Energy and Sustainability Statement

Gordon House

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Prepared on Behalf of:
English Rose Estates

Prepared by:
Sean Mills, Sustainability Consultant

Build Energy Ltd
The Old Stable Block, Priory House Car Park,
Quay Road, Christchurch BH23 1BU
01202 280062 info@buildenergy.co.uk

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Executive Summary

This Energy & Sustainability report has been produced on behalf of English Rose Estates to demonstrate that an application for the creation of nine new dwellings at Gordon House is compliant with the carbon reduction targets set by the Greater London Authority (GLA) and the London Borough of Camden.

Greater London Authority (GLA) Targets

The GLA sets targets for reduction in carbon dioxide (CO_2) emissions above those required by Part L of the Building Regulations where there is a major development. A major development is defined in The Town and Country Planning (Development Management Procedure) (England) Order 2010 as one meeting any one of the following criteria:

- The number of dwelling provided is **ten or more**, or the number of dwellings is not yet known but the development is to be carried out on a site having an area of 0.5 hectares or more.
- The provision of a building or buildings where the floor space to be created by the development is **1,000m^2 or more.**
- The development is carried out on a site having an area of **1 hectare or more**.

The regulated carbon dioxide emissions reduction target set by the GLA for major new build domestic developments is zero carbon (100% over Part L1a of the Building Regulations). This must be achieved with a minimum of 35% on site.

The regulated carbon dioxide emissions reduction target for major new build non-domestic developments is 35% over Part L2a of the Building Regulations.

There are no fixed targets for developments created through change of use, however applicants are still expected to demonstrate how individual elements of the energy hierarchy have been implemented and how reductions in regulated CO_2 emissions over those resulting from minimum compliance with parts L1b and L2b of the Building Regulations have been achieved.

Targets set by the London Borough of Camden

In the case of a minor development, it is the responsibility of the Local Authority to set a target for reduction in CO_2 emissions over Part L of the Building Regulations, in this case the London Borough of Camden.

Reduction in CO_2 achieved at the proposed Gordon House development

The proposed Gordon House scheme is defined as a minor development under the criteria described above. As such the carbon reduction targets set by the London Borough of Camden apply. The development consists of 9 new build homes.

As such there is **a 20% target** reduction in CO_2 emissions over Part L of the Building Regulations through on site solutions following the energy hierarchy. Camden policy CS13 also requires that all developments (existing and new build) achieve a 20% reduction in on-site carbon dioxide emissions through renewable technologies, unless demonstrated that such provision is not feasible.

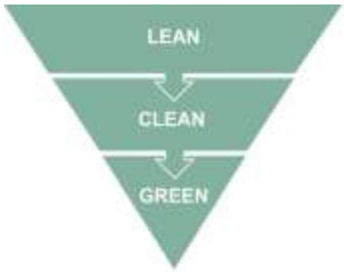
This report outlines the measures and specification put in place to ensure that the Gordon House project follows the energy hierarchy and achieves an improvement of **41.64%** over Part L of the Building Regulations.

The appendices of this report contain graphs and tables demonstrating carbon dioxide emissions and regulation carbon dioxide savings at the Gordon House project at each stage of the energy hierarchy. These have been calculated and presented in accordance with the methods outlined within 'Energy Planning – Greater London Authority guidance on preparing energy assessments (March 2016)'. These are explained in more detail in the rest of this report. Additional sustainability considerations have also been addressed.

1. Establishing CO_2 emissions

This energy assessment seeks to clearly identify the carbon footprint of the development at the Gordon House development after each stage of the energy hierarchy. This includes regulated emissions and, separately, those emissions associated with uses not covered by Building Regulations i.e. unregulated energy uses. The methodologies for calculating emissions in this report have been taken from GLA guidance on preparing energy statements.

The Greater London Authority (GLA) describes the energy hierarchy as follows:



- Baseline Emissions: Compliance with the relevant Part L 2013 Building Regulations only.
- Be Lean: Active and passive demand reduction measures.
- Be Clean: Choice of heating and active cooling equipment.
- Be Green: Use of renewable energy generation on site.

Calculating regulated CO_2 emissions for a Part L 2013 of the Building Regulations compliant development

This energy assessment has established the regulated CO_2 emissions assuming the development complied with Part L 2013 of the Building Regulations, using Building Regulations approved compliance software. Building Regulations approved software is as follows:

- SAP 2012 for Dwellings.
- SBEM for Non-Domestic Buildings.

When determining this baseline, it has been assumed that the heating would be provided by 89.5% efficient gas boilers and that any active cooling present in the final design specification would be provided by electrically powered equipment. This is consistent with Greater London Authority guidance.

Reporting from SAP and SBEM software presents CO_2 emissions as kg/m^2/year. The Greater London Authority has specified a methodology for converting these figures into tonnes of CO_2 per annum for comparisons as follows. For each non-domestic building, the Target Emissions Rate (TER) should be multiplied by its floor area to provide the related regulated CO_2 emissions. For each representative dwelling, the related TER is multiplied by the cumulative floor area for that dwelling type to establish the related CO_2 emissions. The CO_2 emissions for each non-domestic building and dwelling type are then summed to give the total regulated emissions for the development. It is this methodology which has been used when calculating emissions in tonnes per years for the Gordon House development.

Two samples representing all proposed plots have been modelled for the purposes of this report.

The GLA has also stipulated that the carbon dioxide emissions factors used in this energy assessment must be those adopted for Part L 2013 of the Building Regulations. These can be found in Table 12 of SAP 2012. Although the carbon factor from grid electricity may fluctuate significantly during the lifetime of a development, the approach insisted upon by the GLA is to use the value which has been adopted within Building Regulations at the time of the application for planning permission.

As Building Regulations approved software uses the emissions factors adopted within the Building Regulations at the time of writing, by using this software to assess the Gordon House development the correct emissions factors have been used.

The baseline levels of emissions in tonnes of CO_2 per year can be found within the appendices of this report.

To calculate the target emission levels in tonnes of CO_2, the baseline emissions have been multiplied by the 20% target (divided by 100). This is shown in the appendices of this report also.

Calculating regulated CO_2 emissions at each stage of the energy hierarchy

The methodology described with the GLA's guidance on preparing energy statements has been followed for measuring regulated CO_2 emissions at each stage of the hierarchy. This methodology is as follows:

- For dwellings, the Dwelling CO_2 Emissions Rate (DER) is calculated through the Part L 2013 of the Building Regulations methodology SAP 2012. This is then multiplied by the cumulative floor area for the particular dwelling type in question to give the related CO2 emissions. A representative sample must be modelled.

- For non-domestic buildings, a Building CO_2 Emissions Rate (BER) calculated through the Part L 2013 of the Building Regulations methodology based on the National Calculation Methodology (NCM) and implemented through SBEM 15 v5.2d or later or equivalent software. For each building, the related BER is multiplied by its floor area to give the related carbon dioxide emissions.

This is repeated at each stage of the energy hierarchy as regulated emissions are reduced through changes in specification from the baseline.

Unregulated emissions have also been presented alongside regulated emissions in the appendices of this report.

Calculating Unregulated CO_2 Emissions

Unregulated emissions are those produced through uses which are not assessed under Part L of the Building Regulations. These cannot be measured with Building Regulations approved software such as SAP or SBEM and so must be calculated separately.

The Greater London Authority (GLA) has stated in its guidance for producing energy statements that unregulated emissions are to be presented separately alongside regulated emissions. These are not however included in the GLA's methodologies for calculating the baseline emissions, nor those reduced through the stages of the energy hierarchy, which are described earlier in this report. Unregulated emissions in dwellings typically include those resulting from cooking or use of appliances. Non-domestic unregulated emissions are more varied but could refer to uses such as catering, computing, etc.

For domestic unregulated emissions, the GLA recommended that 'BRE Domestic Energy Model (BREDEM) or a similar methodology' is used. The BRE Domestic Energy Model (BREDEM) is a methodology for calculating the energy use and fuel requirements of dwellings based on their characteristics. It shares several features with SAP. The key benefits of BREDEM are that variables such as occupancy rates can be altered if they are known to be different from the assumptions made in similar resources such as SAP 2012 or BRE CSH tools. However, for use in this report there is little basis for altering these assumptions as future occupancy or usage patterns cannot be reasonably predicted.

Unfortunately, no calculator tools are currently available to implement this methodology. Build Energy has sought the advice of John Henderson of BRE (co-author of the 2012 edition of BREDEM model), who advises that other BRE tools are more suitable for the purposes of meeting the requirements set out by the GLA.

BRE's CSH tools were produced to calculate unregulated emissions for use in meeting the planning requirements set under the former Code for Sustainable Homes. These calculate unregulated emissions using regulated emissions figures produced in SAP and a dwelling's total floor area. Like BREDEM, these results are based upon variables for occupancy and usage, however BRE CSH tools rely on assumptions for these variables based on the floor size of the property being assessed.

Build Energy has sought the advice of the GLA on the use of BRE CSH tools, and they have confirmed that this method for calculating unregulated emissions is acceptable to them on the basis that they are similar to BREDEM. It is therefore this method that has been adopted for calculating domestic unregulated emissions.

For non-dwellings, unregulated emissions are established by using individual end use figures (for example catering and computing) from CIBSE guide baselines.

2. Demand Reduction (Be Lean)

The following section of the report outlines measures which have been taken to reduce the energy demand of the development. This includes both architectural and building fabric measures (passive design) and energy efficient services (active design). Introducing demand reduction features has been considered at the earliest design stage of the Gordon House development.

Demonstrating CO_2 savings from demand reduction measures

Active design measures to reduce energy demand are described by the GLA as including high efficiency lighting and ventilation. In addition, it is expected that information is provided on enhanced U-value numbers, air tightness improvement and the development's approach to limiting thermal bridges. The specification for this items as proposed for the Gordon House project is outlined below:

Demand Reduction Measures	**Specification**
Building Fabric - U-Values (W/m²K)	
Walls	0.16
Floors	0.14
Roofs - Sloped (Sloped Ceiling)	0.14
Glazing	1.4
Building Fabric - Other	
Air Permeability (m^2/hm^2)	4.0
Thermal Bridging	Accredited Construction Details Throughout
Services	
Ventilation	Natural
Lower Energy Lighting	100%

Table 1 - Specification for 'Be Lean' Case

The carbon produced and reductions achieved by the Gordon House project when this specification is applied are shown in the appendices of this report. SAP 2012 output documents including DER worksheets for the 'Be Lean' scenario are also provided.

The GLA has stated that passive design measures, including optimising orientation and site layout, natural ventilation and lighting, thermal mass and solar shading, should be set out in the Design and Access statement. As such these are outside of the scope of this report. The glazing percentages of the Gordon House project are shown within the SAP documents which are included within the appendices of this report.

It is the intention of the applicant to provide smart metres at the Gordon House development to support the growth of demand side response.

3. Heating infrastructure including CHP (Be Clean)

The energy systems for use at the Gordon House development have been selected in accordance with the order of preference in Policy 5.6B of the London Plan.

Connection to area wide low carbon heat distribution networks

A Heat Mapping Study completed in 2015 provides heat mapping across the borough, and seeks to establish areas of high heat demand where heat networks could be viable. This development is sited in an area of relatively low heat demand and no networks planned.

Combined Heat and Power (CHP)

A Combined Heat and Power system (CHP) or cogeneration is the simultaneous generation of both heat and power (thermal energy and electricity). This is achieved through recovering heat generated in the production of electricity, which can be utilised in providing space heating and hot water.

The most common fuel used in the UK to power a CHP engine is natural gas although LPG, biogas, ethanol, methane, hydrogen, biofuel, oil or any fuel that can drive an engine can be used. A CHP operating on fossil fuels, e.g. gas, diesel, is not considered a renewable technology. A biomass CHP, however, is considered to be a renewable energy technology but it is only suitable for developments with larger heat and electricity demands.

A CHP system uses on average 35% less primary energy compared to conventional heat-only boilers and power stations approaching efficiencies as high as 75%. Although not a renewable technology, except if biomass is being used, CHP is considered very efficient, reducing carbon emissions related to a site's energy consumption while providing electricity and heat to occupiers.

The GLA does not recommend CHP for use in developments consisting of 500 units or less, as 'at this scale it is generally not economical'.

CHP installed at the Gordon House development to meet the base heat load would require the export of electricity to the national grid as it would likely exceed demand. The GLA continues to state that '…the administrative burden of managing CHP electricity sales at this small scale where energy service companies (ESCOs) are generally not active, and the low unit price available for small volumes of exported CHP electricity, means it is generally uneconomic for developers to pursue'.

CHP requires significant infrastructure and a substantial heat demand. In order to obtain maximum efficiency, it is necessary to have an energy demand profile which is evenly spread throughout the day and night. A CHP unit will operate efficiently when running continuously and so requires its energy to be used continuously to avoid wastage. This usage profile does not match that of the proposed development.

For these reasons the applicant is not specifying a CHP system for the Gordon House development.

Proposed Heating and Cooling Specification

The proposed ‘Be Clean’ specification for the Gordon House development is shown below.

Element	Specification
Heating Infrastructure	
Type	Mains gas boiler.
Efficiency	89.50%
Controls	Time and Temperature Zone Controls Delayed Start Thermostats
Heat Recovery Technologies	Waste Water Heat Recovery
	Flue Gas Heat Recovery
Hot Water	
Type	From main heating.
Ventilation	
Type	Mechanical ventilation system to achieve a minimum Effective Air Change Rate of 7, in line with the London Plan Cooling Hierarchy.

Table 2 - Specification for 'Be Clean' Case

The carbon produced by the Gordon House project when this specification is applied is shown in the appendices of this report. SAP 2012 output documents including DER worksheets for the ‘be clean’ scenario are also provided.

4. Renewable Energy (Be Green)

Technological Consideration

The use of renewables for the Gordon House development has been considered as follows.

Photovoltaic Panels

Photovoltaic panel systems convert energy from the sun into electricity through semi-conductor cells mounted in collector panels. The panels are connected to an inverter to turn the DC output into AC for use in the building to which they are attached and to be fed back into the grid when not required. Photovoltaic arrays provide a quiet and effective renewable energy source with a relatively low aesthetic impact. The major benefit of PV systems is the significant reductions they can achieve in comparison to other technologies, in terms of CO_2 and energy use.

The PV panels should ideally be orientated between southeast and southwest (optimally south). The optimal tilt angle (inclination of panel from horizontal) should be calculated to ensure the best possible output of the system during the year. In the UK, the angles of most pitched roofs are suitable for mounting PV panels. Panels can also be mounted on A-frames on flat roofed buildings. PV technology comes in a range of forms: PV panels that can be retrofitted to the roof of an existing building or equally, sunk to fit flush with the roof line; PV cells that are 'laminated' between sheets of glass to provide shading in a glazed area, and PV cladding.

PV systems are low maintenance as they have no moving parts and panels generally have 25 year warranties, although the lifetime of the panel can be expected to be beyond this time.

The PV systems should not be shaded. Shading caused by other buildings, greenery and roof 'furniture' such as chimneys or satellite dishes, even over a small area of the panel, can significantly reduce performance. Excess energy can be exported to the grid. Although the Feed-in Tariffs are generally not high, exporters can negotiate with their utility company. Future consideration may be given to the benefits of battery storage.

Payback times for this technology are usually approximately twenty years; but this is reducing year on year as the technology matures and are set to reduce further as fuel prices increase. Integrating PV into a building and replacing other building materials can further offset the cost.

PV has been identified as a suitable technology for incorporation at the Gordon House development. A minimum of 0.8kWp per plot has been specified to attain a reduction in carbon dioxide emissions of 41.64% over Part L of the Building Regulations.

Solar hot water systems

Solar water heating systems use the energy from the sun to heat water stored in a hot water cylinder inside the building.

A solar collector comprises a housing that contains piping, through which the carrier fluid circulates, and a glass panel to retain the radiation from the sun. The temperature inside the collector increases and this heat is then transferred to a carrier fluid. In an open loop system, the hot water is heated directly.

Solar thermal panels are generally black in appearance for maximising energy absorption and the glass panels have a special coating in order to retain as much heat as possible.

Two types of collector exist: flat plate and evacuated tube. Flat plate collectors can be mounted on or flush with the roof. The air in the collection tubes can be evacuated to reduce heat losses within the frame by convection. Evacuated tube collectors need to be re-evacuated every few years. They are more difficult to install but are more efficient and allow higher temperature heating.

Solar thermal collectors offer a good price-performance ratio. Solar hot water systems are best suited to developments with high hot water requirements, such as hotels, care homes and leisure centres. Many systems have been installed in the UK and they work well, even without direct sunlight.

Solar thermal systems should be sized to the hot water requirements of the user since any excess heat that is generated cannot be exported elsewhere. The optimal angle for mounting depends on when the water demand is greatest. Ideally, the collectors should be mounted onto a non-shaded, south-facing roof.

Solar thermal technology is a cost effective way to reduce carbon emissions, especially if it is replacing electric water heating.

Due to limited roof space at the Gordon House development, solar hot water cannot be used effectively alongside photovoltaic arrays. Accordingly, it is considered preferable to install photovoltaic arrays over solar hot water where only one technology can be favoured.

Biomass heating

With the long term availability of fossil fuels such as oil and gas, and the persistent number of price rises of oil and natural gas a growing concern in the UK, alternative heating methods such as wood burning boilers are becoming more popular.

Due to technical advances in wood burning technology, and improvements in the preparation of wood fuels, efficiencies of new wood pellet burning boilers have increased to around 90%, with carbon monoxide emissions dropping dramatically.

There are three types of wood burning boiler - logs, woodchips and wood pellets. Wood logs are the most readily available, generally produced as a by-product from forestry and woodland from sawmills, tree surgery and wind damage.

Wood chips have a high moisture content which tends to restrict their efficiency to only 50% and they tend to suffer from blockages hence we would be cautious about their use on this site. Storage space requirements are also high due to the irregularity of the chips. Wood pellets are made from dry waste wood, such as used pallets and off-cuts/sawdust from furniture manufacturers. The waste wood is compressed into uniform, high density pellets that are easier to transport, handle and store than other forms of wood fuel.

Biomass combustion systems (BCS) are generally more mechanically complex than conventional boiler heating systems, especially when it comes to fuel delivery, storage, handling and combustion. The complexity is necessary because of the different combustion characteristics of biomass as compared to conventional fossil fuels. The increased complexity means higher capital costs than for conventional systems. BCSs typically require more frequent maintenance and greater operator attention than conventional systems. As a result, the degree of operator dedication to the system is critical to its success. They often require special attention to fire insurance premiums, air quality standards, ash disposal options and general safety issues.

Domestic scale boilers such as Woodchip-fed systems remain very costly and the requirements for siting both the boiler and the fuel source were considered impractical for this development.

There are also some concerns on current availability of suitable fuel within a reasonable distance of the development as well as the additional traffic that would be associated with it. The use of efficient heat pumps is considered more suitable.

Biomass can be burnt directly to provide heat in buildings using wood from forests, urban tree pruning, and farmed coppices or as liquid biofuel, such as bio diesel. In non-domestic applications, biomass boilers replace conventional fossil fuel boilers and come with automated features to enable reduced user intervention.

Due to the size of the proposed project, biomass energy has not been considered as an economically suitable technology for this development.

Heat Pumps

Air source heat pumps operate by converting the energy of the outside air into heat, creating a comfortable temperature inside the building as well as supplying energy for the hot water system. As with all heat pumps, air source models are most efficient when supplying low temperature systems such as underfloor heating. An air source heat pump extracts heat from the outside air in the same way that a fridge extracts heat from its inside. It can extract heat from the air even when the outside temperature is as low as minus 15°C. Cold water or another fluid is circulated through pipes, picking up the ambient temperature and then passing through the heat exchanger (the evaporator) in the heat pump unit. The heat exchanger extracts heat from the fluid, using a refrigerant compression cycle to upgrade the heat to a usable temperature (+55°C). This heat is then transferred to the heating system via another heat exchanger, the condenser of the heat pump.

Accordingly, ASHP heating systems generally run at a lower temperature than conventional heating systems. There are two main types of air source heat pumps. An air-to-water system uses the heat to warm water. Heat pumps heat water to a lower temperature than a standard boiler system would, so they are better suited to underfloor heating systems than radiator systems.

An air-to-air system produces warm air, which is circulated by fans to heat the building. Whilst heat pumps are not a wholly renewable energy source due to use of electricity, the renewable component is considered as the heat is extracted from the air. It is measured as the difference between heat outputs, less the primary electrical energy input. Using this heat, for every Watt of electrical energy supplied to the system, 4 Watts or more of heating energy can be supplied to a heating system. This 'Coefficient of Performance' (CoP) of 4 is effectively an 'efficiency' of 400% for the system and compares very favourably with even the best gas condensing boiler's efficiency of around 85%. The smaller the temperature difference between the source and the output temperature of the heat pump (i.e. the temperature of the distribution system) the higher the heat pump's CoP.

Unlike boilers, there is no pollution on-site and as the mix of power stations used to supply the electricity grid gets 'cleaner', with more renewable electricity generation being brought on line, so the carbon emissions from the heat pumps system will decrease even further.

The key operational benefit of air source heat pumps for the user is the reduction in fuel bills. In addition, space savings can be made over other plant types as an air source heat pump unit is compact, and requires no storage space for fuel.

Since air source heat pumps produce less heat than traditional boilers, it is essential that the building where the air source heat pump is proposed is well insulated and draught proofed for the heating system to be effective. Fans and compressors integral to the air source heat pump unit generate some noise, but this is generally acceptable especially where outdoor units can be located away from windows and adjacent buildings. By selecting a heat pump with an outdoor sound rating of 7.6 dB or lower and mounting the unit on a noise-absorbing base these issues can be resolved for the site.

Costs for installing a typical system vary but they are considerably more economical to install than an equivalent capacity ground source heat system and can produce similar levels of energy and carbon savings. Actual running costs and savings for space heating will vary depending on a number of factors - including the size and use pattern of the building and how well insulated it is.

Due to outdoor space constraints and noise considerations, it is preferred to opt for photovoltaic panels with high efficiency mains gas boilers for the proposed Gordon House development.

Renewable Technology at the Gordon House Development

PV has been identified as a suitable technology for incorporation at the Gordon House development. A minimum of 0.8kWp per plot mounted south at c.a. 30' has been specified.

The carbon produced by the Gordon House project when this specification is applied is shown in the appendices of this report. The results of these improvements show a **41.64%** reduction in emissions over the Part L compliant base case, exceeding the target, of which **23.90%** has been achieved through renewables alone.

5. Cooling and Overheating

An overheating assessment has been carried out as a part of the process to produce SAP calculations. This assessment is related to the factors that contribute to internal temperature: solar gain (taking account of orientation, shading and glazing transmission), ventilation (taking account of window opening in hot weather), thermal capacity and mean summer temperature for the location of the dwelling. Full details of this methodology and relevant calculations can be found in the latest approved SAP document.

Using these criteria, the proposed Gordon House development has been found to be compliant with overheating rules within SAP. Please see Appendix C for the relevant calculations and results.

6. Carbon Offsetting

This report demonstrates that the proposed Gordon House development is capable of reducing carbon dioxide emissions by 41.64% over Part L of the Building Regulations. This reduction is higher than the required target of 20%, as such there is no requirement for offsetting.

7. Monitoring

English Rose Estates will consider options for post occupancy monitoring of the Gordon House development in accordance with advice and guidance from the GLAs Supplementary Planning Guidance. It is the intention of the applicant to provide smart metres at the Gordon House development to support the growth of demand side response.

8. Additional Sustainability Considerations

The report so far has sought to address sustainability concerns by following guidance from the GLA, however many London Boroughs also operate their own guidance with separate considerations and requirements. The following section of this report looks to address issues not covered by the GLA, but where there may be requirements set by the London Borough of Camden. Solutions to these concerns are presented alongside English Rose Estates' broader efforts to promote and encourage the sustainability of the Gordon House development.

Internal Water Use

It is the intention of English Rose Estates to reduce the consumption of potable water in the Gordon House development from all sources, through the use of efficient fittings and flow restrictors where required. Performance in domestic properties will be assessed under the methodologies set out in Part G of the Building Regulations, once a full design stage sanitary specification has been established.

This will result in all dwellings within the Gordon House development achieving a maximum internal water use of 105 litres per person/day by design.

Flood Risk & Surface Water Run-off

It is recommended that a Flood Risk Assessment and Surface Water Run-off reporting is undertaken to ensure compliance with any local, GLA or national requirements.

Materials and Waste Reduction

Sustainable Specification

Materials will be chosen to lower the environmental impact of the Gordon House development wherever possible. BRE's Green Guide will be consulted when finalising specifications of products and element build types. This applies primarily to:

- Roofs
- External walls
- Internal walls (including separating walls)
- Upper and ground floors (including separating floors)
- Windows

In all cases, it is the applicant's intention to secure Green Guide ratings of between A+ and D, exceeding the requirements of the former Code for Sustainable Homes.

All timber used during the development will come from a 'legal source' and will not be on the CITES list, or in the case of Appendix III of the CITES list, it will not have been sourced from a country seeking to protect this species as listed in Appendix III.

To promote the reduction of emissions of gases with high Global Warming Potential (GWP) associated with the manufacture, installation, use and disposal of foamed thermal and acoustic insulating materials, products will be chosen with a GWP of <5 wherever possible.

Wherever possible, products will be chosen which comply with additional voluntary industry standards for responsible sourcing, including FSC Chain of Custody and BES 6001:2008 Framework Standard for Responsible Sourcing of Construction Products certifications where applicable.

Products such as paints and vanishes will be sourced to minimise the use of Volatile Organic Compounds (Formaldehyde, VCM, etc.).

Minimising Site Waste

A Site Waste Management Plan (SWMP) will be created to include procedures, commitments for waste minimisation and diversion from landfill, as well as setting target benchmarks for resource efficiency in accordance with guidance from:

- DEFRA (Department for Environment, Food and Rural Affairs)
- BRE (Building Research Establishment)
- Envirowise
- WRAP (Waste & Resources Action Programme)
- Environmental performance indicators and/or key performance indicators (KPI) from Envirowise or Constructing Excellence.

The applicant will seek to establish a 'take back' scheme from suppliers in order to avoid the unnecessary waste of excess materials. Care will also be taken to minimise loss through breakage etc. following guidance from the Waste and Resources Action Programme (WRAP) and others.

The London Borough of Camden requires that developers aim to source at least 10% of the total value of materials used during the construction phase of the build from recycled or reused sources. This target will be incorporated into the SWMP.

Biodiversity

The presence of any significant ecological features as defined using guidance from BRE will be noted, and the appropriate measures for protection and conservation undertaken before works begin. Features to promote biodiversity, such as bird and bat boxes will be incorporated into the design wherever feasible.

It is proposed that green roofs are provided on the sloped areas over multi floor units 1 and 3, as well as third floor units 7,8 and 9. Planting will be positioned where space is not already occupied by photovoltaic panels required as a response to carbon reduction through renewables targets. The size and type of green roof will be determined with consultation from a biologist or other suitable expert.

Appendices

Appendix A – Domestic Results Tables
Appendix B – SAP Documents
Appendix C – SAP Overheating Reports

Appendix A - Domestic Results Tables

Cumulative Emissions & Savings

The following tables are presented in accordance with the advice presented within 'Energy Planning - Greater London Authority guidance on preparing energy assessments'.

	Carbon dioxide emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	12.42	2.84
After energy demand reduction	11.77	2.84
After heat network / CHP	10.22	2.84
After renewable energy	7.25	2.84

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings.

	Regulated Carbon dioxide savings	
	(Tonnes CO_2 / annum)	(%)
Savings from energy demand reduction	0.65	5.23
Savings from heat network / CHP	1.55	12.51
Savings from renewable energy	2.97	23.90
Cumulative on site Savings	**5.17**	**41.64**
Total Target Savings	2.48	20.00
Annual Surplus	2.69	

Table 2: Regulated carbon dioxide savings from each stage of the Energy Hierarchy for domestic buildings.

Results by Plot

Baseline

Baseline: Part L 2013 of the Building Regulations Compliant Development	**Domestic Total (Sum)**	Unit 1 (Two Storey)	Unit 6 (Single Storey)
	Cumulative CO_2 Emissions (tonnes CO_2 per annum)	Cumulative CO_2 Emissions (tonnes CO_2 per annum)	Cumulative CO_2 Emissions (tonnes CO_2 per annum)
Baseline	**12.418**	2.084	10.334

Be Lean

After energy demand reduction	**Domestic Total (Sum)**	Unit 1 (Two	Unit 6 (Single
	Cumulative CO_2 Emissions (tonnes CO_2 per annum)	Cumulative CO_2 Emissions (tonnes CO_2 per annum)	Cumulative CO_2 Emissions (tonnes CO_2 per annum)
Baseline	**12.418**	2.084	10.334
Be Lean	**11.769**	2.054	9.715
% Improvement	**5.23**	1.45	5.99

Be Lean & Clean

After heat network / CHP	**Domestic Total (Sum)**	Unit 1 (Two	Unit 6 (Single
	Cumulative CO_2 Emissions (tonnes CO_2 per annum)	Cumulative CO_2 Emissions (tonnes CO_2 per annum)	Cumulative CO_2 Emissions (tonnes CO_2 per annum)
Baseline	**12.418**	2.084	10.334
Be Lean & Clean	**10.216**	1.845	8.371
% Improvement	**17.73**	11.50	18.99

Be Lean, Clean & Green

After renewable energy	**Domestic Total (Sum)**	Unit 1 (Two	Unit 6 (Single
	Cumulative CO_2 Emissions (tonnes CO_2 per annum)	Cumulative CO_2 Emissions (tonnes CO_2 per annum)	Cumulative CO_2 Emissions (tonnes CO_2 per annum)
Baseline	**12.418**	2.084	10.334
Be Lean, Clean & Green	**7.248**	1.486	5.761
% Improvement	**41.64**	28.68	44.25

Unregulated Emissions

Emissions from Sources not Regulated under	**Domestic Total (Sum)**	Unit 1 (Two	Unit 6 (Single

SAP WorkSheet: New dwelling design stage

User Details:

Assessor Name:	Peter Mitchell	**Stroma Number:**	STRO007945
Software Name:	Stroma FSAP 2012	**Software Version:**	Version: 1.0.4.5

Property Address: Unit 1 (GF&FF END) CLEAN

Address : New Dwelling at:, Gordon House, 6 Lissenden Gardens, LONDON, NW5 1LX

1. Overall dwelling dimensions:

	Area(m²)			Av. Height(m)			Volume(m³)	
Ground floor	73.62	(1a)	x	2.4	(2a)	=	176.69	(3a)
First floor	64.14	(1b)	x	3.32	(2b)	=	212.94	(3b)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	137.76	(4)						
Dwelling volume				(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n)		=	389.63	(5)

2. Ventilation rate:

	main heating		secondary heating		other		total		m³ per hour	
Number of chimneys	0	+	0	+	0	=	0	x 40 =	0	(6a)
Number of open flues	0	+	0	+	0	=	0	x 20 =	0	(6b)
Number of intermittent fans							0	x 10 =	0	(7a)
Number of passive vents							0	x 10 =	0	(7b)
Number of flueless gas fires							0	x 40 =	0	(7c)

Air changes per hour

Infiltration due to chimneys, flues and fans = (6a)+(6b)+(7a)+(7b)+(7c) =	0	÷ (5) =	0	(8)

If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)

Number of storeys in the dwelling (ns)		0	(9)
Additional infiltration	[(9)-1]x0.1 =	0	(10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction		0	(11)

if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35

If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0		0	(12)
If no draught lobby, enter 0.05, else enter 0		0	(13)
Percentage of windows and doors draught stripped		0	(14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =	0	(15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =	0	(16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area		4	(17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)	0.2	(18)

Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used

Number of sides sheltered		3	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.78	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.16	(21)

Infiltration rate modified for monthly wind speed

Monthly average wind speed from Table 7

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(22)m=	5.1	5	4.9	4.4	4.3	3.8	3.8	3.7	4	4.3	4.5	4.7

Wind Factor (22a)m = (22)m ÷ 4

(22a)m=	1.27	1.25	1.23	1.1	1.08	0.95	0.95	0.92	1	1.08	1.12	1.18

Adjusted infiltration rate (allowing for shelter and wind speed) = (21a) x (22a)m

0.2	0.19	0.19	0.17	0.17	0.15	0.15	0.14	0.16	0.17	0.17	0.18

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0.5 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0.5 (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = 0 (23c)

a) If balanced mechanical ventilation with heat recovery (MVHR) (24a)m = (22b)m + (23b) × [1 – (23c) ÷ 100]

(24a)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24a)

b) If balanced mechanical ventilation without heat recovery (MV) (24b)m = (22b)m + (23b)

(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24b)

c) If whole house extract ventilation or positive input ventilation from outside

if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

(24c)m=	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	(24c)

d) If natural ventilation or whole house positive input ventilation from loft

if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24d)

Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25)

(25)m=	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Windows Type 1			5.31	x1/[1/(1.4)+ 0.04]		=	7.04			(27)
Windows Type 2			8.12	x1/[1/(1.4)+ 0.04]		=	10.77			(27)
Windows Type 3			2.53	x1/[1/(1.4)+ 0.04]		=	3.35			(27)
Windows Type 4			2.53	x1/[1/(1.4)+ 0.04]		=	3.35			(27)
Windows Type 5			2.53	x1/[1/(1.4)+ 0.04]		=	3.35			(27)
Windows Type 6			2.53	x1/[1/(1.4)+ 0.04]		=	3.35			(27)
Windows Type 7			0.69	x1/[1/(1.4)+ 0.04]		=	0.91			(27)
Windows Type 8			1.27	x1/[1/(1.4)+ 0.04]		=	1.68			(27)
Windows Type 9			3.42	x1/[1/(1.4)+ 0.04]		=	4.53			(27)
Rooflights			12.74	x1/[1/(1.4) + 0.04]		=	17.836			(27b)
Walls	147.2	28.93	118.27	x	0.16	=	18.92			(29)
Roof Type1	9.48	0	9.48	x	0.14	=	1.33			(30)
Roof Type2	71.67	12.74	58.93	x	0.14	=	8.25			(30)
Total area of elements, m²			228.35							(31)
Party wall			37.15	x	0	=	0			(32)
Party wall			11.57	x	0	=	0			(32)

* *for windows and roof windows, use effective window U-value calculated using formula 1/[(1/U-value)+0.04] as given in paragraph 3.2*

** *include the areas on both sides of internal walls and partitions*

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 83.74 (33)

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Heat capacity Cm = S(A x k) ((28)…(30) + (32) + (32a)…(32e) = 0 (34)

Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K Indicative Value: Medium 250 (35)

For design assessments where the details of the construction are not known precisely the indicative values of TMP in Table 1f can be used instead of a detailed calculation.

Thermal bridges : S (L x Y) calculated using Appendix K 16.5 (36)

if details of thermal bridging are not known (36) = 0.15 x (31)

Total fabric heat loss (33) + (36) = 100.24 (37)

Ventilation heat loss calculated monthly (38)m = 0.33 × (25)m x (5)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	64.29	64.29	64.29	64.29	64.29	64.29	64.29	64.29	64.29	64.29	64.29	64.29	(38)

Heat transfer coefficient, W/K (39)m = (37) + (38)m

(39)m=	164.53	164.53	164.53	164.53	164.53	164.53	164.53	164.53	164.53	164.53	164.53	164.53	

Average = Sum(39)$_{1…12}$ /12= 164.53 (39)

Heat loss parameter (HLP), W/m²K (40)m = (39)m ÷ (4)

(40)m=	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	

Average = Sum(40)$_{1…12}$ /12= 1.19 (40)

Number of days in month (Table 1a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(41)m=	31	28	31	30	31	30	31	31	30	31	30	31	(41)

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N 2.91 (42)

if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)

if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 103.38 (43)

Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	

Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)

(44)m=	113.71	109.58	105.44	101.31	97.17	93.04	93.04	97.17	101.31	105.44	109.58	113.71	

Total = Sum(44)$_{1…12}$ = 1240.52 (44)

Energy content of hot water used - calculated monthly = 4.190 x Vd,m x nm x DTm / 3600 kWh/month (see Tables 1b, 1c, 1d)

(45)m=	168.63	147.49	152.2	132.69	127.32	109.86	101.81	116.82	118.22	137.77	150.39	163.31	

Total = Sum(45)$_{1…12}$ = 1626.52 (45)

If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (61)

(46)m=	25.3	22.12	22.83	19.9	19.1	16.48	15.27	17.52	17.73	20.67	22.56	24.5	(46)

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel 0 (47)

If community heating and no tank in dwelling, enter 110 litres in (47)

Otherwise if no stored hot water (this includes instantaneous combi boilers) enter ‘0’ in (47)

Water storage loss:

a) If manufacturer’s declared loss factor is known (kWh/day): 0 (48)

Temperature factor from Table 2b 0 (49)

Energy lost from water storage, kWh/year (48) x (49) = 0 (50)

b) If manufacturer’s declared cylinder loss factor is not known:

Hot water storage loss factor from Table 2 (kWh/litre/day)		0	(51)
If community heating see section 4.3			
Volume factor from Table 2a		0	(52)
Temperature factor from Table 2b		0	(53)
Energy lost from water storage, kWh/year	(47) x (51) x (52) x (53) =	0	(54)
Enter (50) or (54) in (55)		0	(55)

Water storage loss calculated for each month ((56)m = (55) × (41)m

(56)m=	0	0	0	0	0	0	0	0	0	0	0	0	(56)

If cylinder contains dedicated solar storage, (57)m = (56)m x [(50) – (H11)] ÷ (50), else (57)m = (56)m where (H11) is from Appendix H

(57)m=	0	0	0	0	0	0	0	0	0	0	0	0	(57)

Primary circuit loss (annual) from Table 3 — 0 (58)

Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m

(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

(59)m=	0	0	0	0	0	0	0	0	0	0	0	0	(59)

Combi loss calculated for each month (61)m = (60) ÷ 365 × (41)m

(61)m=	50.96	46.03	50.96	49.32	49.52	45.88	47.41	49.52	49.32	50.96	49.32	50.96	(61)

Total heat required for water heating calculated for each month (62)m = 0.85 × (45)m + (46)m + (57)m + (59)m + (61)m

(62)m=	219.59	193.52	203.15	182	176.84	155.75	149.22	166.34	167.53	188.73	199.71	214.27	(62)

Solar DHW input calculated using Appendix G or Appendix H (negative quantity) (enter '0' if no solar contribution to water heating)

(add additional lines if FGHRS and/or WWHRS applies, see Appendix G)

(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)
FHRS	54.42	39.63	30.2	16.04	10.19	8.06	7.72	8.7	8.75	22.92	40.08	55.71	(63) (G2)
WWHRS	-55.17	-48.54	-49.54	-40.75	-37.83	-31.2	-26.4	-31.97	-32.9	-40.69	-47.14	-53.33	(63) (G10)

Output from water heater

(64)m=	108.17	103.69	121.58	123.43	127.03	114.83	113.39	123.89	124.11	123.3	110.71	103.4	

Output from water heater (annual)$_{1…12}$ — 1397.53 (64)

Heat gains from water heating, kWh/month 0.25 ´ [0.85 × (45)m + (61)m] + 0.8 x [(46)m + (57)m + (59)m]

(65)m=	68.81	60.55	63.34	56.45	54.71	48	45.7	51.22	51.64	58.55	62.33	67.04	(65)

include (57)m in calculation of (65)m only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a):

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	174.76	174.76	174.76	174.76	174.76	174.76	174.76	174.76	174.76	174.76	174.76	174.76	(66)

Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5

(67)m=	68.39	60.74	49.4	37.4	27.96	23.6	25.5	33.15	44.49	56.49	65.94	70.29	(67)

Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5

(68)m=	457.99	462.74	450.76	425.27	393.08	362.84	342.63	337.88	349.85	375.35	407.53	437.78	(68)

Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5

(69)m=	55.39	55.39	55.39	55.39	55.39	55.39	55.39	55.39	55.39	55.39	55.39	55.39	(69)

Pumps and fans gains (Table 5a)

(70)m=	3	3	3	3	3	3	3	3	3	3	3	3	(70)

Losses e.g. evaporation (negative values) (Table 5)

(71)m=	-116.51	-116.51	-116.51	-116.51	-116.51	-116.51	-116.51	-116.51	-116.51	-116.51	-116.51	-116.51	(71)

Water heating gains (Table 5)

(72)m=	92.49	90.1	85.14	78.4	73.54	66.67	61.43	68.85	71.72	78.7	86.57	90.11	(72)

Total internal gains = (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m

(73)m=	735.51	730.22	701.95	657.71	611.22	569.75	546.2	556.52	582.7	627.18	676.68	714.82	(73)

6. Solar gains:

Solar gains are calculated using solar flux from Table 6a and associated equations to convert to the applicable orientation.

Orientation:	Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
Northeast 0.9x	0.77	x	2.53	x	11.28	x	0.76	x	0.7	=	10.52	(75)
Northeast 0.9x	0.77	x	2.53	x	11.28	x	0.76	x	0.7	=	10.52	(75)
Northeast 0.9x	0.77	x	2.53	x	11.28	x	0.76	x	0.7	=	10.52	(75)
Northeast 0.9x	0.77	x	2.53	x	11.28	x	0.76	x	0.7	=	10.52	(75)
Northeast 0.9x	0.77	x	2.53	x	22.97	x	0.76	x	0.7	=	21.42	(75)
Northeast 0.9x	0.77	x	2.53	x	22.97	x	0.76	x	0.7	=	21.42	(75)
Northeast 0.9x	0.77	x	2.53	x	22.97	x	0.76	x	0.7	=	21.42	(75)
Northeast 0.9x	0.77	x	2.53	x	22.97	x	0.76	x	0.7	=	21.42	(75)
Northeast 0.9x	0.77	x	2.53	x	41.38	x	0.76	x	0.7	=	38.6	(75)
Northeast 0.9x	0.77	x	2.53	x	41.38	x	0.76	x	0.7	=	38.6	(75)
Northeast 0.9x	0.77	x	2.53	x	41.38	x	0.76	x	0.7	=	38.6	(75)
Northeast 0.9x	0.77	x	2.53	x	41.38	x	0.76	x	0.7	=	38.6	(75)
Northeast 0.9x	0.77	x	2.53	x	67.96	x	0.76	x	0.7	=	63.39	(75)
Northeast 0.9x	0.77	x	2.53	x	67.96	x	0.76	x	0.7	=	63.39	(75)
Northeast 0.9x	0.77	x	2.53	x	67.96	x	0.76	x	0.7	=	63.39	(75)
Northeast 0.9x	0.77	x	2.53	x	67.96	x	0.76	x	0.7	=	63.39	(75)
Northeast 0.9x	0.77	x	2.53	x	91.35	x	0.76	x	0.7	=	85.2	(75)
Northeast 0.9x	0.77	x	2.53	x	91.35	x	0.76	x	0.7	=	85.2	(75)
Northeast 0.9x	0.77	x	2.53	x	91.35	x	0.76	x	0.7	=	85.2	(75)
Northeast 0.9x	0.77	x	2.53	x	91.35	x	0.76	x	0.7	=	85.2	(75)
Northeast 0.9x	0.77	x	2.53	x	97.38	x	0.76	x	0.7	=	90.84	(75)
Northeast 0.9x	0.77	x	2.53	x	97.38	x	0.76	x	0.7	=	90.84	(75)
Northeast 0.9x	0.77	x	2.53	x	97.38	x	0.76	x	0.7	=	90.84	(75)
Northeast 0.9x	0.77	x	2.53	x	97.38	x	0.76	x	0.7	=	90.84	(75)
Northeast 0.9x	0.77	x	2.53	x	91.1	x	0.76	x	0.7	=	84.97	(75)
Northeast 0.9x	0.77	x	2.53	x	91.1	x	0.76	x	0.7	=	84.97	(75)
Northeast 0.9x	0.77	x	2.53	x	91.1	x	0.76	x	0.7	=	84.97	(75)
Northeast 0.9x	0.77	x	2.53	x	91.1	x	0.76	x	0.7	=	84.97	(75)
Northeast 0.9x	0.77	x	2.53	x	72.63	x	0.76	x	0.7	=	67.74	(75)
Northeast 0.9x	0.77	x	2.53	x	72.63	x	0.76	x	0.7	=	67.74	(75)
Northeast 0.9x	0.77	x	2.53	x	72.63	x	0.76	x	0.7	=	67.74	(75)
Northeast 0.9x	0.77	x	2.53	x	72.63	x	0.76	x	0.7	=	67.74	(75)

Northeast	0.9x	0.77	x	2.53	x	50.42	x	0.76	x	0.7	=	47.03	(75)
Northeast	0.9x	0.77	x	2.53	x	50.42	x	0.76	x	0.7	=	47.03	(75)
Northeast	0.9x	0.77	x	2.53	x	50.42	x	0.76	x	0.7	=	47.03	(75)
Northeast	0.9x	0.77	x	2.53	x	50.42	x	0.76	x	0.7	=	47.03	(75)
Northeast	0.9x	0.77	x	2.53	x	28.07	x	0.76	x	0.7	=	26.18	(75)
Northeast	0.9x	0.77	x	2.53	x	28.07	x	0.76	x	0.7	=	26.18	(75)
Northeast	0.9x	0.77	x	2.53	x	28.07	x	0.76	x	0.7	=	26.18	(75)
Northeast	0.9x	0.77	x	2.53	x	28.07	x	0.76	x	0.7	=	26.18	(75)
Northeast	0.9x	0.77	x	2.53	x	14.2	x	0.76	x	0.7	=	13.24	(75)
Northeast	0.9x	0.77	x	2.53	x	14.2	x	0.76	x	0.7	=	13.24	(75)
Northeast	0.9x	0.77	x	2.53	x	14.2	x	0.76	x	0.7	=	13.24	(75)
Northeast	0.9x	0.77	x	2.53	x	14.2	x	0.76	x	0.7	=	13.24	(75)
Northeast	0.9x	0.77	x	2.53	x	9.21	x	0.76	x	0.7	=	8.59	(75)
Northeast	0.9x	0.77	x	2.53	x	9.21	x	0.76	x	0.7	=	8.59	(75)
Northeast	0.9x	0.77	x	2.53	x	9.21	x	0.76	x	0.7	=	8.59	(75)
Northeast	0.9x	0.77	x	2.53	x	9.21	x	0.76	x	0.7	=	8.59	(75)
Southwest	0.9x	0.77	x	5.31	x	36.79		0.76	x	0.7	=	72.03	(79)
Southwest	0.9x	0.77	x	8.12	x	36.79		0.76	x	0.7	=	110.15	(79)
Southwest	0.9x	0.77	x	3.42	x	36.79		0.76	x	0.7	=	46.39	(79)
Southwest	0.9x	0.77	x	5.31	x	62.67		0.76	x	0.7	=	122.69	(79)
Southwest	0.9x	0.77	x	8.12	x	62.67		0.76	x	0.7	=	187.62	(79)
Southwest	0.9x	0.77	x	3.42	x	62.67		0.76	x	0.7	=	79.02	(79)
Southwest	0.9x	0.77	x	5.31	x	85.75		0.76	x	0.7	=	167.88	(79)
Southwest	0.9x	0.77	x	8.12	x	85.75		0.76	x	0.7	=	256.71	(79)
Southwest	0.9x	0.77	x	3.42	x	85.75		0.76	x	0.7	=	108.12	(79)
Southwest	0.9x	0.77	x	5.31	x	106.25		0.76	x	0.7	=	208.01	(79)
Southwest	0.9x	0.77	x	8.12	x	106.25		0.76	x	0.7	=	318.08	(79)
Southwest	0.9x	0.77	x	3.42	x	106.25		0.76	x	0.7	=	133.97	(79)
Southwest	0.9x	0.77	x	5.31	x	119.01		0.76	x	0.7	=	232.98	(79)
Southwest	0.9x	0.77	x	8.12	x	119.01		0.76	x	0.7	=	356.28	(79)
Southwest	0.9x	0.77	x	3.42	x	119.01		0.76	x	0.7	=	150.06	(79)
Southwest	0.9x	0.77	x	5.31	x	118.15		0.76	x	0.7	=	231.3	(79)
Southwest	0.9x	0.77	x	8.12	x	118.15		0.76	x	0.7	=	353.7	(79)
Southwest	0.9x	0.77	x	3.42	x	118.15		0.76	x	0.7	=	148.97	(79)
Southwest	0.9x	0.77	x	5.31	x	113.91		0.76	x	0.7	=	223	(79)
Southwest	0.9x	0.77	x	8.12	x	113.91		0.76	x	0.7	=	341	(79)
Southwest	0.9x	0.77	x	3.42	x	113.91		0.76	x	0.7	=	143.62	(79)
Southwest	0.9x	0.77	x	5.31	x	104.39		0.76	x	0.7	=	204.36	(79)
Southwest	0.9x	0.77	x	8.12	x	104.39		0.76	x	0.7	=	312.51	(79)
Southwest	0.9x	0.77	x	3.42	x	104.39		0.76	x	0.7	=	131.62	(79)
Southwest	0.9x	0.77	x	5.31	x	92.85		0.76	x	0.7	=	181.77	(79)

Southwest	0.9x	0.77	x	8.12	x	92.85		0.76	x	0.7	=	277.97	(79)
Southwest	0.9x	0.77	x	3.42	x	92.85		0.76	x	0.7	=	117.07	(79)
Southwest	0.9x	0.77	x	5.31	x	69.27		0.76	x	0.7	=	135.6	(79)
Southwest	0.9x	0.77	x	8.12	x	69.27		0.76	x	0.7	=	207.36	(79)
Southwest	0.9x	0.77	x	3.42	x	69.27		0.76	x	0.7	=	87.34	(79)
Southwest	0.9x	0.77	x	5.31	x	44.07		0.76	x	0.7	=	86.28	(79)
Southwest	0.9x	0.77	x	8.12	x	44.07		0.76	x	0.7	=	131.93	(79)
Southwest	0.9x	0.77	x	3.42	x	44.07		0.76	x	0.7	=	55.57	(79)
Southwest	0.9x	0.77	x	5.31	x	31.49		0.76	x	0.7	=	61.64	(79)
Southwest	0.9x	0.77	x	8.12	x	31.49		0.76	x	0.7	=	94.26	(79)
Southwest	0.9x	0.77	x	3.42	x	31.49		0.76	x	0.7	=	39.7	(79)
Northwest	0.9x	0.77	x	0.69	x	11.28	x	0.76	x	0.7	=	2.87	(81)
Northwest	0.9x	0.77	x	1.27	x	11.28	x	0.76	x	0.7	=	5.28	(81)
Northwest	0.9x	0.77	x	0.69	x	22.97	x	0.76	x	0.7	=	5.84	(81)
Northwest	0.9x	0.77	x	1.27	x	22.97	x	0.76	x	0.7	=	10.75	(81)
Northwest	0.9x	0.77	x	0.69	x	41.38	x	0.76	x	0.7	=	10.53	(81)
Northwest	0.9x	0.77	x	1.27	x	41.38	x	0.76	x	0.7	=	19.37	(81)
Northwest	0.9x	0.77	x	0.69	x	67.96	x	0.76	x	0.7	=	17.29	(81)
Northwest	0.9x	0.77	x	1.27	x	67.96	x	0.76	x	0.7	=	31.82	(81)
Northwest	0.9x	0.77	x	0.69	x	91.35	x	0.76	x	0.7	=	23.24	(81)
Northwest	0.9x	0.77	x	1.27	x	91.35	x	0.76	x	0.7	=	42.77	(81)
Northwest	0.9x	0.77	x	0.69	x	97.38	x	0.76	x	0.7	=	24.77	(81)
Northwest	0.9x	0.77	x	1.27	x	97.38	x	0.76	x	0.7	=	45.6	(81)
Northwest	0.9x	0.77	x	0.69	x	91.1	x	0.76	x	0.7	=	23.17	(81)
Northwest	0.9x	0.77	x	1.27	x	91.1	x	0.76	x	0.7	=	42.66	(81)
Northwest	0.9x	0.77	x	0.69	x	72.63	x	0.76	x	0.7	=	18.48	(81)
Northwest	0.9x	0.77	x	1.27	x	72.63	x	0.76	x	0.7	=	34.01	(81)
Northwest	0.9x	0.77	x	0.69	x	50.42	x	0.76	x	0.7	=	12.83	(81)
Northwest	0.9x	0.77	x	1.27	x	50.42	x	0.76	x	0.7	=	23.61	(81)
Northwest	0.9x	0.77	x	0.69	x	28.07	x	0.76	x	0.7	=	7.14	(81)
Northwest	0.9x	0.77	x	1.27	x	28.07	x	0.76	x	0.7	=	13.14	(81)
Northwest	0.9x	0.77	x	0.69	x	14.2	x	0.76	x	0.7	=	3.61	(81)
Northwest	0.9x	0.77	x	1.27	x	14.2	x	0.76	x	0.7	=	6.65	(81)
Northwest	0.9x	0.77	x	0.69	x	9.21	x	0.76	x	0.7	=	2.34	(81)
Northwest	0.9x	0.77	x	1.27	x	9.21	x	0.76	x	0.7	=	4.31	(81)
Rooflights	0.9x	1	x	12.74	x	20.24	x	0.76	x	0.7	=	123.44	(82)
Rooflights	0.9x	1	x	12.74	x	40.55	x	0.76	x	0.7	=	247.33	(82)
Rooflights	0.9x	1	x	12.74	x	74.78	x	0.76	x	0.7	=	456.16	(82)
Rooflights	0.9x	1	x	12.74	x	130.19	x	0.76	x	0.7	=	794.13	(82)
Rooflights	0.9x	1	x	12.74	x	183.82	x	0.76	x	0.7	=	1121.29	(82)
Rooflights	0.9x	1	x	12.74	x	200.21	x	0.76	x	0.7	=	1221.24	(82)

Rooflights 0.9x	1	x	12.74	x	185.57	x	0.76	x	0.7	=	1131.99	(82)
Rooflights 0.9x	1	x	12.74	x	142.19	x	0.76	x	0.7	=	867.36	(82)
Rooflights 0.9x	1	x	12.74	x	93.09	x	0.76	x	0.7	=	567.83	(82)
Rooflights 0.9x	1	x	12.74	x	49.71	x	0.76	x	0.7	=	303.23	(82)
Rooflights 0.9x	1	x	12.74	x	25.27	x	0.76	x	0.7	=	154.14	(82)
Rooflights 0.9x	1	x	12.74	x	16.69	x	0.76	x	0.7	=	101.83	(82)

Solar gains in watts, calculated for each month (83)m = Sum(74)m …(82)m

(83)m=	402.26	738.95	1173.16	1756.84	2267.43	2388.92	2245.34	1839.3	1369.2	858.54	491.14	338.48	(83)

Total gains – internal and solar (84)m = (73)m + (83)m , watts

(84)m=	1137.77	1469.18	1875.1	2414.54	2878.65	2958.67	2791.54	2395.82	1951.9	1485.72	1167.82	1053.3	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (°C) | 21 | (85)

Utilisation factor for gains for living area, h1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(86)m=	0.99	0.97	0.91	0.74	0.52	0.35	0.26	0.32	0.56	0.88	0.98	0.99	(86)

Mean internal temperature in living area T1 (follow steps 3 to 7 in Table 9c)

(87)m=	19.91	20.18	20.54	20.86	20.98	21	21	21	20.98	20.73	20.23	19.84	(87)

Temperature during heating periods in rest of dwelling from Table 9, Th2 (°C)

(88)m=	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	19.92	(88)

Utilisation factor for gains for rest of dwelling, h2,m (see Table 9a)

(89)m=	0.99	0.97	0.89	0.69	0.46	0.3	0.2	0.24	0.48	0.84	0.97	0.99	(89)

Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c)

(90)m=	18.49	18.88	19.39	19.79	19.91	19.92	19.92	19.92	19.91	19.65	18.96	18.4	(90)

fLA = Living area ÷ (4) = | 0.47 | (91)

Mean internal temperature (for the whole dwelling) = fLA × T1 + (1 – fLA) × T2

(92)m=	19.15	19.48	19.93	20.29	20.4	20.42	20.42	20.42	20.41	20.15	19.55	19.07	(92)

Apply adjustment to the mean internal temperature from Table 4e, where appropriate

(93)m=	19	19.33	19.78	20.14	20.25	20.27	20.27	20.27	20.26	20	19.4	18.92	(93)

8. Space heating requirement

Set Ti to the mean internal temperature obtained at step 11 of Table 9b, so that Ti,m=(76)m and re-calculate the utilisation factor for gains using Table 9a

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation factor for gains, hm:													
(94)m=	0.99	0.96	0.89	0.7	0.48	0.31	0.22	0.27	0.51	0.85	0.97	0.99	(94)
Useful gains, hmGm , W = (94)m x (84)m													
(95)m=	1122.35	1411.9	1662.21	1700.22	1385.25	931.07	604.36	636.73	992.53	1256.99	1132.62	1042.95	(95)
Monthly average external temperature from Table 8													
(96)m=	4.3	4.9	6.5	8.9	11.7	14.6	16.6	16.4	14.1	10.6	7.1	4.2	(96)
Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m]													
(97)m=	2418.69	2374.95	2184.48	1849.18	1407.54	933.38	604.64	637.46	1012.84	1546.61	2023.93	2421.65	(97)
Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m													
(98)m=	964.47	647.17	388.57	107.26	16.59	0	0	0	0	215.48	641.74	1025.75	

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 4007.02 (98)

Space heating requirement in kWh/m²/year 29.09 (99)

9a. Energy requirements – Individual heating systems including micro-CHP)

Space heating:

Fraction of space heat from secondary/supplementary system		0	(201)
Fraction of space heat from main system(s)	(202) = 1 – (201) =	1	(202)
Fraction of total heating from main system 1	(204) = (202) × [1 – (203)] =	1	(204)
Efficiency of main space heating system 1		90.4	(206)
Efficiency of secondary/supplementary heating system, %		0	(208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year	
Space heating requirement (calculated above)	964.47	647.17	388.57	107.26	16.59	0	0	0	0	215.48	641.74	1025.75		
(211)m = {[(98)m x (204)] } x 100 ÷ (206)	1066.9	715.89	429.83	118.65	18.35	0	0	0	0	238.36	709.89	1134.68		(211)
Total (kWh/year) =Sum(211)$_{1...5,10....12}$=													4432.55	(211)
Space heating fuel (secondary), kWh/month = {[(98)m x (201)] } x 100 ÷ (208) (215)m=	0	0	0	0	0	0	0	0	0	0	0	0		
Total (kWh/year) =Sum(215)$_{1...5,10....12}$=													0	(215)

Water heating

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Output from water heater (calculated above)	108.17	103.69	121.58	123.43	127.03	114.83	113.39	123.89	124.11	123.3	110.71	103.4		
Efficiency of water heater													80.3	(216)
(217)m=	89.27	88.86	87.77	84.7	81.35	80.3	80.3	80.3	80.3	86.44	88.76	89.37		(217)
Fuel for water heating, kWh/month (219)m = (64)m x 100 ÷ (217)m (219)m=	121.18	116.69	138.52	145.73	156.15	143.01	141.2	154.29	154.55	142.63	124.73	115.7		
Total = Sum(219a)$_{1...12}$ =													1654.38	(219)

Annual totals		**kWh/year**	**kWh/year**	
Space heating fuel used, main system 1			4432.55	
Water heating fuel used			1654.38	
Electricity for pumps, fans and electric keep-hot				
mechanical ventilation - balanced, extract or positive input from outside		139.75		(230a)
central heating pump:		30		(230c)
boiler with a fan-assisted flue		45		(230e)
Total electricity for the above, kWh/year	sum of (230a)…(230g) =		214.75	(231)
Electricity for lighting			483.11	(232)

10a. Fuel costs - individual heating systems:

	Fuel kWh/year	**Fuel Price** (Table 12)	**Fuel Cost** £/year