ENERGY STATEMENT

Mixed-Use Development

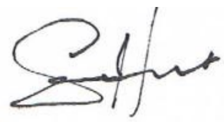
Carrow Works

NORWICH

Prepared for:
Constructive PM

Date:
July 2022

Project Issue Number:
SOL_22_S008_CPM

VERSION CONTROL RECORD			
Contract/Proposal Number:		SOL_22_S008_CPM	
Authors Name:		S. Hunt	
Authorisation Signature:			
Issue	Description of Status	Date	Reviewer Initials
1	For Review	8th July 2022	CM

CONTENTS

EXECUTIVE SUMMARY

This Statement has been compiled in order to provide an Energy Strategy in support of the hybrid planning application redevelopment of the existing Carrow Works site in Norwich.

It has been compiled by Sol Environment Ltd on behalf of Constructive PM ('*the applicant*'). The statement has been formulated to confirm compliance with the Greater Norwich Local Plan (Regulation 19 Publication 2021) and the Joint Core Strategy for Broadland, Norwich and South Norfolk (Adopted March 2011, amendments adopted January 2014).

The energy assessment and subsequent energy strategy has been prepared such that it is aligned with the Energy Hierarchy (see Section 2.1), with focus on sustainable building design (reduction of energy consumption at source) and provision of energy efficiency measures; and to also assess the viability of including building integrated LZC technologies.

To meet current policy requirements, the following strategies are proposed:

Detailed Application: For the refurbished dwellings located in the listed buildings it is proposed that new building fabric will meet the Future Homes Standard as a minimum and within the constraints of the heritage listing existing fabric will be enhanced where feasible. Heating systems will consist of high efficiency gas fired boilers.

Outline Application: The energy strategy for the refurbished and new dwellings and commercial/industrial units included in outline will be based on a fabric first approach utilising passive design measures, well insulated and airtight building fabric (Future Homes Standard as a minimum) and electrically sources heating systems such as air sourced heat pumps.

To achieve the 10% required through low carbon or renewable technologies this will be achieved through a site wide approach utilising measures such as PV, solar thermal and heat pumps.

Specific detail relating to the predicted reductions in annual CO_2 emissions for the dwellings, are detailed within the table below.

Carrow Works: Energy Strategy Summary			
Scenario	Detail Application	Outline Application	Total
Baseline Scenario (Part L 2013) – Regulated CO2 Emissions (kgCO2 / year)	76,620	3,419,553	3,496,173

Scenario without LZC – Regulated CO2 Emissions (kgCO2 / year)	68,867	2,397,093	2,465,960
Proposed Scenario with LZC – Regulated CO2 Emissions (kgCO2 / year)	**68,867**	**2,150,521**	**2,219,388**
Total Saving compared to Baseline Scenario (kgCO2 / year)	7,753	1,269,031	1,276,785 (36.5%)
Total Saving through LZC (kgCO2 / year)	0	246,572	246,571 (10%)
GNLP Policy 2 compliant (Total Saving compared to Part L 2013 >19%)			YES
JCS Policy 3 compliant (Total Saving through LZC >10%)			YES
Part L 2021 compliant (Total Saving compared to Part L 2013 >31%)			YES

The above results conclude that the development achieves a >19% reduction in carbon emissions compared to Part L 2013 through the implementation of the Energy Hierarchy and a >10% reduction through the use of low or zero carbon technologies in accordance with current local planning policy.

The above also concludes that the development should meet the minimum energy performance required by the current building regulations (Part L 2021) by achieving a >31% reduction compared to Part L 2013.

A graphical representation of the cumulative reduction in carbon emissions through implementation of the energy strategy is provided below.

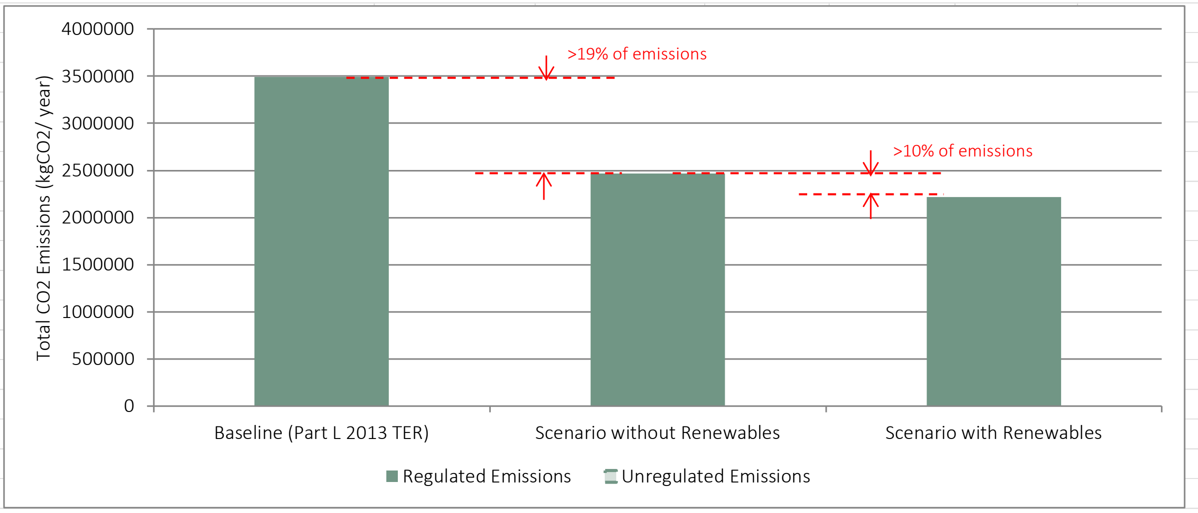


Figure E1: Implementation of the Energy Hierarchy at the Carrow Works, Norwich development.

1. INTRODUCTION

1.1 Background

Sol Environment Ltd ('Sol' hereafter) were engaged by Barratt Homes *('the applicant'* hereafter) to undertake an energy assessment and produce an energy statement in support of the hybrid planning application for the redevelopment of the Carrow Works site in Norwich.

1.2 Proposed Development

The development has the following project description.

A Hybrid planning application (part full, part outline), alongside Listed Building Consent and Demolition within a Conservation Area for the following:

Detailed (Full) Component:

"Full application comprising the construction of the principal means of access, the primary internal road and associated public spaces and public realm, including restoration and change of use of Carrow Abbey to former use as residential (Use Class C3), alteration and extension and conversion to residential use (Use Class C3) of the Lodge, Garage and Gardener's Cottage and the Stable Cottages, development of the former Abbey Dining Room for residential use (Use Class C3), adaptation and conversion for flexible uses (Class E and/or and/or C2 and/or and/C1 and/or C3 and/or F1 and/or F2 and/or B2 and/or B8 and/or Sui Generis) for buildings 207, 92, 206, 7 (7a, 8 and 8a), 209, 35, the Chimney and Class E and/or B2 and/or B8 for the retained Workshop (Block 258), enhanced access to Carrow Abbey and Scheduled Ancient Monument and associated ancillary works".

Outline Component:

"Demolition of existing buildings and replacement with phased residential-led (Use Class C3 and/or Class E and/or F1 and/or F2 and/or C1 and/or C2 and/or B2 and/or B8 and/or Sui Generis), landscaping, open space, new and modified access, car parking and ancillary works."

A schedule of the overall site use relevant to this report is provided in Table 1.1 below.

Table 1.1: Masterplan Site Schedule	
Phase	No. of Dwellings / Units
Detailed Application	
- Refurbished Dwellings in Lodge	3
- Refurbished Dwellings in Abbey	3
Total Detailed Application (Residential)	6

Outline Application	
- New Flats (1 & 2 Bed)	1,339
- New Houses (2, 3, 4 & 5 Bed)	386
- Refurbished Flats	125
Total Outline Application (Residential)	**1,850**
Commercial (new)	7,184m^2
Commercial (refurb)	16,443m^2
Industrial (new)	1,821m^2
Industrial (refurb)	1,182m^2
Total Outline Application (Non-Residential)	**26,630 m^2**

A site illustrative masterplan prepared by JTP Architects showing the proposed development is provided below.

Fig 1.1: Proposed Illustrative Masterplan of the Carrow Works development prepared by JTP Architects.

1.3 Relevant Policy

This report has been prepared by Sol Environment Ltd in cooperation with the applicant and in accordance with the following policies relevant to this report.

Greater Norwich Local Plan (Regulation 19 Publication 2021)

- Policy 2: Sustainable Communities
  10. Minimise energy demand through the design and orientation of development and maximise the use of sustainable energy, local energy networks and battery storage to assist growth delivery. This will include:
    - All new development will provide a 19% reduction against Part L of the 2013 Building Regulations (amended 2016);
    - Appropriate non-housing development of 500 square metres or above will meet the BREEAM "Very Good" energy efficiency standard, or any equivalent successor;

  except where a lower provision is justified because the requirement would make the development unviable.

Joint Core Strategy for Broadland, Norwich and South Norfolk (Adopted March 2011, amendments adopted January 2014)

- Policy 3: Energy and water

  <u>Energy</u>

  Development in the area will, where possible, aim to minimise reliance on non-renewable high-carbon energy sources and maximise the use of decentralised and renewable or low-carbon energy sources and sustainable construction technologies. To help achieve this:
    - all development proposals of a minimum of 10 dwellings or 1,000m2 of non-residential floorspace will be required (a) to include sources of 'decentralised and renewable or low-carbon energy' (as defined in the glossary) providing at least 10% of the scheme's expected energy requirements and (b) to demonstrate through the Design and Access Statement for the scheme whether or not there is viable and practicable scope for exceeding that minimum percentage provision
    - in addition to the above requirement, detailed proposals for major developments (minimum of 500 dwellings or 50,000m2 of non-residential floorspace) will be required to demonstrate through the Design and Access Statement that the scheme has seized opportunities to make the most of any available local economies of scale to maximise provision of energy from sources of 'decentralised and renewable or low carbon energy sources'
    - all development proposals of a minimum of 10 dwellings or 1,000m2 of non-residential floorspace will be required to demonstrate, through the Design and Access Statement, that all viable and practicable steps have been taken to maximise opportunities for sustainable construction

The National Planning Policy Framework

The National Planning Policy Framework ('NPPF') was published in July 2021, replacing the previous NPPF that was adopted in February 2019. The revised NPPF sets out the Government's planning policies for England and how they are expected to be applied. It sets out a framework that aims to achieve sustainable development throughout the planning system with three overarching objectives – economic, social and environmental.

At the heart of the NPPF is a 'presumption in favour of sustainable development', which requires Local Authorities as part of any plan-making or decision-making, to provide clear guidance on how the presumption should be applied locally.

The NPPF sets out how to deliver sustainable development under 17 subheadings. Subheading 14 of the NPPF outlines how the planning system should support the transition to a low carbon future in a changing climate, taking full account of flood risk and coastal change. It should help to: shape places in ways that contribute to radical reductions in greenhouse gas emissions, minimise vulnerability and improve resilience; encourage the reuse of existing resources, including the conversion of existing buildings; and support renewable and low carbon energy and associated infrastructure.

Building Regulations Part L 2021

The current Building Regulations (2021) document published by the Government in January 2021 and adopted in June 2022. Within this document were the interim Part L regulations as a step towards the aim to deliver Zero Carbon ready homes by 2025.

At the time of preparation of this report the current Part L 2021 documents have only just come into force (June 2022). As such modelling software has not yet been issued to allow accurate energy modelling to be undertaken. The government confirmed that the energy performance for Part L 2021 is expected that all new development will be required to produce 31% less carbon emissions for domestic and 27% less carbon emissions for non-domestic than is acceptable by the Part L 2013 minimum standards. Therefore, for the sake of this report a 31% target over and above the minimum required by Part L 2013 has been established as the equivalent of meeting Part L 2021. It is recommended that further calculations are conducted once the modelling software is published to provide more accurate energy performance data for the development.

1.4 Policy Review

This **Energy Statement** has been prepared for the development to show how the proposed will mee the following policy requirements

In accordance with the current JCS **Policy 3**, the following targets must be met:

- decentralised and renewable or low-carbon energy is required to generate 10% of the scheme's expected energy requirements.

In accordance with the emerging GNLP **Policy 2**, the following targets must be met:

- For energy consumption, All new development will provide a 19% reduction against Part L of the 2013 Building Regulations (amended 2016).

2. ENERGY ASSESSMENT

This section comprises the Energy Assessment for the proposed development, in accordance with the Greater Norwich Local Plan and Joint Core Strategy.

The proposed energy strategy is aligned with the Energy Hierarchy (below) with focus on sustainable building design (reduction of energy consumption at source) and provision of energy efficiency measures, including utilising passive design measures, well insulated and airtight building fabric, and a high efficiency gas fuelled heating system.

2.1 The Energy Hierarchy

The Energy Hierarchy adopts a set of principles to guide design development and decisions regarding energy, balanced with the need to optimise environmental and economic benefits. The Hierarchy, which is a widely accepted approach amongst many Councils, seeks to ensure that developments meet the Council's objectives of incorporating energy efficiency through the approach detailed in Figure 2.1.

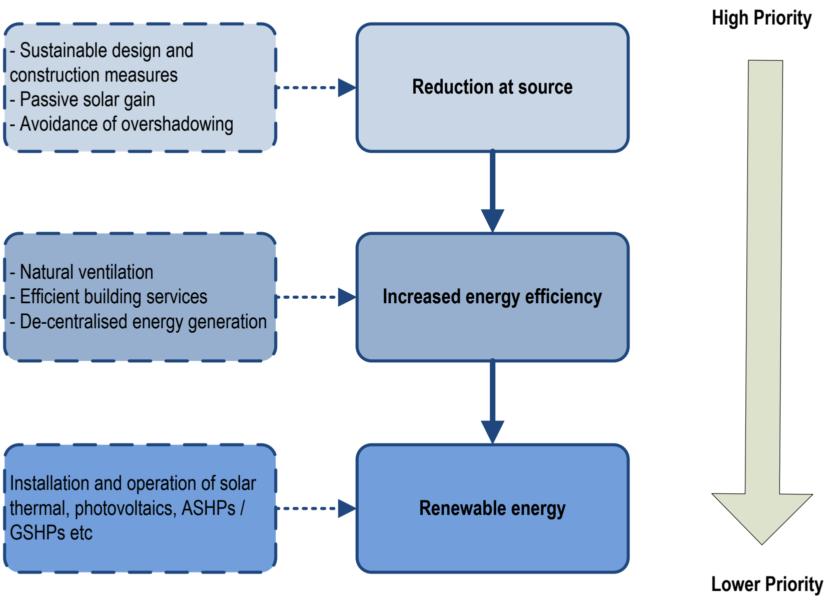


Figure 2.1: The Energy Hierarchy

It is considered that the above principles for carbon reduction form the most appropriate approach from both a practical and financial perspective. The industry is broadly in agreement that energy efficiency and low carbon technologies have the greatest impact in offsetting CO_2 emissions. Therefore, it is logical to encourage enhanced mitigation through energy efficiency and low carbon technologies in the first instance, with the application of renewable energy technologies as a secondary measure to reduce the primary energy requirements of a building.

Consequently, as a result of the above principles, the first stage in the energy strategy for the proposed development is the consideration of energy efficiency measures to ensure that the baseline energy demand is minimised.

2.2 Site Layout and Building Design

2.2.1 Overview

It is stated within the Part L of the 2021 Building Regulations that *'measures to make the building energy efficient must be incorporated within the scheme design.'*

Typically, passive energy efficient design measures can bring about a significant improvement upon the energy performance of new built projects, as a result of energy efficiency measures alone.

2.2.2 Passive Solar Design

Passive design measures manage internal heating through solar gain and as such reduce the need for cooling. Buildings that are aligned in a north-south orientation are observed to maximise daylight and sunlight (i.e. solar gain), subsequently reducing energy consumption associated with excessive heating and lighting requirements.

It is recommended that glazing rates be specified to ensure that high levels of natural light and solar gain are afforded by the use of larger windows to be located on the east-, south- and westerly building aspects. The detail design team should further optimise solar gain through the consideration of the solar orientation of internal facilities. The majority of unoccupied building service areas and stairwells should be incorporated, wherever possible, into the areas which are not served by high levels of natural light.

The site has been designed in consideration of the parameters detailed within Table 2.1 and performance has been maximised in the absence of any constraints. Specific objectives related to overshadowing are referenced in Box 2.1 below.

Box 2.1: *Minimising Overshadowing*
1 – The proposed accommodation rates (number of dwellings per hectare) allow for all dwellings on-site to have the opportunity to be designed and laid out such that potential overshadowing issues are alleviated, through low building heights and the separating distance between them. It is recommended that detailed sun light calculations are undertaken at the reserved matted application stage.

2 – Where no restrictions apply due to the masterplan site layout, service and auxiliary areas (ie those that do not require heating) shall be located to the north of the building, therefore maximising the utilisation of solar gain for living spaces and subsequently lower residual energy consumption.

The internal aspects of the development shall be designed (wherever possible) to further maximise the benefits provided by solar orientation. Subsequently, it is recommended that the building shall be constructed to specified design briefs and the principles detailed in Box 2.2 below.

Box 2.2: *Building Design Principles*

1 – Where orientation provides favourable conditions and no physical restrictions are provided by surrounding buildings, the glazing ratios within the development shall be designed such that potential for solar gain is maximised.

2 – Consideration will be given to the design of the internal envelopes of the proposed development, which will seek to utilise materials that not only provide high insulation values, but also have a high thermal mass.

3 – Accredited Construction Details will be used and to achieve a ***maximum Y-value of 0.05 W/m^{2}K*** *limiting thermal bridging.*

4 – Consideration will be given to the selection of insulation materials for the building, ensuring the following heat loss parameters (U-Values) as a minimum:

Component	*Limiting U-Value (Part L 2021)*	*U Value*
External Walls	0.26	0.21
Roof	0.16	0.11
Floor	0.18	0.15
Doors	1.6	1.2
Windows	1.6	1.2
Rooflights	2.2	2.2

5 – The dwellings shall not exceed a ***maximum air permeability of*** 5.01 ***m^3 / (hr.m^2).*** *This shall be achieved through the following measures;*

- *Adequate sealing between openings / windows and panels;*
- *Adequate sealing of ceiling-to-wall joints;*

- *Provision of a continuous air barrier over ceiling areas and adequate sealing of service ducts (where appropriate);*
- *High specification openings (see Objective B4);*
- *Brick / block construction will be mitigated against through application of wet plastering / parging / dry lining.*

Consideration has also been given to minimising excessive solar gain and subsequent building overheating, thus avoiding excessive use of mechanical cooling systems in the summer months. Mechanical (forced draught) ventilation systems can account for a significant percentage of building energy use due mainly to the forced draught and fan plant required to maintain sufficient through-flow of internal air.

Mechanical ventilation will only be provided in the areas of the buildings where it is required to meet building regulations requirements.

Box 2.4: *Limiting Excessive Solar Gain*

1 – In order to limit the requirement for excessive mechanical cooling, cross or stack-ventilation shall be provided where possible and practicable, in the form of secure openable windows and trickle vents, such that night cooling can be encouraged without compromising building security.

2 – Natural ventilation shall be utilised within all buildings on-site (unless specific conditions require the use of mechanical ventilation such as wet rooms / trickle vents etc).

3 – Where the external envelope has large glazed areas, the windows shall be inset from the main external building facade (wherever possible) or fitted with low emissivity coatings such that potential overheating is minimised.

2.2.3 Energy Efficiency Measures

In addition to regulated emissions (heating, cooling and ventilation), energy consumed by ancillary activities (primarily electricity consumption derived from the use of lighting and electrical appliances) is anticipated to account for approximately 30-40% of the overall CO_2 emissions from the development.

It is recommended that the following energy efficiency measures shall be installed such that unnecessary energy consumption is reduced at source (in accordance with the Energy Hierarchy).

Box 2.5: *Energy Efficiency Measures*
1 *– All fixed lighting will comprise dedicated low energy fittings (i.e. those which are only capable of accepting low energy lamps with a luminous efficacy of ≥60 lumens-per-circuit Watt).* ***2*** *– The building shall be fitted with AMR energy display devices for the provision of half hourly energy consumption data.* ***3*** *– All occupants shall be provided with a 'Home User Guide', which shall provide information on energy systems within the building and details on best practice and energy saving techniques.* ***4*** *–Electric vehicle charging points will be provided.*

2.3 Energy Modelling

2.3.1 Overview

To meet the requirements of current national and local policy, an assessment of the carbon dioxide emissions has been prepared for the development, this will demonstrate the expected carbon dioxide emission savings from low carbon and renewable energy measures incorporated in the development.

The following appraisal reviews the carbon reduction opportunities with a particular focus on meeting the prevailing energy efficiency standards through the implementation of the energy hierarchy, and if required, which on-site LZC technologies will be most suitable to secure a reduction in CO_2 emissions and for this development.

In order to assess opportunities and show required percentage reduction in energy use and CO_2 emissions, the applicant has commissioned a high-level feasibility study to ascertain the predicted energy consumption (and associated carbon dioxide emissions) for the site and select appropriate LZC technologies.

2.3.2 Energy Assessment

In order to determine the energy performance of the development and establish the feasibility of LZC technologies, a detailed baseline modelling and assessment exercise was undertaken.

Proprietary energy demand calculations for the proposed development have been undertaken using SAP/SBEM modelling software.

In accordance with Part L of the current Building Regulations, the performance of the building fabric and services must not exceed the ‘limiting factors’. To achieve the required Part L compliance dwellings fabric u-vales and services efficiencies are significantly better than the Part L limiting factors (as can be seen in Columns 2, 3 and 4 in Table 2.1), and the passive design and energy efficiency measures nominated in Section 2.2 of this report have been implemented. The specifications included within this report are recommendations only and once detailed design is completed it is recommended that detailed modelling is undertaken.

Implementing the following specification details into the energy model, initial energy demand calculations for the buildings have been undertaken; these provide a ‘*baseline’* scenario from which further calculations can be progressed to establish the proposed renewable energy systems.

Indicative SAP and SBEM modelling has been undertaken for each dwelling/unit type.

Table 2.1 below provides a summary of the various modelled scenarios.

Table 2.1: Summary of SAP Modelled Scenarios

Parameter		Scenarios		
		Baseline Part L compliant TER (with limiting factors)	Scenario without LZC	Proposed Scenario
BER/TER (kgCO$_2$/m^2/year)		*14.87 – 35.3 Ave. – 22.54*	*10.26 – 25.77 Ave. – 15.90*	*9.23 – 22.93 Ave. – 14.31*
U-Values (W/m^2.K)	Walls	*0.26*	0.21	0.21
	Roofs	*0.16*	0.11	0.11
	Floors	*0.18*	0.15	0.15
	Doors	*1.6*	1.2	1.2
	Windows	*1.6*	1.2	1.2
Y-Values		0.15	0.05	0.05
Air permeability (m^3/(hr.m^2) @ 50 Pa)		8.0	5.0	5.0
Heating / Domestic Hot Water (DHW)	Type	Notional Gas Boiler	High efficiency gas boiler (Heritage Buildings); Heat pumps (the rest)	High efficiency gas boiler (Heritage Buildings); Heat pumps (the rest)
	Efficiency	85%	>91% (Gas) >300% (ASHPs)	>91% (gas) >300% (ASHPs)
	Fuel	Gas	Gas / Elec	Gas / Elec
	Controls	Room thermostats; programmer	Room thermostats; programmer; TRVs	Room thermostats; programmer; TRVs
	DHW	From Main Heating System	From Main Heating System	From Main Heating System
Cooling		-	ASHPs (non-resi only)	ASHPs (non-resi only)
Internal Lighting		-	100% non-dedicated low energy	100% non-dedicated low energy
Electricity		-	Grid Supplied	Grid Supplied
LZC Technology		-	-	PV to help achieve 10% reduction

2.3.3 Energy Strategy Summary

Table 2.2 below provides a tabular summary of the energy performance of the different scenarios detailed in Table 2.1, detailing a reduction in CO_2 emissions.

Table 2.2: Energy Strategy Summary			
Scenario	Detail Application	Outline Application	Total
Baseline Scenario (Part L 2013) – Regulated CO2 Emissions (kgCO2 / year)	76,620	3,419,553	3,496,173
Scenario without LZC – Regulated CO2 Emissions (kgCO2 / year)	68,867	2,397,093	2,465,960
Proposed Scenario with LZC – Regulated CO2 Emissions (kgCO2 / year)	**68,867**	**2,150,521**	**2,219,388**
Total Saving compared to Baseline Scenario (kgCO2 / year)	7,753	1,269,031	1,276,785 (36.5%)
Total Saving through LZC (kgCO2 / year)	0	246,572	246,571 (10%)
GNLP Policy 2 compliant (Total Saving compared to Part L 2013 >19%)			**YES**
JCS Policy 3 compliant (Total Saving through LZC >10%)			**YES**
Part L 2021 compliant (Total Saving compared to Part L 2013 >31%)			**YES**

The above results conclude that the development achieves a >19% reduction in carbon emissions compared to Part L 2013 through the implementation of the Energy Hierarchy and a >10% reduction through the use of low or zero carbon technologies in accordance with current local planning policy.

The above also concludes that the development should meet the minimum energy performance required by the current building regulations (Part L 2021) by achieving a >31% reduction compared to Part L 2013.

A graphical representation of the cumulative reduction in carbon emissions through implementation of the energy strategy is provided below.

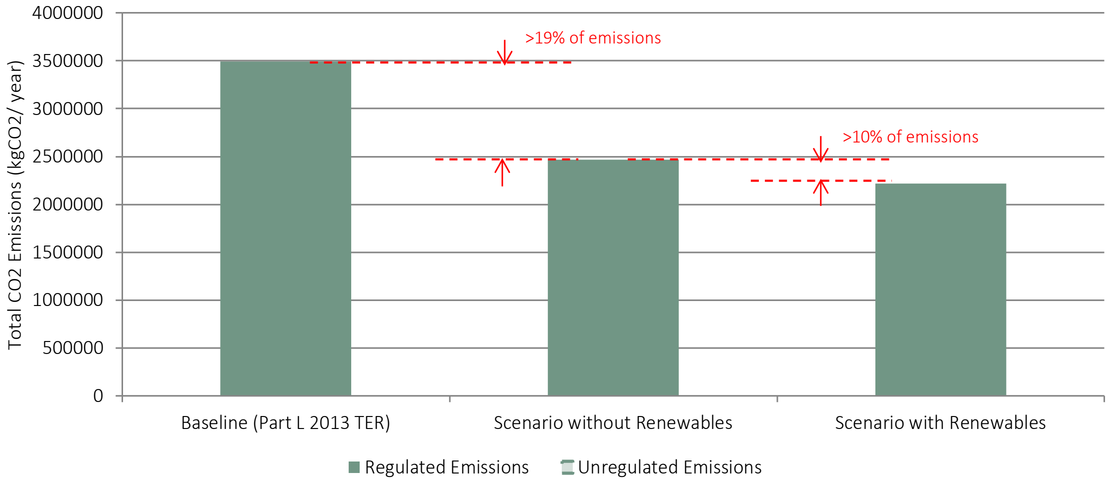


Figure 2.2: Implementation of the Energy Hierarchy at the Carrow Works, Norwich development.

2.4 Low-Zero Carbon Technologies Feasibility Review

Combined Heat & Power and District Heating

CHP comprises combination of the generation of electricity for general consumption, with the recovery of exhausted heat energy (otherwise emitted from power stations / generators as waste heat) which can be used to provide heating for domestic and industrial processes.

Although not considered a renewable source (excepting biofuel-fired plants), CHP plants (typically 75% - 80% efficient) are significantly more efficient than a typical oil / gas fired power station (35% - 45% efficient), even when it is used in combination with fossil fuels such as gas and diesel. Therefore, they are viewed as being more efficient than obtaining energy from the National Grid ('the grid').

In addition, transmission losses (typically 5% when consuming electricity from the grid) are minimised by on-site generation and, as such, a gas-fired CHP can be seen as a relatively carbon efficient means of energy supply.

Box 2.6: Feasibility Summary – CHP
The installation of a CHP system was considered but has been discounted on the basis that the inconsistent load requirements of the development are not suited to a CHP plant. District heating was also considered, but due to the relatively low density of the development, rural location and the lack of an existing district heat network in the vicinity it was discounted as a viable option. There are no existing or planned decentralised heat networks within the vicinity of the proposed site.

Solar Thermal Heating / Hot Water

Solar thermal panels are typically used in order to provide supplementary heat for the purposes of space heating or domestic hot water (DHW).

These systems consist of solar collectors, a pump, a control unit, connecting pipes, hot water tank and a conventional heat source (gas / oil fired boiler). The collectors are usually mounted on the roof and provide heat to a fluid circulated between the collectors and a water tank. The efficiency of solar collector panels depends on a number of factors, including the type of collector, correct installation, location and orientation.

Installing solar thermal heating panels could reduce energy consumption and carbon impacts through significant reductions in electric water heating and typically produce approximately 5-600 kWh/m² of hot water.

Although evacuated tube systems are about 30% more efficient, they have a corresponding increased capital outlay. A collector area of 4–5 m^2 will normally save approximately 230kg of CO_2 emissions per year. A well-designed system should satisfy 70-80% of the hot water demand in the summer and 20-30% in the winter.

Box 2.7: Feasibility Summary – Solar Thermal
Based on the orientation of the buildings and the available roof space DHW heating via installation of solar thermal was considered a viable option. It is recommended that solar thermal panels are considered during the next stage of the design as a viable option to heat generate 10% of the development's energy needs (for the elements under outline) as is required by the planning policy. Therefore, a **roof mounted solar thermal panels are considered a preferred option.**

Ground Source Heat Pumps

Ground Source Heat Pumps (GSHPs) operate by the removal of residual heat from the ground by using various 'loops' containing a water and glycol fluid mix, heat from the ground is absorbed into this fluid and is pumped through a heat exchanger in the heat pump. Low grade heat passes through a compressor and is concentrated into a higher temperature gas capable of heating water for DHW and central heating systems.

There are a number of configurations for GSHP systems. A vertical collector system is considered to be the most appropriate in the context of the proposed development given the large scale of the system and limited area available for horizontal collectors. Vertical collectors can be between 15-180m deep and minimum spacing between adjacent boreholes should be maintained at 5-15m to prevent thermal interference.

The heat yielded from GSHPs is relatively small (collecting approximately 14-20W_{th} per metre of collector loop), therefore the adequacy of the accompanying heat exchanger is vital in ensuring greater heat transfer (although more efficient exchangers have a significantly larger capital cost).

The performance of a GSHP system is entirely dependent on the appropriateness of the ground conditions (i.e. depth of soil cover, the type of soil or rock, ground temperature and thermal conductivity), which would be established subject to a ground survey.

'Reversible' heat pumps systems are also available that give the potential for provision of space cooling, if required. Groundwater can also be used to cool buildings where a suitable source exists, abstraction and discharge permissions can be obtained from the Environment Agency and test bores are favourable.

Box 2.8: Feasibility Summary – Ground Source Heat Pumps
Installation of GSHPs for the provision of primary space / DHW heating for the building is not considered feasible due to financial reasons and the large amount of ground works required to install a GSHP system.

Air Source Heat Pumps

Air source heat pumps (ASHPs) absorb heat from ambient air in order to provide heat for the purposes of space heating and domestic hot water. An evaporator coil mounted outside absorbs the heat; a compressor unit then drives refrigerant through the heat pump and compresses it to the right level to suit the heat distribution system.

Finally, a heat exchanger transfers the heat from the refrigerant for use, depending on which of the two main types of systems (identified below) is installed;

- Air to air system - produces warm air which is circulated by fans to heat a home; and
- Air to water system - uses heat to warm water. Heat pumps heat water to a lower temperature than a standard boiler system; therefore, these systems are more suitable for underfloor heating systems than radiator systems, requiring less space to incorporate, compared with an air to air system.

The efficiency of ASHPs is measured by a coefficient of performance (CoP) i.e. the amount of heat produced compared to the amount of electricity needed for them to operate.

ASHPs are often a more popular (and technically / financially viable) alternative to GSHPs due to lack of requirement for extensive excavation, requiring far less space and easier installation.

Box 2.9: Feasibility Summary – Air Source Heat Pumps

Installation of ASHPs for the provision of primary space / DHW heating for the building is considered the most viable and efficient option for heating and hot water. It is recommended that ASHPs are considered during the next stage of the design as a viable option to provide heating (and cooling) for the elements of the application currently under outline.

Therefore, **air source heat pumps are considered a preferred option.**

Biomass Heating

Biomass boilers replace conventionally powered boilers with an almost carbon neutral fuel (such as wood pellets). In addition, the installation and operation of a biomass boiler in new-build developments could yield significant revenue from the forthcoming Renewable Heat Incentive, a government funded clean energy cashback scheme.

Although many biomass burners will meet Clean Air Act requirements, combustion of woody biomass releases higher quantities of NOx compared to a comparable system fuelled by natural gas. As a consequence, many Local Authorities, particularly in urban areas have concerns about the potential impact on air quality that the widespread uptake of biomass boilers would have. Therefore, a large number of Councils generally approve of the specification of biomass when linked to a large-scale biomass CHP as opposed to being used for individual boilers.

Box 2.10: Feasibility Summary – Biomass Boilers
The use of an energy centre with a biomass boiler was considered a feasible option but due to the relatively small size of the overall development, the potential air quality issues associated with the combustion of woodchips and limited space for such aspects as the fuel storage hoppers etc. it was discounted as a viable option. In addition to these considerations, biomass boilers are considered more feasible for larger scale developments with a district heat network and those within less urban environments.

Photovoltaic Cells

Solar Photovoltaics (PVs) are solar panels which generate electricity through photon-to-electron energy transfer, which takes place in the dielectric materials that make up the cells.

The cells comprise layers of semi-conducting silicon material which, when illuminated by the sun, produces an electrical field which generates an electrical current.
PVs can generate electricity even on overcast days, requiring daylight, rather than direct sunlight. This makes them viable even in the UK, although peak output is obtained at midday on a sunny summer's day. PVs offer a simple, proven solution to generating renewable electricity.

Box 2.11: Feasibility Summary – Photovoltaic Cells
Given the variety of south sloping roofs within the proposed site and the low-rise nature of the development site, a roof mounted solar PV array across the whole development is considered a beneficial technology for the incorporation of LZC technologies on the site. It is recommended that solar PV panels are considered during the next stage of the design as a viable option to help generate 10% of the development's energy needs as is required by the planning policy. Therefore, a **roof mounted solar PV panels are considered a preferred option.**

Micro Wind Turbines

Large wind turbines are an established means of capturing wind energy and converting it into usable electricity. Wind turbines come in various sizes depending on the location and electrical load of a particular site. A wind turbine usually consists of a nacelle containing a generator connected, sometimes via a gearbox, to a rotor generally consisting of three blades.

Box 2.12: Feasibility Summary – Micro Wind Turbines
Owing to site-constraints, micro-wind turbines have not been considered as part of this feasibility study. Although there is a reasonable wind speeds in this area, averaging < 4.7 ms^{-1} the location is not considered suitable for the installation of a wind turbine. Wind turbines are also likely to have a significant visual impact on local environment, as well as health and safety implications for occupiers or users on-site and on adjacent areas as a result of noise and light flicker associated with the wind turbines. Due to the residential aspects of the location, large-scale wind turbines are also not feasible.

2.5 Energy Strategy Summary

To meet current policy requirements, the following strategies are proposed:

Detailed Application: For the refurbished dwellings located in the listed buildings it is proposed that new building fabric will meet the Future Homes Standard as a minimum and within the constraints of the heritage listing existing fabric will be enhanced where feasible. Heating systems will consist of high efficiency gas fired boilers.

Outline Application: The energy strategy for the refurbished and new dwellings and commercial/industrial units included in outline will be based on a fabric first approach utilising passive design measures, well insulated and airtight building fabric (Future Homes Standard as a minimum) and electrically sources heating systems such as air sourced heat pumps.

To achieve the 10% required through low carbon or renewable technologies this will be achieved through a site wide approach utilising measures such as PV, solar thermal and heat pumps.

The energy strategy results conclude that the development achieves a >19% reduction in carbon emissions compared to Part L 2013 through the implementation of the Energy Hierarchy and a >10% reduction through the use of low or zero carbon technologies in accordance with current local planning policy.

They also concludes that the development should meet the minimum energy performance required by the current building regulations (Part L 2021) by achieving a >31% reduction compared to Part L 2013.