Integration

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12A Church Row
Energy & Sustainability Statement

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Contents

Executive Summary

An Energy and Sustainability Assessment has been carried out in support of the full planning application for the proposed 12A Church Row development, within the London Borough of Camden, which involves the extension of an existing dwelling.

The proposed development has been shown to have a **58% total onsite improvement in carbon dioxide (CO_2) emissions** compared to Part L of the UK Building Regulations 2021. The proposed design achieves this via high-performance building fabric, passive low energy design and low energy building services systems such as mechanical ventilation with heat recovery (MVHR) and LED lighting.

The proposed design elements have been shown to achieve a **renewable energy CO_2 emissions reduction of 57%.** This is achieved through the provision of **100% of space heating and hot water via heat pump** and 2.7kWp roof top solar PV.

The table below shows both the total regulated and unregulated energy use.

Carbon dioxide emissions (Tonnes CO_2 per annum)	Regulated	Unregulated
Baseline: Part L 2021 (Building Regulations) Compliance	9.90	1.2
After “Be Lean” (energy demand reduction)	9.77	1.2
After “Be Clean” (heat network / CHP)	9.77	1.2
After “Be Green” (renewable energy)	4.16	1.2

Table 1: Summary of dwelling carbon emissions

This performance can be expressed as savings between each stage in the energy hierarchy. The reductions are calculated against the previous stage (except the total, which is calculated against the Baseline), in line with Camden’s reporting methodology.

Regulated carbon dioxide savings	(Tonnes CO_2 per annum)	(%)
Savings from "Be Lean" (energy demand reduction)	0.13	1.3
Savings from "Be Clean" (heat network / CHP)	0.00	0.0
Savings from "Be Green" (renewable energy)	5.61	57.4
Total cumulative on-site savings	5.74	58.0

Table 2: Residential regulated CO_2 emissions savings after each stage of the Energy Hierarchy

In addition to the low energy performance set out above, the scheme benefits from several sustainability aspects. These include the use of water saving devices to achieve 105 litre per person per day. Health and wellbeing is supported by aspects such as high levels of fresh air provided by mechanical ventilation with heat recovery. In terms of sustainable travel, the scheme has covered bicycle storage and benefits from easy access to public transportation such as Hampstead Underground Station and Finchley Road & Frognal Overground Station. The scheme is also demand side response (DSR) enabled through the provision of a large centralised electric-powered heat pump system with large energy storage vessels in order to work with National Grid signalling / time of use tariffs. This supports the transition to low carbon electricity while reducing energy costs for residents.

1 Introduction

Integration Consultancy Limited has been appointed to undertake an Energy and Sustainability Assessment in support of the full planning application for the proposed 12A Church Row development within the London Borough of Camden planning authority. The report is one of several that accompany the planning application and should be read in conjunction with these documents.

The importance of developing a robust well-considered energy and sustainability strategy cannot be overstated. This strategy sets out the roadmap for the entire project and ultimately the success of the strategy will translate into the success of the building's performance on practical completion and throughout its lifecycle.

Underpinning the energy strategy is the 'Be Lean', 'Be Clean' and 'Be Green' design framework which has been adopted by the London Plan.

- 'Be Lean' (energy demand minimisation through 'passive' and 'active' design measures)
- 'Be Clean' (efficient energy supply)
- 'Be Green' (renewable energy generation)

This report sets out the scheme's energy and sustainability aspirations and demonstrates, via the approved calculation methodologies, how these will be achieved through the detailed design and construction stages.

As part of this exercise, the feasibility of implementing a variety of low carbon technologies and renewable energy systems is considered based on aspects such as site location and climate, potential carbon savings, economic viability, environmental impacts and practical aspects such as integration and maintenance considerations.

1.1 THE DEVELOPMENT SITE

The site is located at 12A Church Row, London, NW3 6UU.

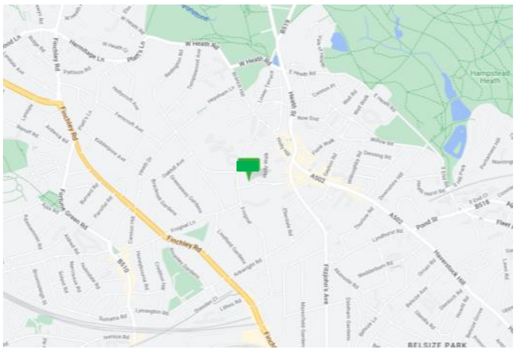

Figure 1: Site Location

Figure 2: Aerial view of site

1.2 PROPOSED DEVELOPMENT OVERVIEW

The project comprises the extension of an existing 2-storey (plus loft space) dwelling into a 4-storey dwelling.

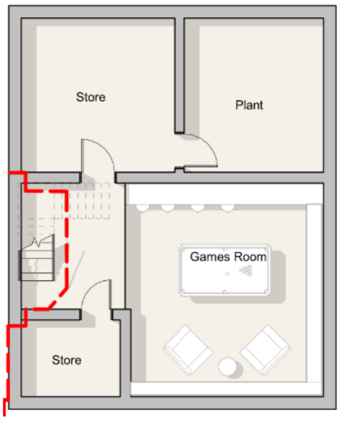

Figure 3: Proposed basement floor plan

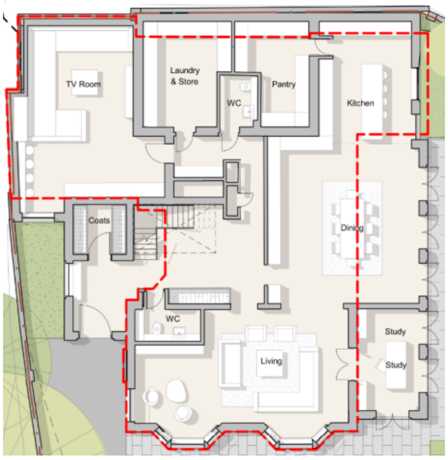

Figure 4: Proposed ground floor plan

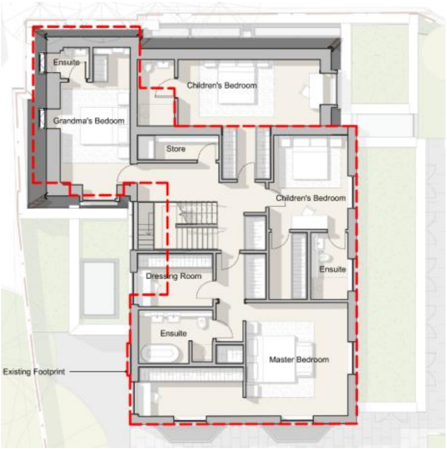

Figure 5: Proposed first floor plan

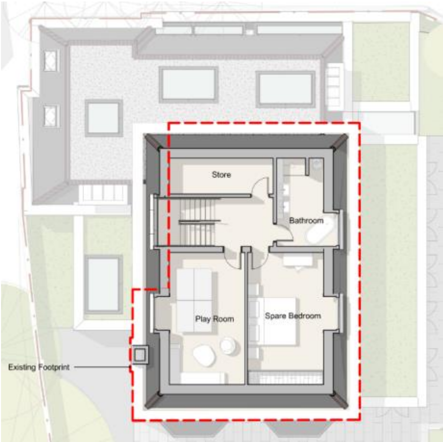

Figure 6: Proposed second floor plan

Figure 7: Proposed roof plan

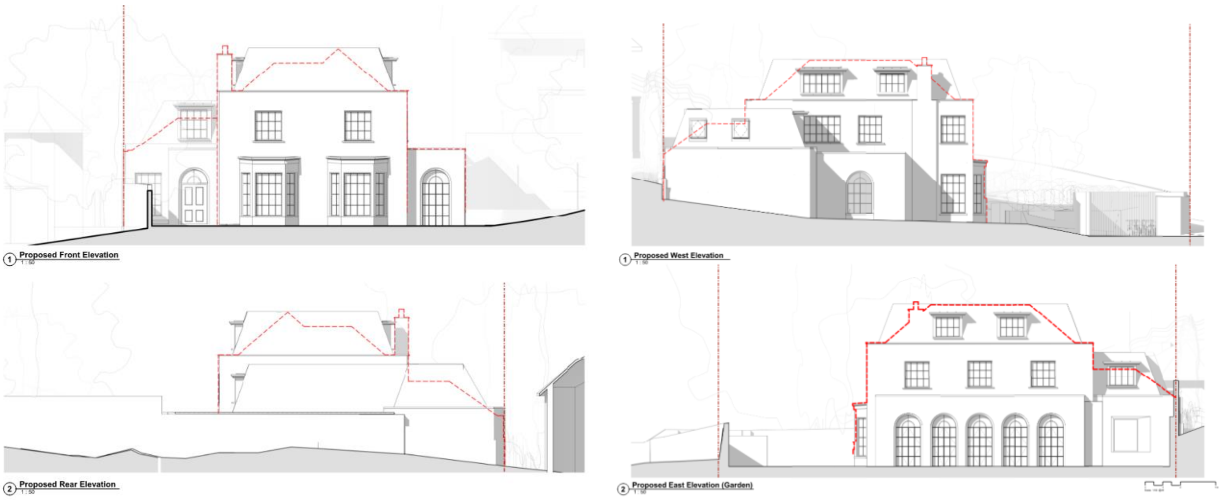

Figure 8: Proposed elevations (top left – south, bottom left – north, top right – west, bottom right – east)

The proposed accommodation is summarised below.

Level	Area (m^2)
Basement	90
Ground	255
1st Floor	158
2nd floor	70

Table 3: Accommodation summary

1.3 ENERGY AND SUSTAINABILITY ASPIRATIONS

The scheme has adopted energy and sustainability targets including:

Zero Fossil Fuels on site: In order to achieve zero carbon on-site by 2050, the scheme aims not to use any fossil fuels on site.

Low CO_2 emissions: Achieve a minimum on-site carbon reduction contribution as close to 100% below Part L as possible.

Flexible Energy use: The scheme aims to be able to use low-to-zero carbon electricity available at off peak periods, to charge thermal stores for space heating and hot water.

Low Water Use: The development aims to meet the London Plan target of achieving at least 105l/p/d.

Sustainable Transport: Promoting public transport and cycle use.

2 Design Approach - Sustainability

2.1 WATER USE

The development adopts equipment specification in line with the higher water use standard of 105 l/p/day.

Fitting	Water Consumption
WC	4 / 2.6 litres dual flush
Shower	8 litres / minute
Washbasin	5 litres / minute
Kitchen sink	6 litres / minute
Dishwasher	1.25 litres/place setting
Washing machine	8.17 litres/kg

Table 4: Minimum water fitting standards for units.

2.2 AIR QUALITY

The scheme supports air quality by:

- The use of heat pumps for all space heating and hot water use which means no fossil fuel combustion on site.
- Mechanical ventilation with heat recovery (MVHR) offers a means for occupants to filter fresh air.
- Construction environmental management plan (CEMP) to incorporate best practice for air quality and dust control.

2.3 NOISE

Quality of life is improved by reducing the number of people adversely affected by noise and promoting more quiet and tranquil spaces. The scheme supports low noise impacts through improved air tightness and the use of MVHR reduces external noise ingress for occupants.

2.4 LANDSCAPING AND BIODIVERSITY

The landscape has been designed to be supportive of local wildlife and to encourage biodiversity. Generous planting areas provide space for a wide variety of flowering, fruiting and wildlife friendly plants, shrubs and trees. New trees of various sizes and species will be planted including native species such as hawthorn, birch and field maple. The proposed mature trees will provide screening and aesthetic benefit. Large planting areas and permeable driveway surfacing have been designed to mitigate water run-off and flooding.

Extensive green roofs will help regulate and lower the indoor temperature, while providing sustainable urban drainage and supporting wildlife habitats.

Reclaimed yorkstone paving will lower the embodied carbon of the hard landscaping.

Figure 9: Proposed landscape plan

2.5 SUSTAINABLE MATERIALS & MINIMISING WASTE

New materials will be sustainably procured and using local supplies where feasible, following the BRE Green Guide to Specification[1]. The construction build-up for each element can be rated from A+ to E where A+ is least likely to affect the environment and E is likely to have the most impact. The materials for the extension will aim to achieve a rating between A to C.

All timber used during the site preparation and construction will be Forest Stewardship Council (FSC) certified or Programme for the Endorsement of Forestry Certification (PEFC) and all non-timber materials to be sourced from organisations with an environmental management system such as ISO 14001 or BES 6001. This standard enables construction product manufacturers to ensure and then prove that their products have been made with constituent materials that have been responsibly sourced. The standard describes a framework for the organisational governance, supply chain management and environmental and social aspects that must be addressed in order to ensure the responsible sourcing of construction products.

A construction waste recycling requirement will be included in the contractor specification to ensure a construction waste management plan is in place. This will include ways to design out waste, reduce amounts of packaging and to participate in packaging take back schemes as well as ensuring that all waste is sent to private local dedicated construction waste plants with high landfill diversion rates.

2.6 SUSTAINABLE TRANSPORT

The site has good links to low energy public transportation. The site is a 5-minute walk from Hampstead Underground Station, providing links to the Northern line, and an 11-minute walk from the Finchley Road & Frognal Overground Station. The site is near to a number of bus stops; the closest is Heath Street Hampstead Station (Stop D) approximately a 4-minute walk away, offering services on Routes 46 and 603.

[1] *www.bregroup.com/greenguide/podpage.jsp?id=2126*

2.7 COOLING & OVERHEATING

The cooling and overheating strategies are summarised in the table below using the cooling hierarchy which has been applied to the design.

Hierarchy Measure	Application to proposed development
1. Minimise Internal Heat Gains	- Low energy LED lighting
2. Minimise External Heat Gains	- High level of insulation - Horizontal shading elements to provide solar shading -Internal blinds with light coloured external facing surfaces (with relatively high reflective properties - Green roof to minimise solar gains through the roof and add to green mass (external greenery) which helps creates a cool microclimate through evapotranspiration
3 & 4 Heat Management and Passive Ventilation	-High openable window area -Nighttime ventilation strategy with heavy-weight existing walls
5 & 6. Mechanical systems	- Mechanical Ventilation with Heat Recovery (MVHR) is specified. System will have "heat recovery by-pass" mode in order to be operable in summer night-cooling mode

Table 5: Cooling hierarchy

2.8 FLEXIBLE ENERGY USE

Demand-side response / flexibility initiatives are encouraged by the London Plan, as referred to in Policy SI 2 Minimising greenhouse gas emissions. Demand side flexibility refers to the ability of a system to reduce or increase energy consumption for a period of time in response to an external driver (e.g. energy prices or signals from network managers).

Smart buildings have been identified and acknowledged as key enablers of future energy systems for which there will be a larger share of distributed and renewable power and heat generation. Demand-side flexibility can allow demand/supply matching and make best use of existing network connections and local renewable energy generation capacity.

The scheme facilitates the use of Demand Side Response and reduces peak energy demand by:

- The use of electrical equipment such as heat pumps which can be turned up/down.
- A large central energy store integrated into the centralised heat pumps system.
- Limiting demand such as peak solar gains (refer to cooling and overheating section).
- The installation of smart meters.

Integration has carried out a research project which quantifies the savings from flexible hot water and heating use. The study analysed real-life hourly carbon factors from the UK's electricity grid taken over a 12-month period. The graph below illustrates the diurnal cycling of carbon factors for 3 example days. So can be seen there are frequent opportunities where carbon saving can be made by using electricity during low carbon periods and avoiding use during periods where the carbon intensity is high.

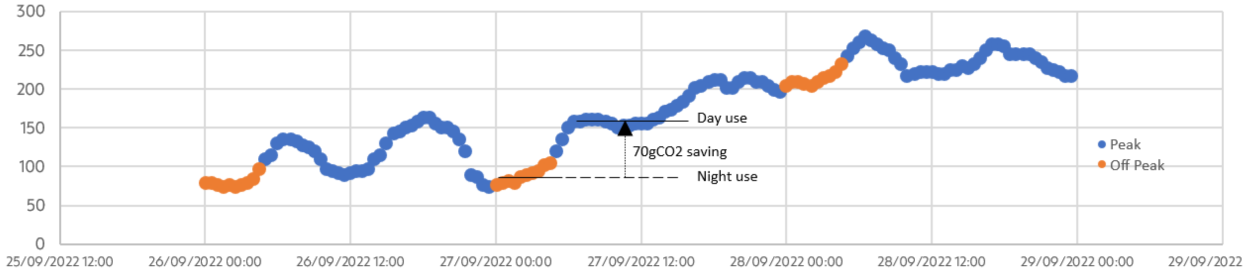

Figure 10: Example daily carbon intensity variations – (example off peak thermal store charging from midnight to 4am shown in orange).

The best carbon reduction performance was provided by the heat pump system which used the largest buffer vessel. This enhanced storage capacity offered the greatest flexibility for charging and generated most cost savings. This flexibility also saved the most carbon emissions, in addition to those achieved by the heat pump's inherent high efficiency. The selected strategy has been calculated to achieve a 93% of the maximum possible for space heating and hot water use, which is A rated for flexibility according to the in-house rating system.

As the UK electricity grid continues to decarbonise, the performance benefits will increase significantly.

Not only can energy users save money on their energy bills by being flexible, they can also earn money. The first demand side response scheme has already been launched by National Grid marking a new era of energy use. This scheme highlights the value to shifting electric use during peak times. National Grid paid £3 for each kWh shifted which is more than seven times the value of daytime electricity and more than 23 times the cost of nighttime electricity. This means shifting 1 kWh of energy use from peak times allows you to use 23 kWh at nighttime for free.

3 Design Approach - Energy

3.1 THE ENERGY HIERARCHY

The energy hierarchy, as referred to in the London Plan and illustrated below, sets out a staged approach to strategic decision-making for the reduction of energy and associated greenhouse gas emissions. The evaluation of the scheme's carbon emissions, as presented in the subsequent sections, follows this structure.

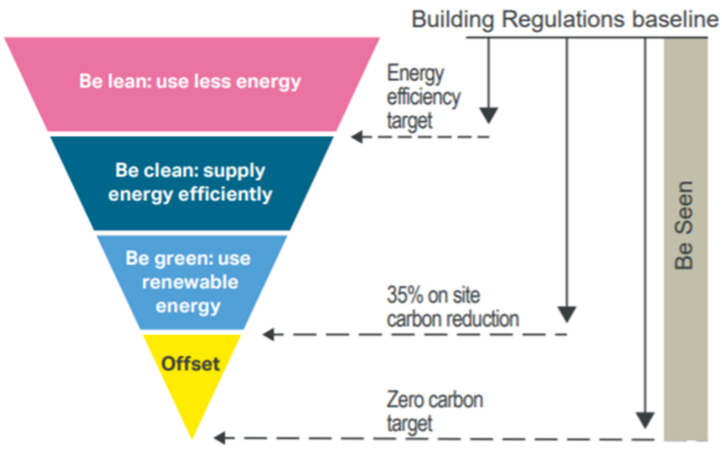

Figure 11: Energy Hierarchy Methodology

BE LEAN - Minimise Energy Demand
Passive design such as optimising form, orientation and site layout, natural ventilation with thermal mass, daylight and solar shading as well as active design measures such as LED lighting and efficient mechanical ventilation with heat recovery.

BE CLEAN - Deliver Energy Efficiently
Efficient energy provision for space heating and cooling infrastructure e.g. high efficiency cooling plant, combined heat and power (CHP) or, if available, connection to a district heating/cooling network.

BE GREEN - Use Renewable Energy
Energy supply derived from local renewable resources including solar irradiation, wind energy, hydropower and local heat sources such as geothermal energy. Provision of non-local options can also be considered.

3.2 CLIMATE ANALYSIS

The London climate is heating dominated, hence the key passive measures to be implemented are high levels of insulation and air-tightness. Temperatures in the summer can occasionally rise above comfortable levels and this will tend to intensify as a consequence of climate change and further urbanisation.

The diurnal temperature variations are high with an average daily temperature swing of 8-10°C even during peak summer. This creates potential for passive summertime cooling using night-time cooling via openable windows or mechanical ventilation.

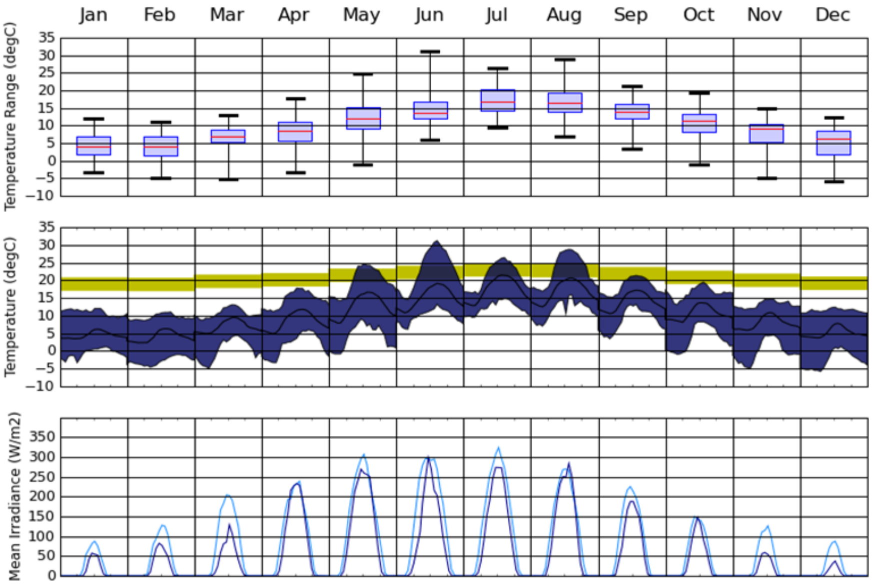

Figure 12: Average historic climate data for London

3.3 BUILDING FABRIC PERFORMANCE & INSULATION

High levels of insulation are proposed for the new elements as summarised later in this section, with additional insulation to be added to the existing external elements. The thermal performance of all exposed elements equals or exceeds the minimum requirements for Building Regulations 2021. This will significantly reduce energy consumption and ensure optimum occupant comfort all year round by retaining heat in the winter and reducing heat gains in the summer.

This is particularly relevant for glazed surfaces that can be a cause of overheating in summer or overcooling and condensation formation in winter. As such the windows will be upgraded to high-performance double glazing, which will improve occupant comfort by reducing radiant temperature asymmetry which can be a comfort issue especially during the winter months.

3.4 AIR TIGHTNESS, INFILTRATION AND THERMAL BRIDGING

An improved air-permeability rate has been targeted as summarised later in this section. The key to achieving high levels of airtightness is the build quality of construction. Improvements to the existing air-permeability rate have been proposed primarily through draught proofing.

Minimising thermal bridging is an important aspect of the design. The approach to limiting thermal bridging in the extension is to implement psi values to a similar level to Accredited Details[2] for key new-build elements. Please see appendix A for more details.

3.5 NATURAL VENTILATION & THERMAL MASS

Daytime natural ventilation can assist in removing excess heat during the mid-season and summer months and enables the provision of high air quality. When used in combination with exposed thermal mass, natural ventilation will reduce high internal daily temperature fluctuations and minimise the overheating risk in the summer. Therefore, occupant comfort can be maintained with reduced reliance on mechanical cooling systems.

The summer ventilation strategy includes large openable areas for windows/doors to allow for good natural ventilation. Secure openable windows allow for night ventilation to pre-cool thermal mass (e.g. the existing heavy-weight walls).

2 www.planningportal.co.uk/info/200135/approved_documents/74/part_l_-_conservation_of_fuel_and_power/6

3.6 SOLAR EXPOSURE & DAYLIGHT

Maximising exposure to solar energy and daylight is essential to reduce reliance on artificial lighting, reduce winter daytime heating requirements and contribute to the general wellbeing of occupants.

The site has good access to solar energy and natural daylight. This makes the development's roof suitable for solar energy harvesting as discussed further the in the Be Green section.

Fenestration on the facades maximises natural daylight to provide amenity and reduce artificial lighting energy use. External shading in the form of horizontal overhangs on dormer windows limits solar gains while still allowing for good daylight. Internal shading can be incorporated to minimise the risk of overheating and glare without overly compromising daylight availability.

3.7 ACTIVE BUILDING SERVICES SYSTEMS

The existing building currently uses an old, centralised gas boiler for space heating and hot water provision. The development will present an opportunity to upgrade this to a high efficiency system. Space heating and hot water will be provided via a central high-efficiency heat pump system.

Energy use associated with domestic hot water (DHW) will be minimised by the use of water efficient fittings together with optimised hot water temperatures.

High-efficiency mechanical ventilation with heat recovery (MVHR) will be used to provide fresh air efficiently during the heating season. The system will have a summer bypass to support night-time free cooling of thermal mass.

Low-energy fixed lighting, generally comprising of high-efficiency LED fittings, will be installed throughout the development with timer, daylight dimming, and motion-sensor control as appropriate.

All building services systems will be in accordance with and exceed the efficiency requirements outlined in the Building Service Compliance Guide.

4 Carbon Emissions

4.1 BASELINE

The existing building has an EPC rating of D with walls and the roof rated as "very poor". The existing energy use was calculated to be 44,708 kWh per year for heating and 3,047 kWh per year for hot water. A total of 56,931 kWh/m^2/a was calculated for total regulated and unregulated energy.

Energy demand and annual carbon emissions for the proposed development are calculated using BRE accredited energy compliance SAP 10.2 software.

The amount of carbon emission reductions achieved by the proposed scheme is compared to the notional Target Emission Rate (TER) which forms the baseline comparison target. This notional dwelling is produced by the energy model and intends to replicate the actual building in terms of area, form, orientation and usage. The fabric parameters and system efficiencies for this notional building meet/exceed the minimum requirements for compliance with Part L of the 2021 Building Regulations.

To ensure high performance of each individual element, limiting fabric values are set out in approved document Part L1 and limiting building services efficiencies set out in the Domestic Building Services Compliance Guide have been followed.

The Notional Building baseline values are:

Element	Notional dwelling performance
External walls U-value (W/m^2/°C)	0.18
Exposed floor U-value (W/m^2/°C)	0.13
Roof U-value (W/m^2/°C)	0.11
Windows/Glazed Doors U-value (W/m^2/°C)	1.2
Rooflights U-value (W/m^2/°C)	1.7
Windows/Glazed Doors g-value	0.63
Solid doors U-value (W/m^2/°C)	1.0
Air Permeability (m^3/m^2/h @50Pa)	5.0
Ventilation type	Natural with intermittent extract fans
Space heating	Mains Gas (89.5% SEDBUK 2009)
Wastewater heat recovery (WWHR)	Showers connected to WWHR (36% recovery efficiency utilisation of 0.98)
Lighting	100% low energy lighting, (80lm/W)
Photovoltaic (PV) system	For houses: kWp = 40% of ground floor area, including unheated spaces / 6.5.

Table 6: Notional dwelling specification for new-build (Table 1.1, Part L1)

4.2 "BE LEAN" EMISSIONS

As part of the "Be Lean" approach, seeking to minimise energy demand, the following energy-related specifications have been proposed.

Element	Proposed dwelling performance
External walls U-value (W/m^2/°C)	Extension: 0.15 W/m^2/°C Upgraded: 0.25 W/m^2/°C
Exposed floor U-value (W/m^2/°C)	0.10 W/m^2/°C
Roof U-value (W/m^2/°C)	0.10 W/m^2/°C
Windows/Glazed Doors U-value (W/m^2/°C) (g-value)	1.4 W/m^2/°C (0.55 g-value)
Rooflights U-value (W/m^2/°C) (g-value)	1.4 W/m^2/°C (0.55 g-value)
Air Permeability (m^3/m^2/h @50Pa)	5.0 m^3/m^2/h @50Pa
Thermal Bridging	Extension: psi values provided in appendix A
Ventilation type	Mechanical ventilation with heat recovery (MRXBOXAB-ECO2)
Heating	Be Lean: Mains Gas (Be Green: Heat Pump)
Hot water	Be Lean: Mains Gas (Be Green: Heat Pump)
Lighting	100% low energy lighting, (90lm/W)

Table 7: Proposed residential development – Be Lean

"Be Lean" Total Carbon Emissions

The "Be Lean" CO_2 emissions associated with regulated energy consumption, the Dwelling Emissions Rate (DER), are given below in relation to the baseline TER (Target Emission Rate).

Area (m^2)	TER (kg.CO_2/m^2/yr.)	DER (kg.CO_2/m^2/yr.)
572	9.90	9.77

Table 8: Be Lean regulated emissions for development

4.3 "BE CLEAN" EMISSIONS

Connection to Third Party Heat Networks

The London Heat Map tool[3] shows that the site is over 1km from the nearest heat network. As a non-major scheme, connection to third party heat networks is not considered viable for this development.

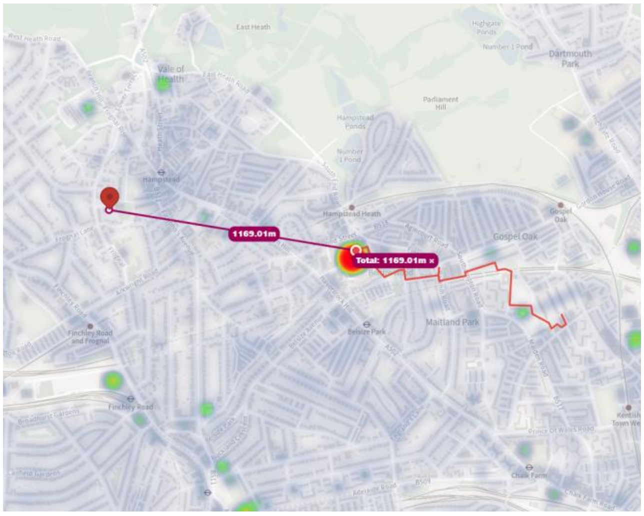

Figure 13: London Heat Map tool showing proposed heat networks (purple)

CHP Combined Heat and Power

The London Plan limits the role of CHP to low-emission CHP and only in instances where it can support the delivery of an area-wide heat network at large, strategic sites, according to the Energy Assessment Guidance Greater London Authority guidance on preparing energy assessments as part of planning applications. Therefore, CHP has not been adopted.

[3] https://maps.london.gov.uk/heatmap

4.4 "BE GREEN" EMISSIONS

A renewable energy feasibility exercise has been carried out in order to determine the most viable option(s) for the development (see Appendix B). The viable technology options, ground source heat pumps and Photovoltaic (PV) panels, are presented below.

Heat Pumps

Heat pumps extract heat energy from sources that are naturally replenished. They can create around 3-4kW of renewable thermal energy for every 1kW of electrical power consumed, which makes them one of the lowest carbon reliable heating technologies available.

The scheme proposes to use heat pumps to provide 100% of heating and hot water needs. A ground-source heat pump is currently the preferred technology. A potential layout for four boreholes is shown below.

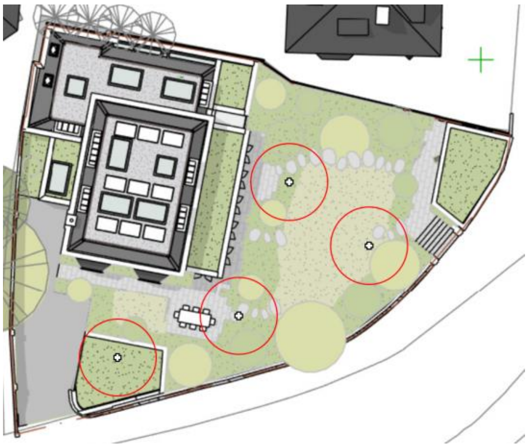

Figure 14: Potential bore hole layout

Photovoltaic (PV) panels

The proposed roof plan below shows the amount of roof that is available within the development and that could be viable to install photovoltaic panels subject to a detailed roof survey.

Total installed capacity of the system:	2.7 (kWp)
Panel inclination:	15 degrees
Panel orientation:	South
Energy generation:	1098 kWh/a
Carbon emission reduction:	0.14 tonnes of CO_2/a

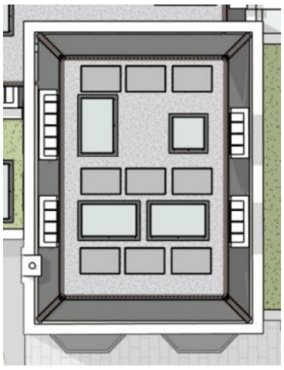

Figure 15: Potential solar PV layout (subject to design development and detailed survey of the roof)

"Be Green" Total Carbon Emissions

The CO_2 emissions associated with regulated energy consumption are given below.

Area (m^2)	TER ($kg.CO_2/m^2/yr.$)	DER ($kg.CO_2/m^2/yr.$)
572	9.90	4.16

Table 9: Be Green regulated emissions

5 Summary

5.1 SUSTAINABILITY SUMMARY

In addition to the low energy performance set out below, the scheme benefits from several sustainability aspects. These include the use of water saving devices to achieve 105 litre per person per day. Health and wellbeing is supported by aspects such as high levels of fresh air provided by mechanical ventilation with heat recovery. In terms of sustainable travel, the scheme has covered bicycle storage and benefits from easy access to public transportation such as Hampstead Underground Station and Finchley Road & Frognal Overground Station. The scheme is also demand side response (DSR) enabled through the provision of a large centralised electric-powered heat pump system with large energy storage vessels in order to work with National Grid signalling / time of use tariffs. This supports the transition to low carbon electricity while reducing energy costs for residents.

5.2 OVERALL DEVELOPMENT CARBON EMISSIONS SUMMARY

The predicted total annual CO_2 emissions of the proposed development following the introduction of energy efficiency measures, passive and active design (Be Lean), Low carbon supply technologies (Be Clean) and renewable energy systems (Be Green) are summarised below in the format recommended by the GLA.

The table below shows both the total regulated and unregulated energy use.

Carbon dioxide emissions (Tonnes CO_2 per annum)	Regulated	Unregulated
Baseline: Part L 2021 (Building Regulations) Compliance	9.90	1.2
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Total cumulative on-site savings	5.74	58.0

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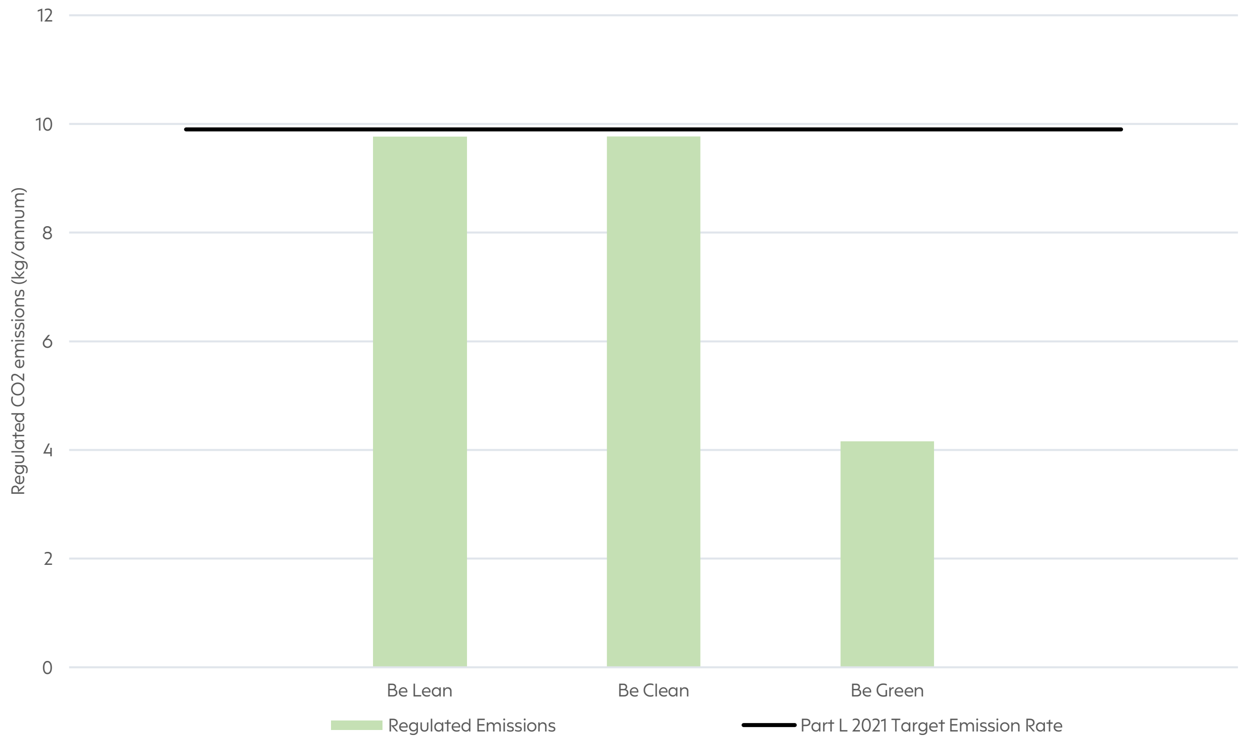

Figure 16: Summary of target and energy savings for each stage of the energy hierarchy

5.3 FUTURE PROOFING TO 2050 SUMMARY

The site has been future-proofed to achieve zero carbon on-site emissions by 2050 through several mechanisms. The main strategy is by avoiding fossil fuels on site and using electricity for 100% of the energy requirements. This means that as the UK electricity grid continues its decarbonisation towards the 2050 goal of net zero, the scheme will be able to be supplied by zero carbon electricity.

Appendix A: New-build elements – psi values

Junction	Junction Name	Psi Value (W/mK)
E2	Lintel	0.3
E3	Sill	0.04
E4	Jamb	0.05
E5	Ground Floor	0.16
E16	Corner (normal)	0.09
E22	Basement Floor	0.07
R8	Roof to wall (rafter)	0.06
R9	Roof to wall (flat ceiling)	0.04

Table A1: Summary of non-default psi values for new-build elements

Appendix B: Technology Feasibility Study Summary

The overall summary of the feasibility exercise is presented below.

Technology	Assessment/Viability	
Wind Power	Wind turbine installed on the roof of the development.	Due to the high cost per kW for smaller building-mounted turbines and the impacts in terms of visual, noise and shadow flicker, wind turbines are not considered a viable technology for the development. CONCLUSION: NOT CONSIDERED FEASIBLE
Heat Pumps	Open or closed loop GSHP system requiring extraction of ground water and / or deep boreholes, or electric powered external plant serving each ASHP unit providing heating and hot water.	Heat pumps are one of the lowest carbon methods of providing reliable low-carbon heat and require low maintenance. A ground-source heat pump is currently the preferred technology for this scheme. CONCLUSION: CONSIDERED FEASIBLE
Solar Thermal Collectors	Roof-mounted solar thermal panels providing hot water heating	Roof areas have good potential for solar thermal energy collection. However, the integration with a heat pump would result in a complex system. Therefore, solar PV is preferred over solar thermal technology. CONCLUSION: NOT CONSIDERED FEASIBLE
Solar Photovoltaic Panels	Roof mounted Photovoltaic panels (PV) provide electricity directly to the scheme, exporting any surplus production to the grid.	The roof has some potential for solar PV. This technology also supports heat pump use. CONCLUSION: CONSIDERED FEASIBLE
Combined Heat & Power (CHP)	Gas powered turbine generating electricity on site. Waste heat is also made available for on-site use	Carbon offsetting potential of CHP is significantly reduced now that the UK's electricity grid is much cleaner after the increase in renewable energy deployment and decrease in coal generation. CONCLUSION: NOT CONSIDERED FEASIBLE
Electrical Energy Storage	Standalone battery storage	Battery scheme is not considered beneficial as there are limited carbon saving benefits due to the significant daytime energy use on site relative to the amount of PV installed. In addition, batteries have high embodied carbon emissions and initial capital costs. CONCLUSION: NOT CONSIDERED FEASIBLE
Biomass Heating	Biomass-fired community heating system.	Biomass heating is an established technology but has high maintenance requirements, fuel storage and delivery issues and is a source of increase in pollution, notably particulates (PM10), SO2 and NOX emissions. CONCLUSION: NOT CONSIDERED FEASIBLE

Table B1: Summary of Low and Zero Carbon Study Analysis Results