ZENKO CONSULTING

9-12 New College Parade

Energy Strategy

Revision 2

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Document History

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Disclaimer

Whilst Zenko Consulting has made every effort to guarantee the precision of the information provided in this report, it is essential to recognise specific constraints. Factors such as the intricacies of building physics and variations in the surrounding environment introduce complexities that could lead to differences between computer-generated simulations and real-world results.

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Executive Summary

Zenko Consulting has created this energy report on behalf of New College Ltd – 'the Applicant' to support the planning application for the proposed development located at 9-12 New College Parade, Finchley Road, NW3 5EX in the London Borough of Camden, hereafter referred to as the 'Development'.

The development comprises the replacement of the existing two storey building, with the retention of the existing two storey Edwardian Baroque façade. The proposal looks to deliver a 59-room boutique hotel with restaurant on the lower ground floor and 3 residential flats on the first floor.

The scheme has been developed in accordance with the London Plan 2021 "The Spatial Development Strategy for Greater London, March 2021" and the Sustainable Design and Construction SPG. According to the planning policies, the scheme should achieve the following targets:

- **Zero carbon target**
- **Minimum on-site CO2 reduction:** At least 35% beyond Building Regulations
- **Residential development CO2 improvement**: 10% through energy efficiency measures (Be Lean stage)
- **Non-domestic development CO2 improvement:** 15% through energy efficiency measures (Be Lean stage)

If the zero-carbon target cannot be fully achieved on-site, any shortfall should be addressed, in agreement with the borough, through one of the following methods:

- **Cash in lieu contribution:** To the borough's carbon offset fund
- **Off-site measures:** Provided an alternative proposal is identified and its delivery is certain

Energy Strategy

Our energy strategy is firmly rooted in the nationally accepted energy hierarchy, which encompasses three fundamental principles: 'Be Lean,' 'Be Clean,' and 'Be Green.' These principles provide a structured and holistic approach to energy management and sustainability, ensuring that we make responsible and environmentally conscious choices in our energy practices.

Be Lean - Reduce Energy Demand:

The first step in our energy hierarchy is to "Be Lean," which places a strong emphasis on reducing energy demand. To achieve this, we are implementing a range of measures designed to enhance energy efficiency and minimise wastage.

Be Clean - Choose Sustainable Energy Sources:

The second principle, 'Be Clean,' involves selecting clean and sustainable energy sources. In this regard, we are dedicated to sourcing our energy from renewable and low-carbon options. By doing so, we reduce our carbon footprint and contribute to a cleaner, more sustainable energy landscape.

Be Green - Promote Renewable Energy Generation:

The final principle, 'Be Green,' revolves around actively promoting renewable energy generation. As part of our long- term sustainability vision, we may explore opportunities to install on-site renewable energy systems such as solar panels or wind turbines. These initiatives not only reduce our reliance on external energy sources but also demonstrate our commitment to fostering a greener and more resilient energy infrastructure.

In summary, our energy strategy aligns with the nationally accepted energy hierarchy. Through these principles, we are dedicated to optimising energy efficiency, adopting clean energy sources, and promoting renewable energy generation, all of which contribute to a sustainable and responsible energy future.

Predicted Development CO_2 Emissions

We've meticulously assessed CO2 emission reductions for the Development, adhering to Building Regulations Part L 2021 standards. Our rigorous assessments utilised the advanced IES Virtual Environment [IES VE) platform, offering a comprehensive framework for optimising energy performance.

Site Wide	Total regulated emissions kgCO2/m^2/annum)	Cumulative CO2 savings (tCO2/annum)	Accumulative Percentage Savings
Baseline*	32.76	41,571	-
After Lean Measures	21.89	25,953	33.18
After Clean Measures	-	-	-
After Green Measures	13.01	18,789	60.29

Domestic	Total regulated emissions kgCO2/m^2/annum)	Cumulative CO2 savings (tCO2/annum)	Accumulative Percentage Savings (%)
Baseline*	19.51	38,911	-
After Lean Measures	12.02	23,973	38.39
After Clean Measures	-	-	-
After Green Measures	9.02	17,989	53.77

Non-Domestic	Total regulated emissions kgCO2/m^2/annum)	Cumulative CO2 savings (tCO2/annum)	Accumulative Percentage Savings
Baseline*	13.25	2660	-
After Lean Measures	9.87	1980	25.51
After Clean Measures	-	-	-
After Green Measures	3.99	800	69.89

Contents

1. CO_2 Emissions Assessment Approach

The CO2 emissions assessment approach, often referred to as the 'energy hierarchy' is a concept that outlines a preferred sequence for addressing energy-related issues and reducing carbon dioxide (CO2) emissions. It provides a structured framework for making choices about energy sources and technologies to mitigate climate change. The energy hierarchy typically consists of hierarchy of steps or priorities, with the most environmentally friendly options at the top and the least desirable at the bottom.

1.1. Energy Hierarchy

The energy hierarchy is a structured approach to prioritise energy management for efficiency and sustainability. It involves three main stages:

1. Be Lean - Reduce Energy Demand: This stage focuses on minimising energy consumption through efficient practices and design, such as improving insulation and reducing waste.
2. Be Clean - Use Clean Energy Sources: After reducing demand, the emphasis shifts to using clean and sustainable energy sources while moving away from fossil fuels.
3. Be Green - Promote On-Site Renewable Energy: The highest level involves generating energy locally from renewables, such as solar panels or wind turbines.

The energy hierarchy serves as a valuable instrument to attain energy efficiency, sustainability, financial savings, and environmental advantages. It offers a methodical framework for making well-informed decisions regarding energy matters that are in harmony with a diverse array of objectives and priorities.

1.2. Methodology

The methodology employed in this report adheres to the guidelines provided by the Greater London Authority (GLA) for formulating energy strategies, as outlined in the document "Energy Assessment Guidance: Greater London Authority guidance on preparing energy assessments as part of planning applications (June 2022)." The scheme has been developed in alignment with the London Plan 2021.

The calculations and simulations necessary to forecast the development's CO2 emissions, in accordance with the Building Regulations Part L Dynamic Systems Modelling (DSM) methodology, have been performed using the IES Virtual Environment dynamic thermal simulation software version 2023.5.1.0.

The software considers the regulated energy consumption of the building for lighting, heating, cooling, hot water, and auxiliary (ventilation) purposes when calculating CO2 emissions. The 'equipment' load provides an estimate of unregulated energy consumption, but it is not reflected in the CO2 emission rate figures. Each activity zone is assigned standard activity templates based on the National Calculation Methodology (NCM).

1.3. Carbon Dioxide Emissions Factors

The emissions factors for carbon utilised in this report (as shown in below) rely on the Building Regulations Part L 2021 recommendations, which make use of tables 29 and 30 from the National Calculation Methodology guide. These factors were updated on June 15, 2022, along with the Part L revision, to reflect the enhanced effectiveness of the electric grid more reliably in the UK.

Fuel Source	Part L 2021 (kgCO2/kWh)
Natural Gas	0.210
Grid Supplied Electricity	0.139*

*Annual average taken as the carbon factor of grid supplied electricity varies month by month.

1.4. Carbon Offsetting

London Plan 2021 Policy SI2 mandates that carbon dioxide reductions must be achieved on-site as much as possible. A cash-in-lieu contribution is considered acceptable only when it is clearly demonstrated that no further on-site savings can be made. Any remaining reductions needed to reach zero carbon can be achieved either off-site or through a cash-in-lieu contribution.

To determine the annual shortfall, the overall regulated carbon dioxide savings are subtracted from the target savings. This shortfall is then multiplied by the assumed 30-year lifetime of the development's services to calculate the cumulative shortfall. The cumulative shortfall is further multiplied by the carbon dioxide offset price to establish the required cash-in-lieu contribution. The current offset price is £95 per tonne.

2. Energy Hierarchy – Baseline

The concept of the "baseline" structure is a fundamental aspect of sustainable building design, rooted in the principles of minimising carbon dioxide (CO2) emissions from structures. It represents a theoretical or standard design approach that strictly adheres to the minimum CO2 emission criteria mandated by the Target Emissions Rate (TER) calculation, as outlined in Building Regulations Part L 2021.

Building Regulations Part L 2021, which governs the conservation of fuel and power in buildings, sets forth specific requirements for new construction projects and major renovations. One of its central objectives is to reduce the environmental impact of buildings by curbing energy consumption and CO2 emissions. To achieve this, the TER is established as a benchmark against which the actual energy performance of a building is measured.

The "baseline" structure is essentially a hypothetical building design that serves as a reference point for evaluating the energy performance of a proposed construction project. It represents the minimum allowable level of CO2 emissions that a building must meet to comply with regulatory standards.

	Regulated emissions tCO2/annum]	Unregulated CO2 Emissions (kgCO2/annum)	Regulated energy (MWh/annum)	Unregulated energy (MWh/annum)
Domestic	2.66	3.86	19.06	18.64
Non-Domestic	38.91	5.67	278.34	40.85

3. Energy Hierarchy – Be Lean

The "Be Lean Energy" approach represents a holistic and forward-thinking strategy for revolutionising energy production and consumption. At its core, this approach prioritises efficiency, optimisation, and sustainability as the cornerstones of a cleaner and more responsible energy landscape. It recognises that by reducing waste and improving resource utilisation across all sectors, from industry to transportation to residential buildings, we can create a more streamlined and environmentally friendly energy system. By embracing energy-efficient technologies, such as LED lighting, and promoting resource optimisation in electrical conditioning and renewable energy production, Be Lean Energy aims to minimise waste and maximise the output while mitigating environmental impacts.

One of the standout features of the Be Lean Energy approach is its alignment with lean manufacturing principles, which emphasise the elimination of inefficiencies in energy production processes. This entails identifying and eliminating redundancies, unnecessary resource consumption, and energy waste, thereby streamlining energy generation and distribution. Furthermore, Be Lean Energy advocates for decentralisation in energy generation and distribution systems, which means generating energy closer to where it's needed. By doing so, it reduces transmission losses and enhances the overall efficiency of energy delivery. Through technological advancements, behavioural changes, data analytics, continuous improvement, and an emphasis on economic benefits and environmental sustainability, Be Lean Energy paves the way for a more efficient, cost-effective, and environmentally responsible energy future.

3.1. Passive Demand Reduction Measures

Passive design integrates architectural features that harness natural resources, reducing reliance on traditional heating, ventilation, and lighting systems. It includes techniques like passive solar heating, natural ventilation, daylighting, solar shading. These strategies optimise energy efficiency and sustainability, creating environmentally responsible building designs.

3.1.1. Material Efficiency

Throughout the design and construction stages, there will be a meticulous assessment of material efficiency, aiming to specify the most sustainable and effective materials when they are deemed suitable. An essential aspect of this process involves the insulation of the building's fabric, which plays a pivotal role in creating a comfortable indoor environment. It's imperative that insulation strikes the right balance between minimising winter heating requirements and averting excessive cooling demands in the summer. In light of these considerations, various options have been reviewed resulting in implementing the following U-Values:

Fabric U Values (W/m^{2}k)	2021 Building Regulations	Proposed
External Wall	0.26	0.13 (existing 0.30)

Fabric U Values (W/m²k)	2021 Building Regulations	Proposed
Ground Floor	0.18	0.11
Exposed Floor	0.18	0.11
Roof	0.18	0.16
Window – Non-Domestic	1.60	1.10 (G-Value 0.40)
Window - Domestic	1.20	1.10 (G-Value 0.60)

The air permeability of a building refers to the volume of air that passes through the building envelope per unit time and area, typically measured in m3/hr/m2. It is essential to optimise the air permeability in light of the temperature fluctuations observed throughout the year in this region. While the Approved Document Part L specifies a maximum limit of 8 $m3^3$/hr/m2, the Development will strive to attain a value of 3 m3/hr/m2 or better to guarantee a thermally efficient design.

3.1.2.Thermal Bridging

The scheme will be designed according to best practice guidelines, aiming to minimize heat losses through thermal bridging. A detailed thermal bridging analysis will be conducted during the technical design stage to ensure the achievement of the specified psi-values.

3.2. Active Demand Reduction Measures

Active design is a deliberate approach that uses technology to shape buildings for optimal performance, energy efficiency, and occupant well-being. It deploys engineered systems to achieve goals like energy efficiency, comfort, and security. Unlike passive design, it relies on mechanical systems for specific purposes.

3.2.1.Heating

Domestic: In the 'Be Lean' scenario, the scheme has been modelled with a gas boiler boasting an efficiency of 89.5%, as mandated by the GLA. For the 'Be Green' final scenario, a communal air source heat pump with a minimum COP of 3.50 will be proposed as the primary heating system. Heat distribution will be via underfloor heating (pipes embedded in screed above insulation) and radiators, managed through a charging system linked to community usage with time and temperature zone control. The scheme aims to achieve a distribution loss factor of less than 1.1.

Non-Domestic: In the 'Be Lean' scenario, the scheme has been modelled with an air source heat pump (ASHP) with a minimum COP of 2.64, meeting the Part L 2021 requirements. For the 'Be Green' final scenario, a communal air source heat pump with a minimum COP of 3.50 will be proposed as the main heating system. Heat will be delivered via radiators to the circulation areas and hotel/residential shower facilities, by split systems to the retail areas, and by VRF systems to the hotel, with local time and temperature controls.

3.2.2.Hot Water

Domestic: In the 'Be Lean' scenario, hot water will be supplied by the main gas heating system, featuring gas boilers with an efficiency of 89.5%. For the 'Be Green' final scenario, hot water will be provided by a communal air source heat pump with a minimum COP of 3. An electric immersion heater will serve as a top-up, covering less than 20% of the hot water demand. The scheme aims for a distribution loss factor of less than 1.1. Additionally, a waste-water heat recovery system with a heat recovery efficiency of at least 0.42 (such as Recoup Drain+ or similar) has been specified.

Non-Domestic: In the 'Be Lean' scenario, hot water will be provided by an air source heat pump (ASHP) with a minimum COP of 2.86, in compliance with Part L 2021 requirements. For the 'Be Green' final scenario, hot water will be supplied by the air source heat pump with a minimum COP of 3. An electric immersion heater will provide less than 20% of the hot water demand. A waste-water heat recovery system with a heat recovery efficiency of at least 0.42 (such as Recoup Drain+ or similar) has been specified.

3.2.3.Ventilation

Domestic: Balanced ventilation with heat recovery has been specified for the apartments.

Apartments with one toilet have been modelled with a Specific Fan Power (SFP) of 0.42 W/l/s and a heat recovery efficiency of 91%.

Apartments with two toilets have been modelled with an SFP of 0.44 W/l/s and a heat recovery efficiency of 91%.

Non-Domestic: Mechanical ventilation with heat recovery and demand-controlled ventilation (dependent on gas sensors and speed control) has been specified for the retail spaces, hotel reception, and hotel rooms. These systems will have a minimum heat recovery efficiency of 85% and an SFP of 1.3 W/l/s. Extract ventilation has been specified for the toilets, with a flow rate of less than 5 l/s/m² and an SFP of less than 0.3 W/l/s.

3.2.4.Cooling

Domestic: No cooling has been specified for the apartments.

Non-Domestic: Cooling for the retail spaces, hotel reception, and hotel rooms will be provided by the communal air source heat pump, which has an EER of 5 and an SEER of 6.

3.2.5.Lighting

Domestic: High-efficiency lighting has been specified for the development, with a minimum efficacy of 80 lumens/W. For this stage, each flat is assumed to have 15 luminaires of 10W each.

Non-Domestic: High-efficiency lighting has been specified for all areas, with a minimum efficacy of 130 lumens/W. PIR sensors with a parasitic power of less than 0.1W/m² have been specified for all areas. Additionally, photoelectric-controlled daylight dimming sensors with a parasitic power of less than 0.1W/m² have been specified for the retail spaces and hotel reception.

3.3. Be Lean Development CO_2 Emissions & Energy Demand

The 'Be Lean' strategy combines 'Passive' and 'Active' measures to comprehensively reduce regulated energy consumption. This all-encompassing approach addresses various facets of energy efficiency and sustainability within the project.

The subsequent results reflect the previously detailed elements.

	Regulated emissions tCO2/annum]	Unregulated CO2 Emissions (kgCO2/annum)	Regulated energy (MWh/annum)	Unregulated energy (MWh/annum)
Domestic	1.98	3.86	13.57	18.64
Non-Domestic	23.97	5.53	171.88	40.85

4. Cooling & Overheating

This section aims to reduce the urban heat island effect in London and promote the design of spaces to prevent overheating and excessive heat generation, as well as to mitigate the impacts of climate change on overheating.

When design measures and natural or mechanical ventilation are insufficient to ensure occupant comfort, the cooling strategy for the development must include details of the proposed active cooling systems. This should cover their efficiencies and the potential for utilizing free cooling and renewable cooling sources.

Where applicable, the cooling strategy should explore opportunities to enhance cooling efficiencies using locally available sources such as ground cooling and river or dock water cooling.

4.1. The Cooling Hierarchy in Policy SI4

Developments should aim to reduce potential overheating and dependence on air conditioning systems, demonstrating compliance with the Cooling Hierarchy:

1. Reduce heat entry: Utilise orientation, shading, high albedo materials, fenestration, insulation, and green infrastructure to limit the amount of heat entering the building.
2. Minimize internal heat generation: Incorporate energy-efficient design to reduce heat produced within the building.
3. Manage internal heat: Use exposed internal thermal mass and high ceilings to manage heat within the building.
4. Provide passive ventilation: Implement strategies for natural airflow.
5. Provide mechanical ventilation: Use mechanical systems to enhance ventilation.
6. Provide active cooling systems: Employ active cooling systems when necessary.

4.2. Avoiding overheating: measures taken

The following measures have been implemented in line with the cooling hierarchy to reduce overheating and the need for cooling:

1. **Reduce heat entry**: Employ orientation, shading, high albedo materials, fenestration, insulation, and green infrastructure to limit heat entering the building.
    - **Solar control**: Various methods to control solar gain within tolerable limits have been considered. The location, size, design, and type of window openings and glazing have been optimized, with low emissivity windows specified to reduce solar gain.
    - **High albedo materials**: A reflective surface has been specified for the roof and vertical facades to minimize heat absorption, complemented by significant thermal insulation to prevent heat transfer into the building.

- **Maximized insulation**: Insulation levels have been maximized, resulting in U-values lower than those required by Building Regulations, effectively preventing heat penetration. Refer to the 'Be Lean' section of this report for target U-values.
- **Reduced air permeability**: A reduced air permeability rate has been targeted to minimize uncontrolled air infiltration, requiring meticulous detailing and sealing. Details on achieving this can be found in the 'Be Lean' section of this report.

2. Minimise internal heat generation through energy-efficient design
    - **Reduce internal heat gains**: Internal heat gains have been minimized where possible. Energy-efficient appliances will help reduce internal heat gain and the need for cooling.
    - **Energy-efficient lighting**: Lighting will be specified to be energy-efficient, as detailed in the 'Be Lean' section. Occupancy and daylight sensors will be used to reduce unnecessary lighting usage.
    - **Optimized heat distribution**: The heat distribution infrastructure will be designed to minimize pipe lengths, particularly lateral pipework in apartment block corridors. A twin pipes configuration will be adopted to minimize heat loss.

3. Manage heat within the building through exposed internal thermal mass and high ceilings
    - **High thermal mass:** Building fabric materials such as concrete floors and dense masonry external walls have been utilized to maximize thermal mass. These materials act as 'thermal batteries,' absorbing heat during occupied periods and releasing it slowly, thereby stabilizing daytime temperatures. Ventilation strategies will facilitate nighttime heat dissipation, resetting the thermal cycle. A 'ground-coupled' system utilizing the ground's thermal storage capacity has not been specified, as passive ventilation has been chosen instead.
    - **Room heights:** The building features high ceilings, a design traditionally used in warmer climates to promote thermal stratification. This allows occupants to occupy cooler lower spaces while minimizing heat transfer through the roof. Ceiling heights exceed 2.5m, and the well-insulated roof significantly reduces heat penetration, meeting building regulations.

4. Provide passive ventilation

    - **Openable windows:** All building facades feature specified openable windows.
    - **Dual aspect units:** Shallow floorplates with dual aspect units have been prioritized where feasible to facilitate cross ventilation. This design allows for windows to be opened on two facades, ensuring a clear airflow path.
    - **Night-time cooling:** Night-time cooling strategies will complement the use of high thermal mass materials. Taking advantage of the larger temperature difference between internal and external environments during nighttime, effective ventilation will purge accumulated heat within the structure from daytime activities.

5. Provide mechanical ventilation

    - Mechanical ventilation with summer bypass: All residential units will employ mechanical ventilation with a summer bypass feature. This system allows for 'free cooling' by utilizing outside air temperatures lower than those inside the building during summer months.

- Mixed mode system: A mixed mode system will be implemented, complementing passive cooling measures. During summer, mechanical ventilation using fans will expel hot air from the building. The building's zoned design will facilitate natural ventilation where feasible and mechanical ventilation in areas with higher cooling demands.

- Compliance with building regulations: The mechanical systems will adhere to the Domestic and Non-Domestic Building Services Compliance Guide, as detailed in the 'Be Lean' section of this report.

5. Energy Hierarchy – Be Clean

In an era marked by growing energy demands, environmental concerns, and a compelling need for sustainability, the "Be Clean" energy approach stands as a beacon of innovation and responsibility. At its core, this approach champions efficiency, reduction, and the pursuit of a leaner, more sustainable energy future. Within the framework of "Be Clean," one of the most transformative concepts is the adoption of decentralised energy systems.

Decentralised energy represents a pivotal shift in our energy paradigm. Rather than relying solely on traditional centralised power grids, decentralised systems empower us to generate, manage, and consume energy at or near the point of use. This paradigm shift aligns with the "Be Clean" ethos by promoting efficiency, reducing waste, and enhancing energy security.

5.1. Heating Infrastructure

Once energy demand has been minimized, developments are required to demonstrate how their energy systems have been selected in accordance with London Plan 2021 Policy SI3. This process entails a thorough evaluation of opportunities to connect to existing or planned heating networks, as well as the implementation of on-site communal and Combined Heat and Power (CHP) systems.

In areas designated as Heat Network Priority Areas (HNPAs), the following hierarchy should guide energy system selection:

Prioritize Connection to Heat Networks: Developers should explore options to connect to local heat networks that are either established or in the planning phase.

Utilize Zero-Emission or Local Secondary Heat Sources: Where feasible, consider using heat sources that are emissions-free or locally sourced, possibly integrating heat pumps as needed.

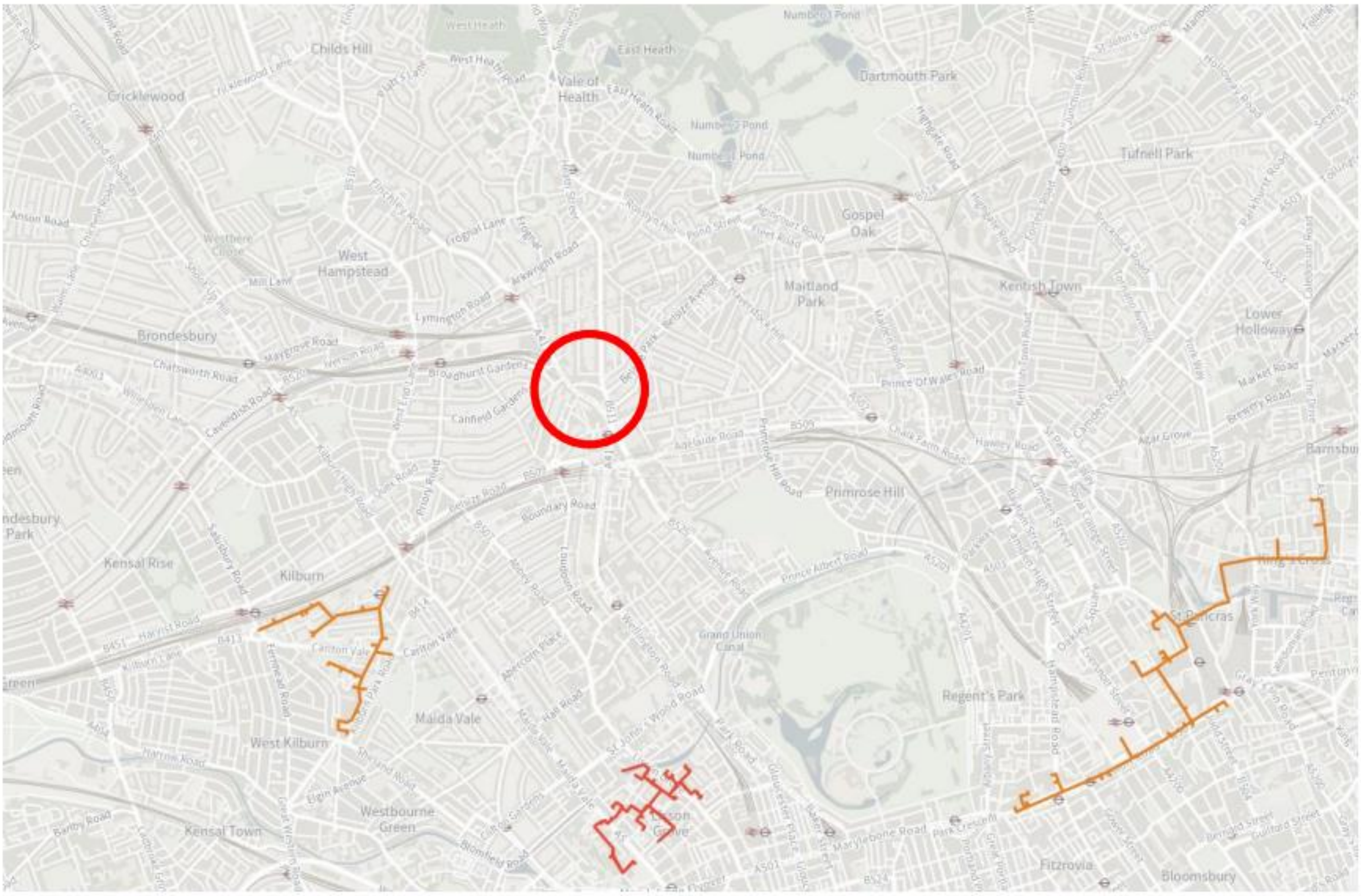
Consider Low-Emission CHP Systems: Evaluate the potential benefits of low-emission CHP systems, particularly where they can support broader area-wide heat networks, fulfill electricity demands, and provide flexibility to the local electricity grid.

Use Ultra-Low NOx Gas Boilers as a Last Resort: As a final consideration, utilize ultra-low NOx gas boilers only when other options are impractical or not cost-effective.

By adhering to this structured approach, developments can ensure alignment with London Plan 2021 guidelines while promoting sustainable and efficient energy use in urban environments.

5.2. Connecting to Local Existing or Planned Heat Network

The diagram below depicts the London heat map. Existing heat networks are marked in red lines, while proposed heat networks are indicated in orange lines. The red circle highlights the location of the proposed development.



A review of the London Heat Map demonstrates that there are no existing or planned networks present within connectable range of the scheme. Therefore, a connection is not possible.

5.3. Combined Heat and Power (CHP)

For a CHP system to be economically viable, it typically needs to operate continuously for at least 17 hours per day, seven days a week, with minimal interruptions. If the system does not have a sufficient base load, it may frequently shut down. Any excess heat generated by the CHP system can be dissipated using an intercooler, but if the amount of heat rejection is too high, the system may not be cost-effective. When sizing a CHP system, it is generally recommended to base the size on the hot water generation requirements. However, due to the lack of consistent demand for hot water, this technology may not currently provide reasonable CO2 savings, or be financially attractive to the development.

5.4. Summary

Implementing CHP and district heating systems in this development poses challenges due to factors like scale, infrastructure complexities, operational demands, environmental considerations, economic viability, and alternative solutions. Furthermore, environmental risks and compliance issues add complexity. Economic viability depends on various factors, and alternative energy solutions may be more suitable.

Considering these challenges, it's advisable to explore tailored, cost-effective energy solutions aligned with the development's unique characteristics. This could involve energy-efficient building designs, on-site renewable energy integration (e.g., solar panels), decentralised heating and cooling systems (like heat pumps), energy storage (via batteries), and advanced energy management systems. By taking a holistic approach to energy planning and considering the specific constraints and opportunities, the development can identify environmentally responsible and economically viable solutions without the complexities of CHP and district heating systems.

6. Energy Hierarchy – Be Green

Aligned with Policy SI2 of the London Plan 2021, the "Be Green Energy" approach leads the global shift towards sustainable energy practices. Emphasizing eco-friendly renewables like solar and wind power, this approach aims to combat climate change by reducing reliance on finite fossil fuels and cutting greenhouse gas emissions. By diversifying the energy mix, it enhances energy security while shrinking the ecological footprint of energy production.

6.1. Options Appraisal

6.1.1. Biomass

Biomass, a renewable energy source, brings:

1. Sustainability: It's renewable when replaced by new plant growth.
2. Lower Emissions: Biomass emits fewer greenhouse gases than fossil fuels.
3. Waste Reduction: It minimizes landfill waste by utilizing organic waste.
4. Local Energy Production: Reduces reliance on foreign sources, fostering local economies.
5. Versatility: It's usable for electricity, heating, and fuels.
6. Job Creation: Creates employment in agriculture, forestry, and energy sectors.
7. Carbon Neutrality Potential: Can balance emitted and absorbed carbon when managed sustainably.

Biomass encounters various challenges:

1. Resource Limitations: Availability is affected by location, seasons, and energy demands for processing and transport.
2. Environmental Impact: Intensive production can harm ecosystems and soil quality, leading to habitat destruction.
3. Storage Challenges: Biomass requires specialized storage, increasing costs and logistical issues.
4. Emissions and Efficiency: Incomplete combustion causes pollution, and biomass technology is less efficient compared to other renewables.
5. Sustainability Risks: Unsustainable harvesting can lead to deforestation and ecosystem disruption, endangering long-term sustainability.
6. Investment Requirements: Developing efficient biomass technologies demands substantial infrastructure and research investment.

6.1.2. Ground Source Heat Pump (GSHP)

Ground source heat pumps (GSHPs) offer key advantages:

1. High Efficiency: Utilize stable ground temperatures, reducing utility bills by efficiently heating and cooling.
2. Cost-Effective Operation: Despite higher setup costs, GSHPs have lower maintenance expenses and long-term savings compared to conventional systems.
3. Environmental Friendliness: Emit fewer greenhouse gases, reducing a building's carbon footprint by using ground temperature.
4. Versatile and Integrated: Suited for heating and cooling, adaptable to diverse buildings, and compatible with radiant floor heating systems.
5. Reliable Performance: Ground temperature stability ensures consistent, year-round heating and cooling reliability.
6. Long Lifespan: With proper maintenance, GSHP systems outlast traditional HVAC systems, contributing to sustainability.
7. Incentives and Rebates: Eligible for financial benefits in some regions, offsetting initial installation costs.
8. Reduced Noise, Space-Efficient Design: Operate quietly and don't require visible outdoor units, saving space and making them suitable for various property types.

Constraints of Ground Source Heat Pumps (GSHPs):

1. High Installation Costs: Costs are notably higher due to significant upfront expenses, especially from ground loop installation.
2. Site Limitations: Unsuitability in certain locations due to soil conditions or limited space poses installation challenges.
3. Complex Installation and Maintenance: Specialized knowledge and equipment result in potentially costly and intricate processes.
4. Electricity Dependency: Reliance on electricity may lead to a carbon footprint and issues during power outages.
5. Potential Ground Loop Issues: Leaks or system degradation could necessitate costly repairs over time.
6. Regulatory Compliance Complexity: Meeting local regulations and environmental standards adds complexity and time to the installation process.
7. Varied Efficiency: Performance may fluctuate based on climate, soil, and property size, affecting efficiency in extreme weather.
8. Noise Considerations: While generally quiet, some systems might produce noise, posing concerns in specific settings or for noise-sensitive individuals.

6.1.3. Air Source Heat Pump (ASHP)

Air source heat pumps (ASHPs) provide numerous advantages:

1. Enhanced Energy Efficiency: Extracts heat from the outside air, offering efficient heating and cooling, potentially reducing utility bills compared to traditional systems.
2. Cost-Effective Operation: Despite higher installation costs, ASHPs have lower long-term operating and maintenance expenses.
3. Environmental Friendliness: Produces fewer greenhouse gas emissions, reducing the carbon footprint compared to conventional heating systems.
4. Year-round Versatility: Suitable for both heating and cooling, efficiently functioning in diverse climates.
5. Ease of Installation: Simpler to install compared to ground source heat pumps, adaptable to various property types.
6. Safety and Convenience: Operates without combustion, reducing accident risks and eliminating on-site fuel storage needs.
7. Rapid Heat Recovery: Quickly and effectively heats or cools spaces, ensuring prompt comfort for occupants.
8. Incentives and Rebates: Eligible for incentives, tax credits, or rebates in some regions, offsetting initial installation costs.

Air source heat pumps (ASHPs) present several constraints:

1. Temperature Dependency: Efficiency decreases in very cold weather, potentially requiring additional heating for adequate warmth.
2. Operational Noise: Some ASHP units generate noise, which might be problematic in noise-sensitive or residential areas.
3. Space Requirements: Installation may need significant outdoor space, limiting suitability in compact or space-constrained locations.
4. Fluctuating Efficiency: Performance varies with climate, impacting energy efficiency in extreme weather conditions.
5. Installation Challenges: Not all structures accommodate ASHP installation due to existing systems or construction limitations, often necessitating substantial alterations.
6. Defrost Cycle Impact: Cold weather triggers defrost cycles, affecting heating efficiency during these periods.
7. Electricity Reliance: Dependency on electricity makes the system susceptible to power outages or electrical issues.
8. High Initial Costs: Despite long-term savings, higher installation costs compared to traditional systems might create a financial barrier for some users.

6.1.4. Solar Hot Water

Solar hot water systems offer advantages:

1. Renewable Energy Source: Utilize sunlight, reducing reliance on non-renewable resources for water heating.
2. Energy Cost Savings: Harness solar energy, offering significant savings in water heating costs, especially in sun-rich areas.
3. Environmental Benefits: Produce clean energy, reducing reliance on fossil fuels, cutting greenhouse gas emissions, and minimizing the carbon footprint.
4. Low Maintenance and Long Lifespan: With minimal upkeep and a long operational life, they ensure efficient performance over many years.
5. Diverse Application: Versatile in providing hot water for residential, commercial, and industrial needs.
6. Energy Independence: Decrease reliance on external energy sources, fostering a level of energy self-sufficiency.
7. Incentives and Rebates: Governments offer incentives, rebates, or tax credits, reducing initial installation costs in many regions.
8. Scalability and Compatibility: Systems are adaptable to meet various hot water demands, from small residential setups to larger commercial or industrial applications.

Constraints of solar hot water systems:

1. Initial Costs: Higher installation costs might pose a financial barrier initially, despite long-term savings.
2. Space Requirement: Need for substantial installation space, particularly for solar thermal collectors, limiting applicability in compact settings.
3. Weather Dependency: Efficiency impacted by weather conditions, reducing effectiveness in heating water during overcast days or low sunlight.
4. Performance Variability: Seasonal changes may affect consistent hot water supply.
5. Maintenance Needs: Although generally low, periodic upkeep and repairs contribute to overall costs.
6. Regulatory Barriers: Local regulations, zoning, or building codes can complicate system installation.
7. Installation Challenges: Not all buildings suit solar thermal collectors, requiring structural modifications.
8. Backup Heating Requirement: Additional heating may be needed for periods of low sunlight or high hot water demand.

6.1.5.Solar Photovoltaics

Solar photovoltaics PV benefits:

1. Renewable Energy Source: Harness sunlight, reducing reliance on non-renewable energy.
2. Lower Energy Costs: Reduces electricity bills, especially in sun-rich areas, offering long-term savings.
3. Environmentally Friendly: Produces clean energy, cutting reliance on fossil fuels and combating climate change.
4. Energy Independence: Generates electricity, reducing dependency on external energy sources.
5. Low Maintenance, Long Lifespan: Minimal upkeep and extended operational life ensure reliable energy for years.
6. Diverse Applications: Usable in residential, commercial, and industrial settings.
7. Incentives and Rebates: Government incentives reduce initial installation costs, promoting adoption.
8. Scalability and Modularity: Tailored to various energy needs, from small residential to larger utility applications.
9. Grid Independence, Backup Power: Off-grid capability and battery storage ensure continuous power during outages or in remote areas.

Constraints of solar photovoltaics:

1. High Initial Costs: Upfront installation expenses can be a financial barrier for users despite long-term savings.
2. Weather Dependence: Efficiency affected by weather conditions, reducing effectiveness during overcast days or in regions with less sunlight.
3. Space Requirements: Larger systems need significant space, potentially limiting installation in compact areas.
4. Energy Storage Challenges: Additional solutions like batteries are often necessary for power during low sunlight, increasing complexity and costs.
5. Performance Variability: Fluctuations due to seasonal changes or shading affect consistent electricity generation.
6. Regulatory Hurdles: Local regulations and building codes might complicate or restrict PV system installation.
7. Intermittency and Grid Integration: Challenges in integrating intermittent energy production into existing power infrastructure.
8. Maintenance and Lifespan Concerns: While typically low, periodic upkeep and component replacement influence overall system costs over its lifespan.

6.1.6. Wind Energy

Wind energy is a renewable and sustainable power source that provides several significant benefits:

1. Renewable and Sustainable: Wind energy is inexhaustible, providing a constant power source without depleting natural resources.
2. Low Environmental Impact: Wind turbines generate electricity without emitting greenhouse gases or pollutants, significantly reducing the environmental footprint.
3. Cost-Effective: Once established, wind energy has low operational costs, making it increasingly cost-competitive for new electricity generation.
4. Energy Independence: Wind energy reduces dependence on imported fuels, enhancing energy security.
5. Job Creation: The wind energy sector creates jobs in manufacturing, installation, maintenance, and support services.
6. Scalability: Wind farms can be built on various scales, from small local projects to large commercial farms.
7. Technological Advancements: Ongoing improvements in turbine technology enhance the viability and output of wind power.
8. Land Use: Wind turbines have a small footprint, allowing the surrounding land to be used for agriculture or other purposes.
9. Community Benefits: Wind projects can provide income for landowners and communities through leasing agreements and tax revenues.
10. Grid Stability: With proper integration and storage solutions, wind energy can help balance supply and demand, contributing to grid stability and resilience.

While wind energy offers numerous benefits, it also faces challenges:

1. Intermittency: Variable production requires storage or backup systems.
2. High Initial Costs: Significant upfront investment, balanced by low operational costs.
3. Location Limitations: Ideal sites are often remote or offshore, increasing grid connection and transmission costs.
4. Aesthetic and Noise Concerns: Turbines can be visually and audibly intrusive, leading to local opposition.
5. Environmental Impact: Potential effects on wildlife and ecosystems during construction and operation.
6. Land Use Conflicts: Competition with agriculture, forestry, or recreation for land.
7. Grid Integration: Difficulty in integrating fluctuating wind power into existing grids without advanced management and storage.
8. Resource Availability: Uneven distribution of suitable wind resources across regions.
9. Maintenance and Repair: Costly upkeep, particularly in harsh environments.
10. Regulatory and Permitting Challenges: Complex processes for project approval and compliance.

6.2. Options Selection

Following a thorough assessment in the Options Appraisal, two distinct renewable technologies were carefully selected for further consideration and subsequent integration into the ongoing development process. These chosen technologies underwent a meticulous evaluation process, demonstrating significant promise in meeting the sustainability goals and energy needs of the project. Their selection marks a pivotal phase in the project's development, where each technology will be meticulously examined, integrated, and implemented, aligning with the overarching objectives of sustainability and environmentally conscious initiatives.

6.2.1. Solar Photovoltaics

Solar photovoltaics (PV) have been selected for several compelling reasons, reflecting their diverse benefits and strategic advantages in sustainable energy production:

1. Environmental Benefits:
   - No Local Air Quality Impacts: Solar PV systems generate electricity without emitting pollutants, contributing to cleaner air.
   - High Carbon Savings: They significantly reduce carbon emissions by producing renewable energy and minimizing reliance on fossil fuels.
2. Utilization of Space:
   - Unutilized Roof Space: They can be installed on rooftops, converting idle space into productive energy-generating areas, which is especially advantageous in urban settings where land is scarce.
3. Operational Advantages:
   - No Noise Issues: Solar PV systems operate silently, making them ideal for residential areas and noise-sensitive environments.
   - Minimal Maintenance: They require limited servicing, typically one visit per year, and have few moving parts, reducing long-term maintenance concerns.
4. Economic Considerations:
   - Feed-in Tariff and Incentives: Financial incentives such as Feed-in Tariffs can help offset the initial installation costs, making solar PV a more attractive investment.
   - Typical Payback Period: The payback period for solar PV systems ranges from 10 to 15 years, after which the system continues to generate free electricity, providing long-term economic benefits.
5. Energy Independence:
   - Minimal Grid Electricity Use: By generating their own electricity, solar PV systems reduce dependence on the grid, enhancing energy security and resilience.
6. Technological and Installation Factors:
   - Good Orientation and Buildability: While optimal orientation and slightly increased buildability efforts are required for wiring and metering, these are manageable considerations given the overall benefits.

Despite the high embodied energy of the panels and the need for inverter replacement during the system's lifespan, the long-term environmental and economic benefits of solar PV systems make them a highly attractive and strategic choice for sustainable energy production.

6.2.2.Solar Photovoltaics - Performance

A photovoltaic panel system totalling 25.2 kWp (comprising 63 panels at 400W each) has been specified for the entire development. This section provides a detailed overview of the lifecycle costs, revenue projections, and payback analysis associated with these photovoltaic panels.

The proposed high efficiency panels have a lifecycle of 25 years. The calculation of their lifecycle cost includes maintenance and replacement expenses. The total costs for the system's projected lifetime are summarized in the table below.

	Value
Capital Cost (£)	30,000
Maintenance Cost (£)	2,000
Operational Cost (£)	1,000
Total (£)	33,000
Cost of Electricity (p/kWh)	17.0
Electricity Generation (kWh/yr)	16,872
% of Energy Used on Site	100
Savings (£)	3,573
Summary	
Cost Performance Criteria	Value
Extra Cost Over Life Cycle (£)	33,000
Predicted Annual Saving (£)	3,573
Payback Period (yrs)	9.2
Energy & Carbon Performance Criteria	Value
Predicted Annual Energy Saved (kWh/yr)	16,872
Annual Carbon Emissions Reductions (kg CO2/year)	2,137
Emissions Reduction (%)	11.88

*The above calculations are based on the non-domestic elements of the development.

6.2.3. Air Sourced Heat Pump (ASHP)

Air Source Heat Pumps (ASHPs) have been selected for several compelling reasons, reflecting their advantages in both environmental and operational contexts. Here are the key factors behind their selection:

1. Environmental Benefits:
   - No Local Air Quality Impacts: ASHPs produce heat without emitting pollutants, thus contributing to cleaner air in the local environment.
   - Medium Carbon Savings: By displacing gas, ASHPs offer significant carbon savings, particularly as the electricity grid becomes more decarbonized.
2. Space Utilization:
   - Use of Unutilized Roof Space: ASHPs can be installed in areas that might otherwise be unused, such as rooftops, making efficient use of available space.
3. Operational Considerations:
   - Low Noise Issues: ASHPs operate with relatively low noise, making them suitable for residential and other noise-sensitive areas.
   - Limited Servicing and Maintenance: They require minimal servicing, typically just one visit per year, though mechanical parts may need replacement over their lifespan.
4. Economic and Financial Factors:
   - Renewable Heat Incentive (RHI): Financial incentives like the RHI can help offset the medium to high capital costs of installation, improving the economic viability of ASHPs.
   - Payback Period: Although the typical payback period is more than 15 years when displacing gas, the long-term benefits can justify the initial investment.
5. Technological and Installation Factors:
   - Increased Buildability Issues: ASHPs require additional considerations for pipework and heating emitters internally, but these challenges are manageable.
   - High Embodied Energy: While the equipment has high embodied energy, the long-term operational savings and environmental benefits can outweigh this initial impact.
6. Efficiency and Performance:
   - Less Efficient in Winter: ASHPs are less efficient in colder temperatures, but they still offer a viable heating solution, particularly when paired with a decarbonizing electricity grid.

Overall, the selection of ASHPs is driven by their ability to provide efficient, low-emission heating, their operational and maintenance simplicity, and the financial incentives that support their adoption. Despite the challenges of higher installation costs and efficiency drops in colder weather, ASHPs present a sustainable and environmentally friendly heating solution.

6.2.4. Air Sourced Heat Pump – Performance

The proposed system has a lifecycle of 15 years. To calculate the total lifecycle cost of the ASHP (Air Source Heat Pump), we will consider maintenance costs and the electricity consumption for running the pumps.

The communal ASHP is expected to achieve a Coefficient of Performance (CoP) of 3.5 for space heating and 3.0 for meeting 80% of the hot water demand. The remaining 20% of the hot water demand will be addressed by an immersion heater. A thermal store will be included to optimize the system's efficiency.

The table below provides a summary comparing the reduction in carbon emissions and the lifecycle cost of the ASHP system versus a gas boiler.

	Gas Boiler	Air Sourced Heat Pump
	Heating & Hot Water	Heating & Hot Water
Installation Cost (£)	15,000	60,000
Maintenance and replacement cost (£)	20,000	30,000
Total (£)	35,000	90,000
Energy demand (kWh/yr)	210,962	110,713
Cost of gas/electricity (p/kWh)	8.0	17.0
Annual operational cost (£)	26,747	20,910

It should be noted that the figures presented are for CO_2 compliance. Given the nature of the compliance models and calculations undertaken, they are not ideal for investment appraisals due to their limited accuracy in estimating actual energy consumption. It is anticipated that under real-world operating conditions and consumption patterns, the lifecycle savings for ASHP will likely exceed those of a boiler.

Furthermore, the proposed servicing strategy is aligned with sustainability goals and compliance with GLA (Greater London Authority) requirements. This approach is intended to prioritise energy strategy considerations over simplistic economic payback assessments.

Cost Performance Criteria	Value
Extra Cost Over Life Cycle (£)	55,000
Predicted Annual Saving (£)	5,837
Payback Period (yrs)	9.4
Energy & Carbon Performance Criteria	**Value**
Predicted Annual Energy Saved (kWh/yr)	100,249
Annual Carbon Emissions Reductions (kg CO2/year)	3,847
Emissions Reduction (%)	18.80

6.3. Be Green Development CO_2 Emissions

	Regulated emissions tCO2/annum]	Unregulated CO2 Emissions (kgCO2/annum)	Regulated energy (MWh/annum)	Unregulated energy (MWh/annum)
Domestic	0.80	3.86	9.29	18.64
Non-Domestic	17.99	5.67	144.51	40.85

7. Conclusion

The development is at the forefront of sustainable design, dedicating substantial efforts to align its strategy with the energy hierarchy. This strategic approach places a strong emphasis on minimising energy demand as the primary goal before considering other measures. This is achieved by prioritising passive design measures and adopting a fabric-first approach. By focusing on optimising the building's envelope, the development effectively lowers the demand for heating and power. This initial step is pivotal in the broader effort to mitigate carbon dioxide (CO2) emissions associated with the building's operation.

In summary, the developments holistic approach to sustainable design prioritises energy demand reduction through passive design measures and a fabric-first approach. By integrating these strategies with energy-efficient building services, the development not only demonstrates its dedication to environmental responsibility but also sets a robust example in the pursuit of sustainable and energy-efficient buildings.

Site Wide	Total regulated emissions kgCO2/m^2/annum)	Cumulative CO2 savings (tCO2/annum)	Accumulative Percentage Savings
Baseline*	32.76	41,571	-
After Lean Measures	21.89	25,953	33.18
After Clean Measures	-	-	-
After Green Measures	13.01	18,789	60.29

Domestic	Total regulated emissions kgCO2/m^2/annum)	Cumulative CO2 savings (tCO2/annum)	Accumulative Percentage Savings (%)
Baseline*	19.51	38,911	-
After Lean Measures	12.02	23,973	38.39
After Clean Measures	-	-	-
After Green Measures	9.02	17,989	53.77

Non-Domestic	Total regulated emissions kgCO2/m^2/annum)	Cumulative CO2 savings (tCO2/annum)	Accumulative Percentage Savings
Baseline*	13.25	2660	-
After Lean Measures	9.87	1980	25.51
After Clean Measures	-	-	-
After Green Measures	3.99	800	69.89

Appendix

Residential Be Lean, Be Clean & Be Green

Non-Domestic Be Lean, Be Clean & Be Green