities, process control planning optimization tools, including the industry's only dual-phase heat transfer model and we will support a portion of development costs associated with the study.

Ultimately, our aim is to earn our place as the leading preheat solution provider to UK gas industry and we appreciate the opportunity to support Northern in this Network Innovation Competition.

Yours Sincerely,

Stefan M. Romocki
Managing Director
ProHeat Systems Limited

Stefan Romocki | Managing Director | sromocki@proheatsytems.com
9 Devonshire House, London EC2M 4YF | 07847 630 492 | 0203 586 1701 ext 1702
www.proheatsystems.com

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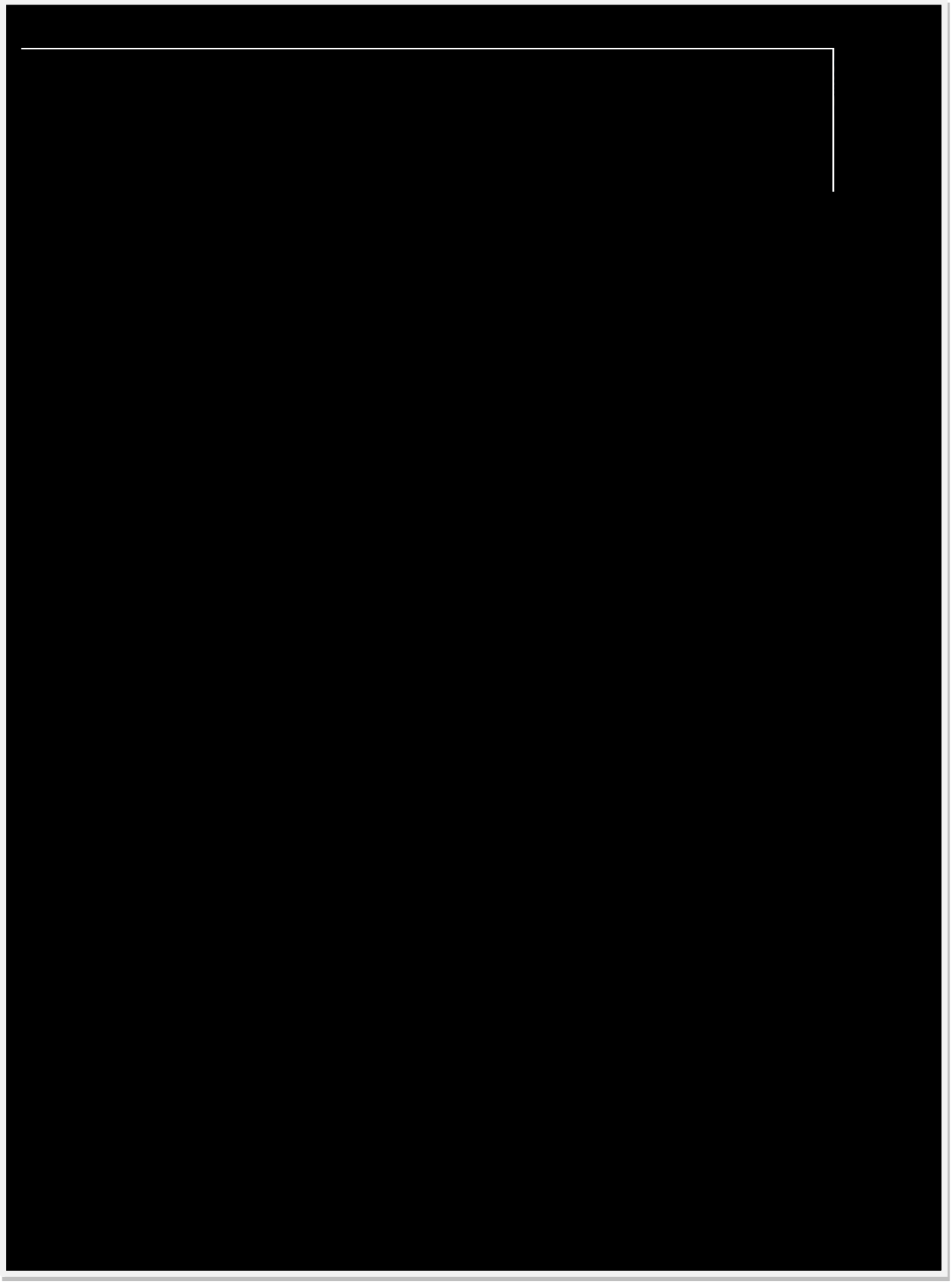
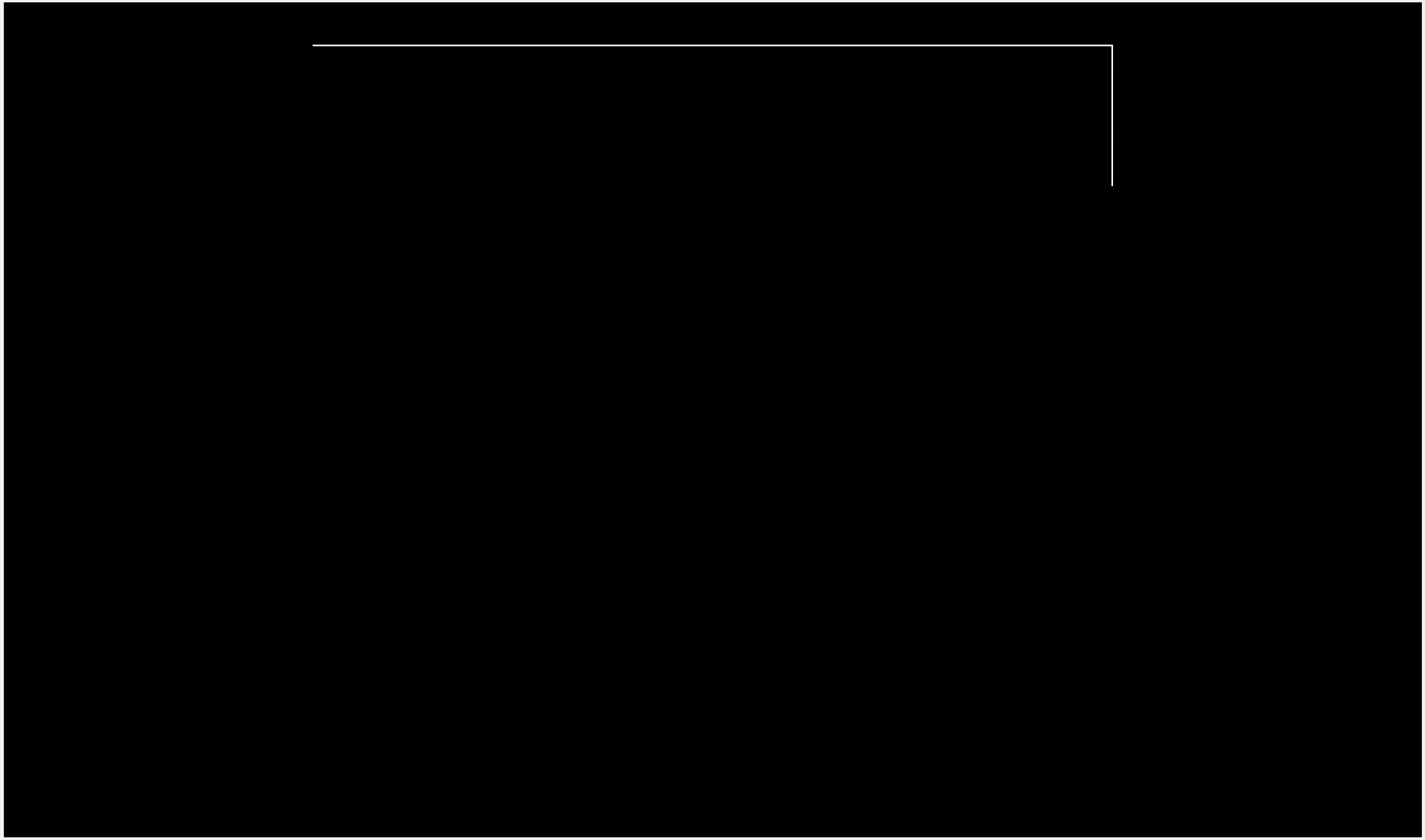
Appendix E: Project Risk Summary Report





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Appendix F: Tables and Charts

SAMPLE TABULATED DATA FROM WHICH GRAPHS HAVE BEEN PRODUCED

	Year	1	2	3	4	5	6	7	8	9	10	11
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Non-traded sector carbon emissions (£/tonne)		57	58	59	60	61	62	63	64	65	66	67
WBH (500kW system)												
Gas costs (600,000kWh @4.5p)		27000	27000	27000	27000	27000	27000	27000	27000	27000	27000	27000
Elec costs (negligable @ 13.3p)		0	0	0	0	0	0	0	0	0	0	0
CCL rates Gas (0.182p/kWh)												
CCL rates Elec (0.524p/kWh)												
Capital costs		215000										
No of faults pa		10	10	10	10	10	10	10	10	15	20	25
Cost to address faults (£)		2000	2000	2000	2000	2000	2000	2000	2000	3000	4000	5000
Subby reactive maintenance (£)		0	0	0	0	0	0	0	0	0	0	0
Subby planned maintenance (£)		0	0	0	0	0	0	0	0	0	0	0
Excess Gas costs (25% efficient)		81000	81000	81000	81000	81000	81000	81000	81000	81000	81000	81000
Excess CCL rates for gas (25% efficient)		0	0	0	0	0	0	0	0	0	0	0
Non-traded carbon cost per year		25116	25557	25998	26438	26879	27320	27760	28201	28642	29082	29523
Cost for year		350116	135557	135998	136438	136879	137320	137760	138201	139642	140082	142523
Cumulative Total		4,050,116	4485,674	4621,671	4758,110	4894,989	41,032,308	41,170,069	41,308,270	41,447,911	41,588,994	41,731,516
Carbon emissions (gas 0.1836, elec 0.5246)		440,640	440,640	440,640	440,640	440,640	440,640	440,640	440,640	440,640	440,640	440,640
Cumulative carbon emissions		440,640	881,280	1,321,920	1,762,560	2,203,200	2,643,840	3,084,480	3,525,120	3,965,760	4,406,400	4,847,040
WBH Whole Life cost	4,691,996											
BH (500kW system)												
Gas costs (600,000kWh @4.5p)		27000	27000	27000	27000	27000	27000	27000	27000	27000	27000	27000
Elec costs (11,000kWh @ 13.3p)		1463	1463	1463	1463	1463	1463	1463	1463	1463	1463	1463
CCL rates Gas (0.182p/kWh)												
CCL rates Elec (0.524p/kWh)		5764	5764	5764	5764	5764	5764	5764	5764	5764	5764	5764
Capital costs		215000										
No of faults pa		10	10	10	10	10	10	10	10	15	20	25
Cost to address faults (£)		2000	2000	2000	2000	2000	2000	2000	2000	3000	4000	5000
Subby reactive maintenance (£)		975	975	975	975	975	975	975	975	975	975	975
Subby planned maintenance (£)		975	975	975	975	975	975	975	975	975	975	975
Excess Gas costs (75% efficient)		9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
Excess CCL rates for gas (75% efficient)		0	0	0	0	0	0	0	0	0	0	0
Non-traded carbon cost per year		8701	8854	9006	9159	9312	9464	9617	9770	9922	10075	10228
Cost for year		270878	56031	56183	56336	56489	56641	56794	56947	58099	58252	60405
Cumulative Total		4270,878	4326,909	4383,092	4439,428	4495,917	4552,558	4609,352	4666,299	4724,398	4782,650	4844,055
Carbon emissions (gas 0.1836, elec 0.5246)		152651	152651	152651	152651	152651	152651	152651	152651	152651	152651	152651
Cumulative carbon emissions		152,651	305,301	457,952	610,602	763,253	915,904	1,068,554	1,221,205	1,373,855	1,526,506	1,679,157
BH Whole Life cost	3,188,709											
Hotcat												
Gas costs (600,000kWh @4.5p)		27000	27000	27000	27000	27000	27000	27000	27000	27000	27000	27000
Elec costs (11,000kWh @ 13.3p)		1463	1463	1463	1463	1463	1463	1463	1463	1463	1463	1463
CCL rates Gas (0.182p/kWh)												
CCL rates Elec (0.524p/kWh)		5764	5764	5764	5764	5764	5764	5764	5764	5764	5764	5764
Capital costs		450000										
No of faults pa		8	8	8	8	8	8	8	8	8	8	10
Cost to address faults (£)		1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	2000
Subby reactive maintenance (£)		0	0	0	0	0	0	0	0	0	0	0
Subby planned maintenance (£)		0	0	0	0	0	0	0	0	0	0	0
Excess Gas costs (65% efficient)		14588.46154	14588.46154	14588.46154	14588.46154	14588.46154	14588.46154	14588.46154	14588.46154	14588.46154	14588.46154	14588.46154
Excess CCL rates for gas (65% efficient)		0	0	0	0	0	0	0	0	0	0	0
Non-traded carbon cost per year		9989	10164	10340	10515	10690	10865	11041	11216	11391	11566	11742
Cost for year		460455	460630	460805	460980	461156	461331	461506	461681	461857	462032	462507
Cumulative Total		4510,455	4570,884	4631,589	4692,470	4753,525	4814,756	4876,162	4937,743	4999,500	5,061,432	5,123,939
Carbon emissions (gas 0.1836, elec 0.5246)		175248	175248	175248	175248	175248	175248	175248	175248	175248	175248	175248
Cumulative carbon emissions		175,248	350,495	525,743	700,990	876,238	1,051,485	1,226,733	1,401,980	1,577,228	1,752,475	1,927,723
HotCat Whole Life cost	3,641,021											
LP Steam												
Gas costs (600,000kWh @4.5p)		27000	27000	27000	27000	27000	27000	27000	27000	27000	27000	27000
Elec costs (2,000kWh @ 13.3p)		266	266	266	266	266	266	266	266	266	266	266
CCL rates Gas (0.182p/kWh)												
CCL rates Elec (0.524p/kWh)		1048	1048	1048	1048	1048	1048	1048	1048	1048	1048	1048
Capital costs		450000										
No of faults pa		2	2	2	2	2	2	4	4	4	4	6
Cost to address faults (£)		400	400	400	400	400	400	800	800	800	800	1200
Subby reactive maintenance (£)		0	0	0	0	0	0	0	0	0	0	0
Subby planned maintenance (£)		0	0	0	0	0	0	0	0	0	0	0
Excess Gas costs (65% efficient)		4764.705882	4764.705882	4764.705882	4764.705882	4764.705882	4764.705882	4764.705882	4764.705882	4764.705882	4764.705882	4764.705882
Excess CCL rates for gas (65% efficient)		0	0	0	0	0	0	0	0	0	0	0
Non-traded carbon cost per year		7447	7578	7708	7839	7970	8100	8231	8362	8492	8623	8754
Cost for year		490926	41056	41187	41318	41448	41579	42310	42340	42371	42502	48332
Cumulative Total		4490,926	4531,982	4573,169	4614,487	4655,935	4697,514	4739,824	4781,864	4824,235	4866,736	4904,769
Carbon emissions (gas 0.1836, elec 0.5246)		130649	130649	130649	130649	130649	130649	130649	130649	130649	130649	130649
Cumulative carbon emissions		130,649	261,298	391,948	522,597	653,246	783,895	914,544	1,045,194	1,175,843	1,306,492	1,437,141
LP Steam Whole Life cost	2,457,217											

Assumptions

WBH

1 500kW system uses 600,000kWh gas per year (ie heating season is: full fire for 1,200 hours per year)
2 Electrical use of WBH is negligible
3 Capital costs are the same as a BH
4 Fault data begins at 10pa and inreases to 50pa at year 15 when investment is needed to upgrade
5 Cost to address a fault is £200
6 There is no reactive or planned sub-contractor maintenance required
7 WBH is 25% efficient

BH

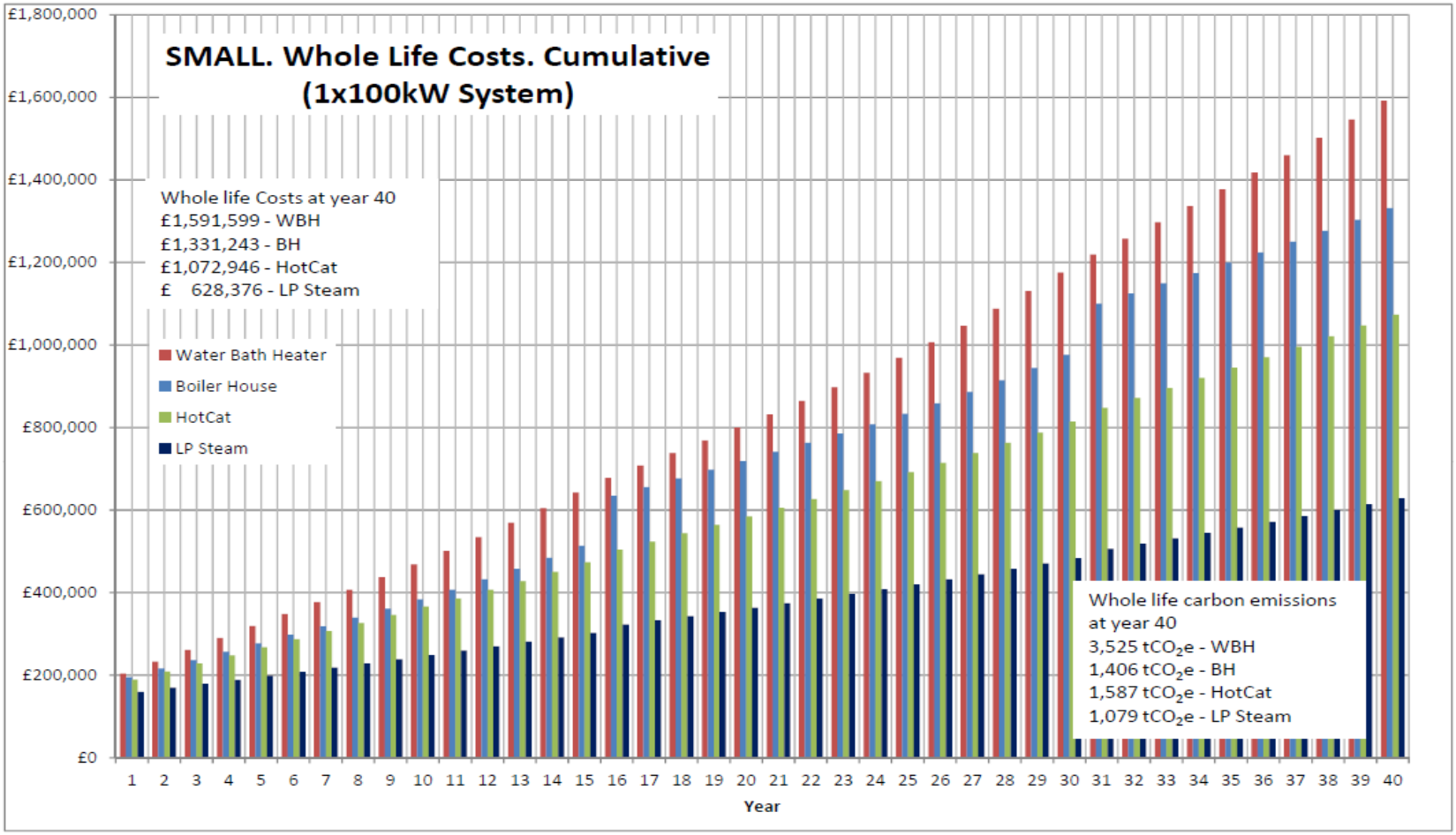
8 500kW system uses 600,000kWh gas per year
9 Electrical use of BH is 11,000kWh per year
10 A 500kW BH would cost £800k to install
11 Fault data begins at 10pa and inreases to 50pa at year 15 when investment is needed to upgrade
12 Cost to address a fault is £200
13 Reactive maintenance costs £975pa on average
14 Planned maintenance costs £975pa on average
15 BH is 75% efficient

Hotcat

16 500kW system uses 600,000kWh gas per year
17 Electrical use of Hotcat is the same as a BH (11,000kWh per year)
18 A 500kW Hotcat would cost £450k to install
19 Fault data begins at 8pa and inreases to 24pa at year 15 when investment is needed to upgrade (reduced number of faults due to simple design)
20 Cost to address a fault is £200
21 There is no reactive or planned sub-contractor maintenance required
22 Hotcat is 65% efficient

LP Steam

23 500kW system uses 600,000kWh gas per year
24 Electrical use of LP Steam is (2,000kWh per year)
25 A 500kW LP Steam system would cost £450k to install
26 Fault data begins at 2pa and inreases to 6pa at year 15 when investment is needed to upgrade (reduced number of faults due to simple design)
27 Cost to address a fault is £200
28 There is no reactive or planned sub-contractor maintenance required
29 LP Steam is 85% efficient


SMALL. Whole Life Costs. Cumulative (1x100kW System)
Whole life Costs at year 40
£1,591,599 - WBH
£1,331,243 - BH
£1,072,946 - HotCat
£ 628,376 - LP Steam
Water Bath Heater
Boiler House
HotCat
LP Steam
Whole life carbon emissions at year 40
3,525 tCO2e - WBH
1,406 tCO2e - BH
1,587 tCO2e - HotCat
1,079 tCO2e - LP Steam
£1,800,000
£1,600,000
£1,400,000
£1,200,000
£1,000,000
£800,000
£600,000
£400,000
£200,000
£0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Year

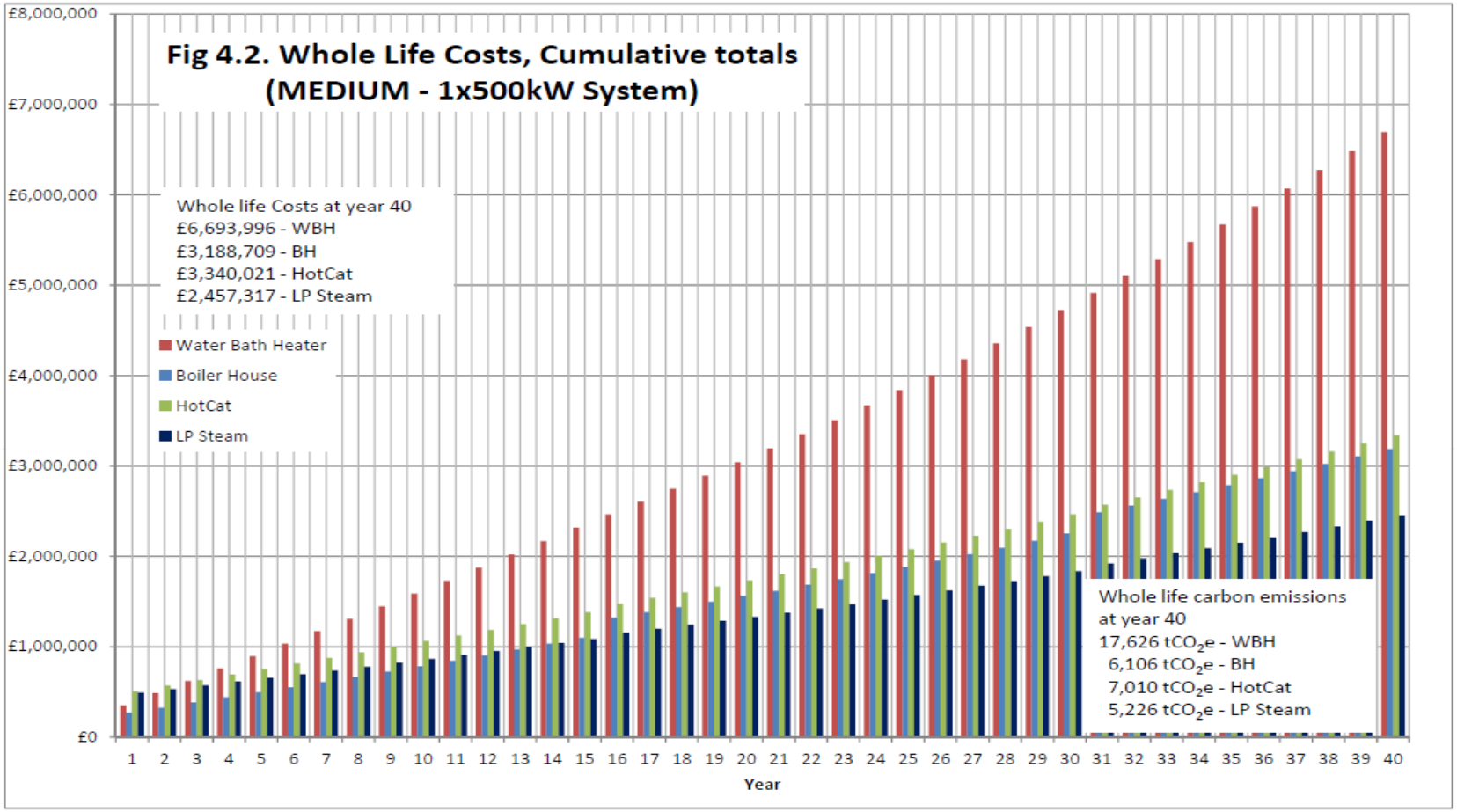
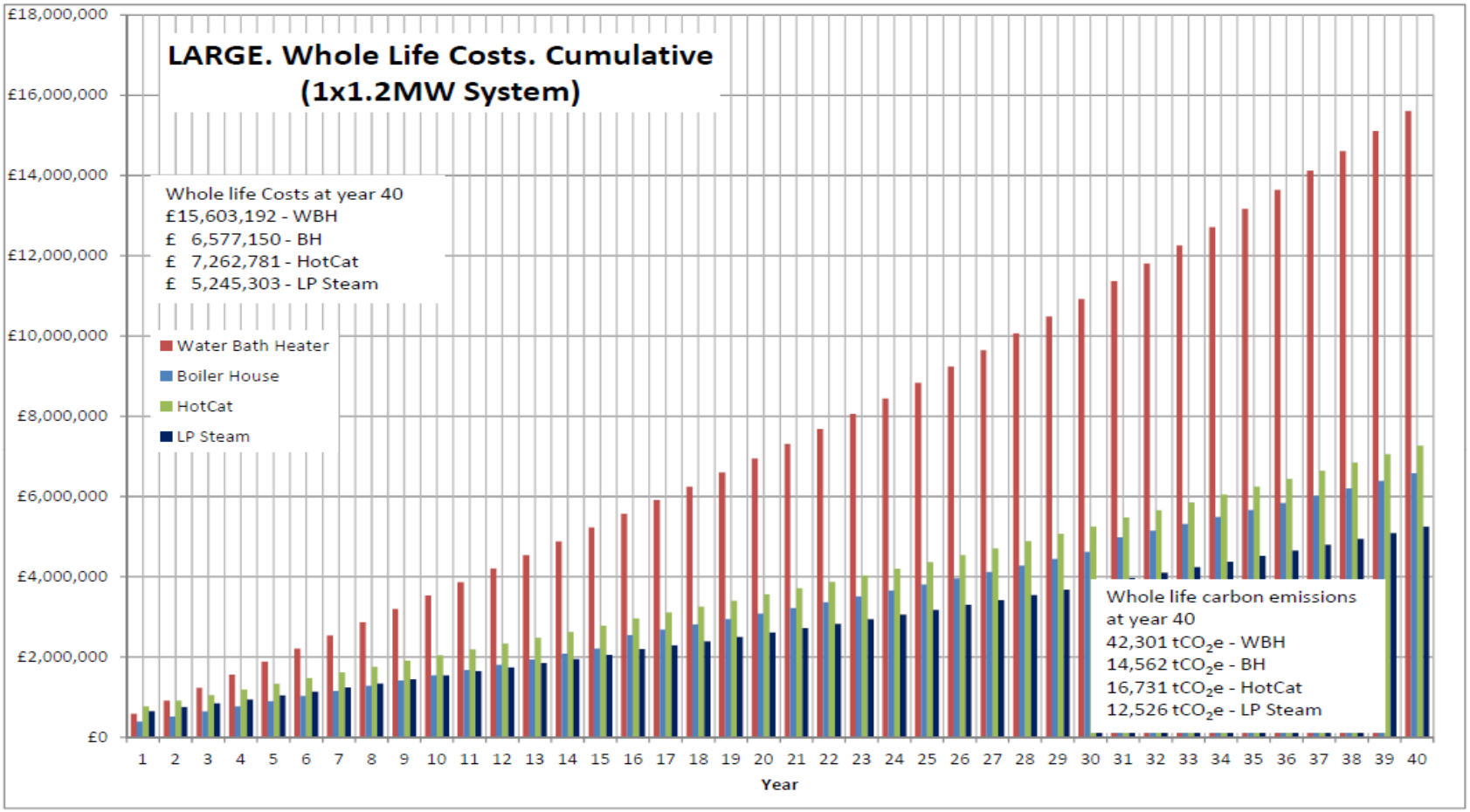


Fig 4.2. Whole Life Costs, Cumulative totals (MEDIUM - 1x500kW System)
Whole life Costs at year 40
£6,693,996 - WBH
£3,188,709 - BH
£3,340,021 - HotCat
£2,457,317 - LP Steam
Water Bath Heater
Boiler House
HotCat
LP Steam
Whole life carbon emissions at year 40
17,626 tCO2e - WBH
6,106 tCO2e - BH
7,010 tCO2e - HotCat
5,226 tCO2e - LP Steam
£8,000,000
£7,000,000
£6,000,000
£5,000,000
£4,000,000
£3,000,000
£2,000,000
£1,000,000
£0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Year


LARGE. Whole Life Costs. Cumulative
(1x1.2MW System)
Whole life Costs at year 40
£15,603,192 - WBH
£ 6,577,150 - BH
£ 7,262,781 - HotCat
£ 5,245,303 - LP Steam
Water Bath Heater
Boiler House
HotCat
LP Steam
Whole life carbon emissions
at year 40
42,301 tCO2e - WBH
14,562 tCO2e - BH
16,731 tCO2e - HotCat
12,526 tCO2e - LP Steam
£18,000,000
£16,000,000
£14,000,000
£12,000,000
£10,000,000
£8,000,000
£6,000,000
£4,000,000
£2,000,000
£0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Year

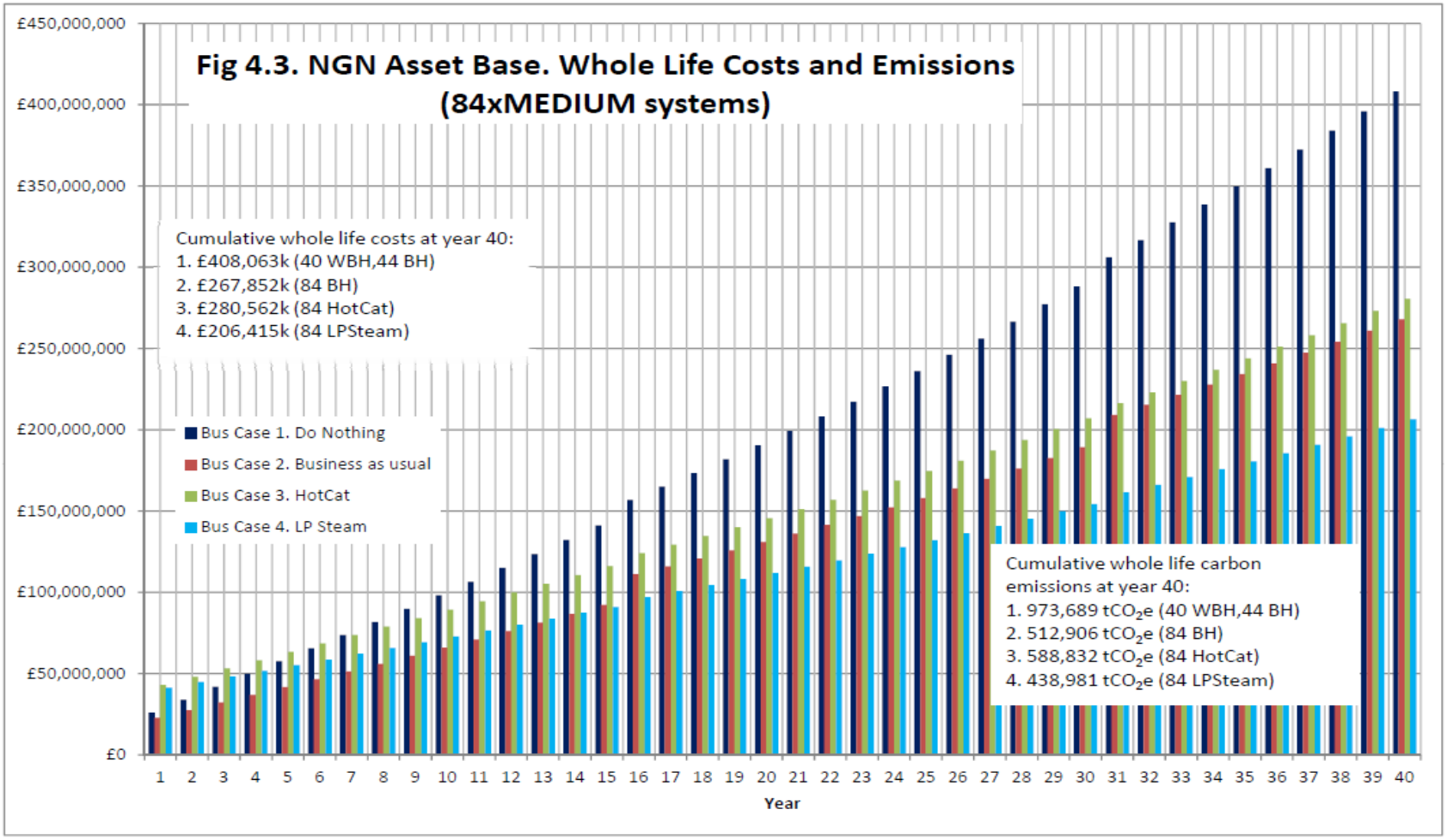
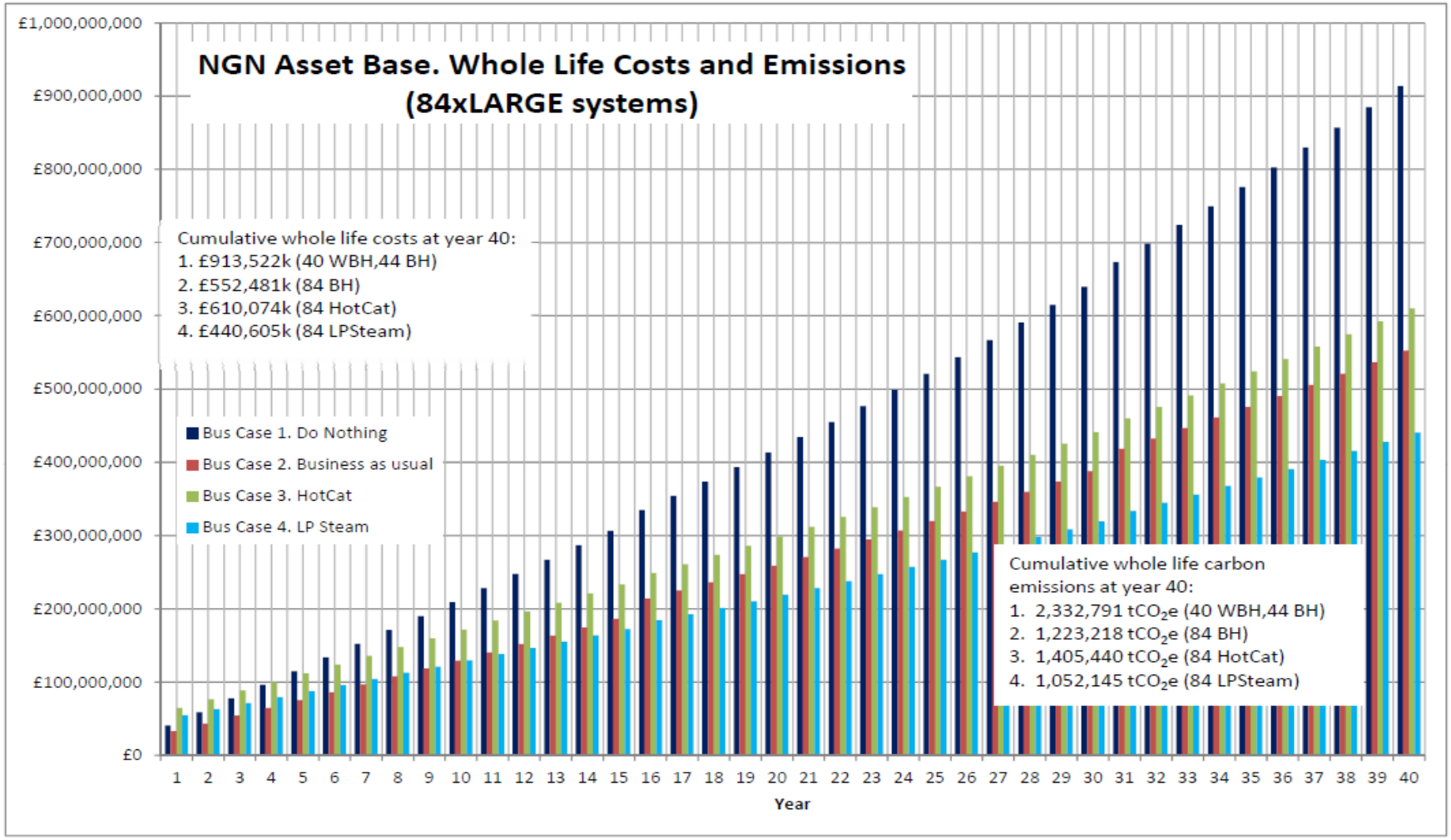
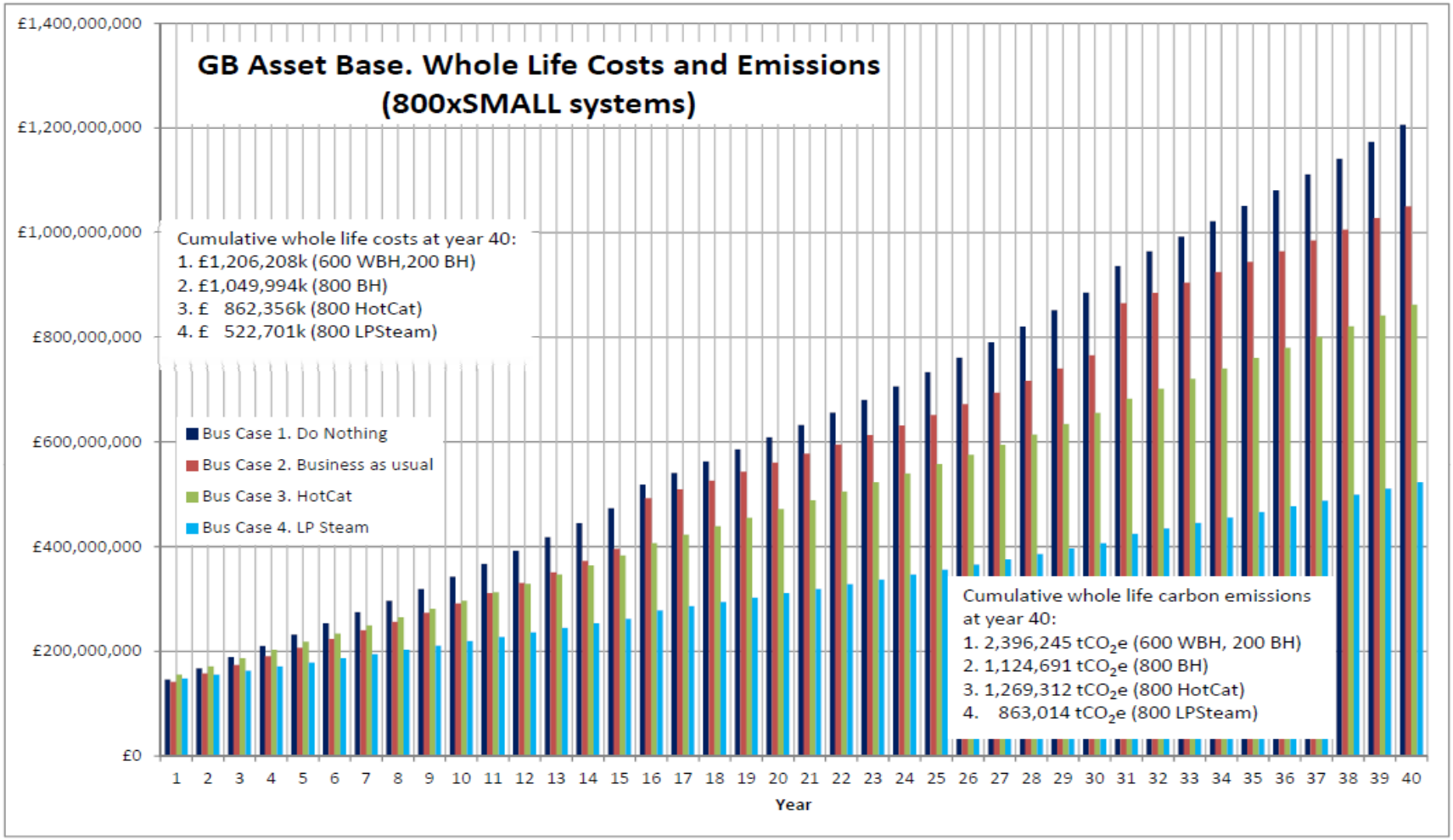


Fig 4.3. NGN Asset Base. Whole Life Costs and Emissions (84xMEDIUM systems)
Cumulative whole life costs at year 40:
1. £408,063k (40 WBH,44 BH)
2. £267,852k (84 BH)
3. £280,562k (84 HotCat)
4. £206,415k (84 LPSteam)
Bus Case 1. Do Nothing
Bus Case 2. Business as usual
Bus Case 3. HotCat
Bus Case 4. LP Steam
Cumulative whole life carbon emissions at year 40:
1. 973,689 tCO2e (40 WBH,44 BH)
2. 512,906 tCO2e (84 BH)
3. 588,832 tCO2e (84 HotCat)
4. 438,981 tCO2e (84 LPSteam)
£450,000,000
£400,000,000
£350,000,000
£300,000,000
£250,000,000
£200,000,000
£150,000,000
£100,000,000
£50,000,000
£0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Year


NGN Asset Base. Whole Life Costs and Emissions (84xLARGE systems)
Cumulative whole life costs at year 40:
1. £913,522k (40 WBH,44 BH)
2. £552,481k (84 BH)
3. £610,074k (84 HotCat)
4. £440,605k (84 LPSteam)
Bus Case 1. Do Nothing
Bus Case 2. Business as usual
Bus Case 3. HotCat
Bus Case 4. LP Steam
Cumulative whole life carbon emissions at year 40:
1. 2,332,791 tCO2e (40 WBH,44 BH)
2. 1,223,218 tCO2e (84 BH)
3. 1,405,440 tCO2e (84 HotCat)
4. 1,052,145 tCO2e (84 LPSteam)
£1,000,000,000
£900,000,000
£800,000,000
£700,000,000
£600,000,000
£500,000,000
£400,000,000
£300,000,000
£200,000,000
£100,000,000
£0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Year


GB Asset Base. Whole Life Costs and Emissions (800xSMALL systems)
£1,400,000,000
£1,200,000,000
£1,000,000,000
£800,000,000
£600,000,000
£400,000,000
£200,000,000
£0
Cumulative whole life costs at year 40:
1. £1,206,208k (600 WBH,200 BH)
2. £1,049,994k (800 BH)
3. £ 862,356k (800 HotCat)
4. £ 522,701k (800 LPSteam)
Bus Case 1. Do Nothing
Bus Case 2. Business as usual
Bus Case 3. HotCat
Bus Case 4. LP Steam
Cumulative whole life carbon emissions at year 40:
1. 2,396,245 tCO2e (600 WBH, 200 BH)
2. 1,124,691 tCO2e (800 BH)
3. 1,269,312 tCO2e (800 HotCat)
4. 863,014 tCO2e (800 LPSteam)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Year

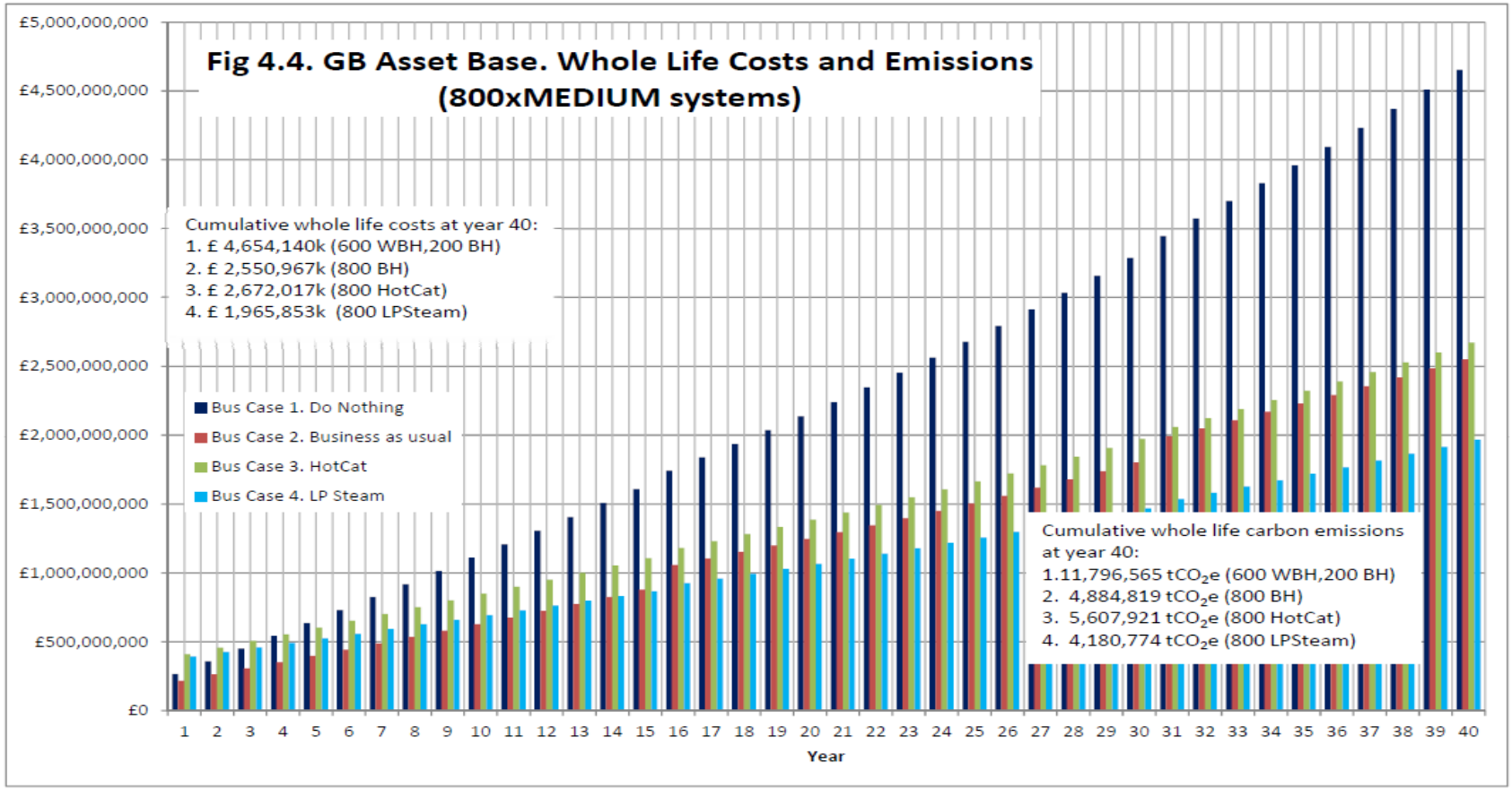
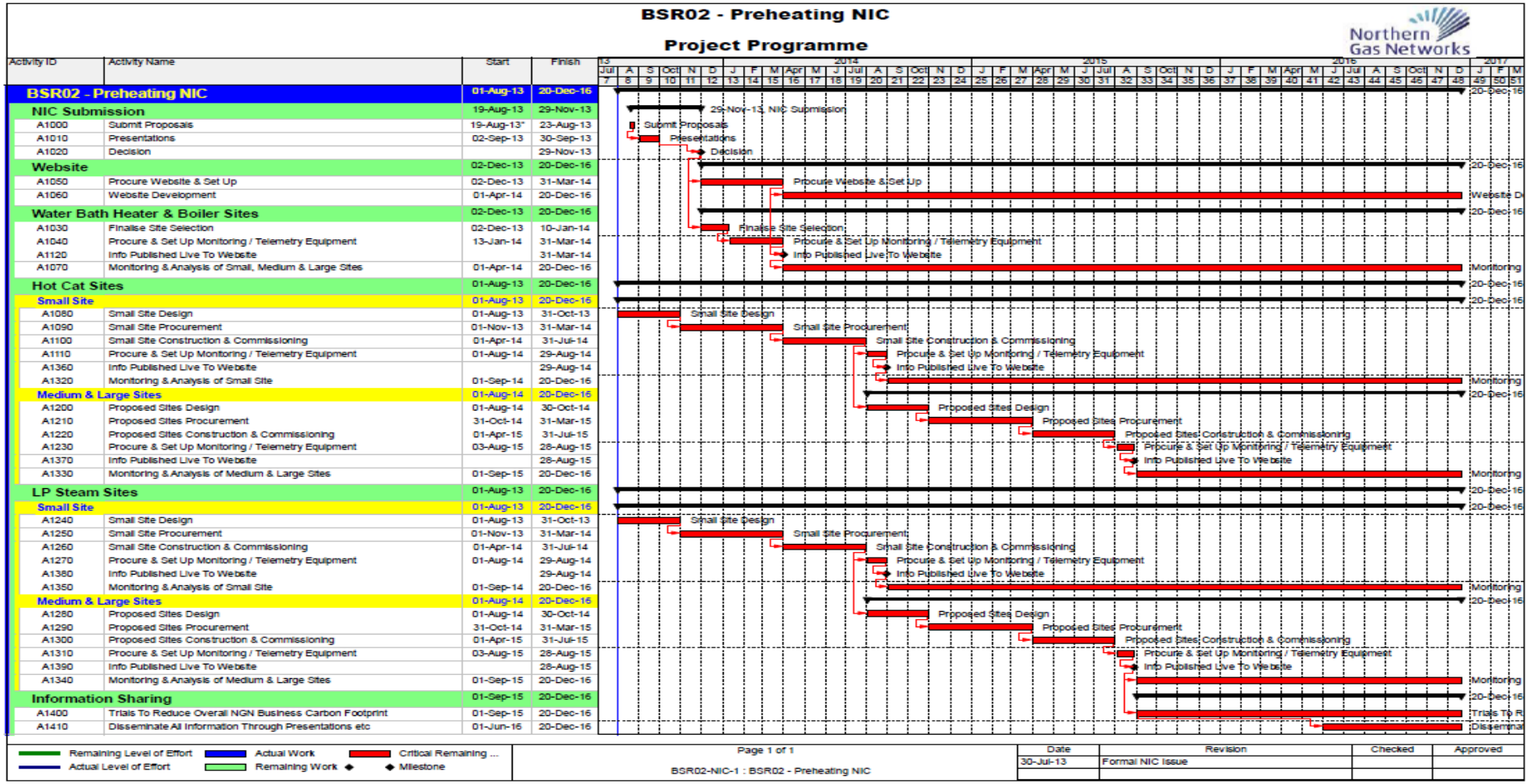


Fig 4.4. GB Asset Base. Whole Life Costs and Emissions (800xMEDIUM systems)
Cumulative whole life costs at year 40:
1. £ 4,654,140k (600 WBH,200 BH)
2. £ 2,550,967k (800 BH)
3. £ 2,672,017k (800 HotCat)
4. £ 1,965,853k (800 LPSteam)
Bus Case 1. Do Nothing
Bus Case 2. Business as usual
Bus Case 3. HotCat
Bus Case 4. LP Steam
Cumulative whole life carbon emissions at year 40:
1.11,796,565 tCO2e (600 WBH,200 BH)
2. 4,884,819 tCO2e (800 BH)
3. 5,607,921 tCO2e (800 HotCat)
4. 4,180,774 tCO2e (800 LPSteam)
£5,000,000,000
£4,500,000,000
£4,000,000,000
£3,500,000,000
£3,000,000,000
£2,500,000,000
£2,000,000,000
£1,500,000,000
£1,000,000,000
£500,000,000
£0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
Year

Gas Network Innovation Competition Full Submission Pro-forma

Appendix G: Project Plan



Gas Network Innovation Competition Full Submission Pro-forma

Appendix H: EXP 01 – Expenditure Approval form

Northern Gas Networks	Exp-1 Expenditure Approval		Confidential Issue 1 : 26/11/12
Business Strategy Record	NIC 2013 Submission	**Project Name**	Low Carbon Gas Preheating
Approval required	ISG		
Project Driver	This project will form NGN's Network Innovation Competition (NIC) 2013 submission. GDNs preheating requirement is currently delivered using aging Water Bath Heaters (WBH) or more modern Boiler Package technologies (BH). However, there are several key issues that GDNs currently face when appraising investment options for preheating technology. Firstly, the whole life costs and in particular the carbon impact of currently available technologies is not understood. Secondly, there has been limited research or development in this area resulting in no financially viable alternative to existing technologies. And finally, the current shrinkage arrangements provide no incentive to target reductions in BCF associated with preheating. For more information see the full NIC submission.		
Deliverables	The Low Carbon Gas Preheating (LCGP) project will address these three issues directly. The project will install two alternative preheating technologies across six NGN sites of differing scale - three Thermo Catalytic Systems (HotCat) and three Low Pressure Steam Systems (LP Steam). Smart metering technology will be installed on each of the six sites to provide data required to calculate and publish the system efficiency of each site and each technology. Additionally, smart metering technology will be installed separately on six sites that employ existing technologies. System efficiencies will be calculated and published for direct comparison.		
Project Manager	**Adam Sadler**	**Delivery Partner**	Pro Heat / Bruest and NGN's Design and Delivery framework contractors.

[redacted]