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ENERGY STRATEGY
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FOREWORD

About /INTEGRATION

INTEGRATION provide building services and environmental design consultancy for architects, developers and private clients.

INTEGRATION was founded on the principle that for buildings to be sustainable its designers must integrate sustainability into their day-to-day design processes and ongoing learning and development programmes.

About the author:

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As a Director of Integration, Alan brings fifteen-years' experience spanning sustainable building and energy design, development, implementation and post-occupancy evaluation.

He has worked on several prestigious developments such as one of the first BREEAM "Excellent" buildings (The National Assembly of Wales) and one of the first BREEAM "Outstanding" buildings (the London School of Economics Student Centre) as well as major international developments such as Central Market and the Zayed National Museum in Abu Dhabi. He also led the technical development of the Blind Light exhibition for artist Antony Gormley. He has studied the real-world energy performance of large commercial buildings and carried out numerous energy audits for clients such as the Crown Estate.

He has a 1st Class Degree and PhD in engineering, is a Chartered Environmentalist (CEnv) and a member of the Energy Institute (MEI) and has been lecturing for over ten years at one of the leading architectural schools, the Architectural Association in London, to Sustainable Environmental Design (SED) Masters students and undergraduates. He was the lead author of the Urban Wind Energy book and the journal paper: "London 2012 Velodrome – integrating advanced simulation into the design process". The main industry body, CIBSE, now use examples of his project work to exemplify best practice building simulation in their latest industry guides.

CONTENTS

EXECUTIVE SUMMARY

This energy assessment has been prepared by Integration Consultancy Limited in support of the planning application for the proposed refurbishment and extension at 5 Denmark Street in the London Borough of Camden.

National, Regional and Local Policy, in particular the London Plan 2016 and the Borough of Camden development management policies, outline main aspects which should be addressed in the planning application for the proposed development. In line with these policies, the development's energy aspirations are to minimise CO_2 through aspects such as a high-performance fabric and achieve **renewable energy deployment which meets 20% of the CO_2 emissions** associated with the development's regulated energy demand where feasible**.**

For the new residential areas the proposed design achieves a **25.2% carbon dioxide emissions reduction** compared to the building regulations Part L1B (2013) baseline. The breakdown in accordance with the London Plan's energy hierarchy is shown below.

The **renewable energy contribution of the scheme is 20.6%** of the CO_2 emissions from the total regulated energy demand (Be Lean") of the new residential areas compared with a target of 20%. This is achieved using 3.48kW$_{peak}$ of solar photovoltaic (PV) modules located at roof level.

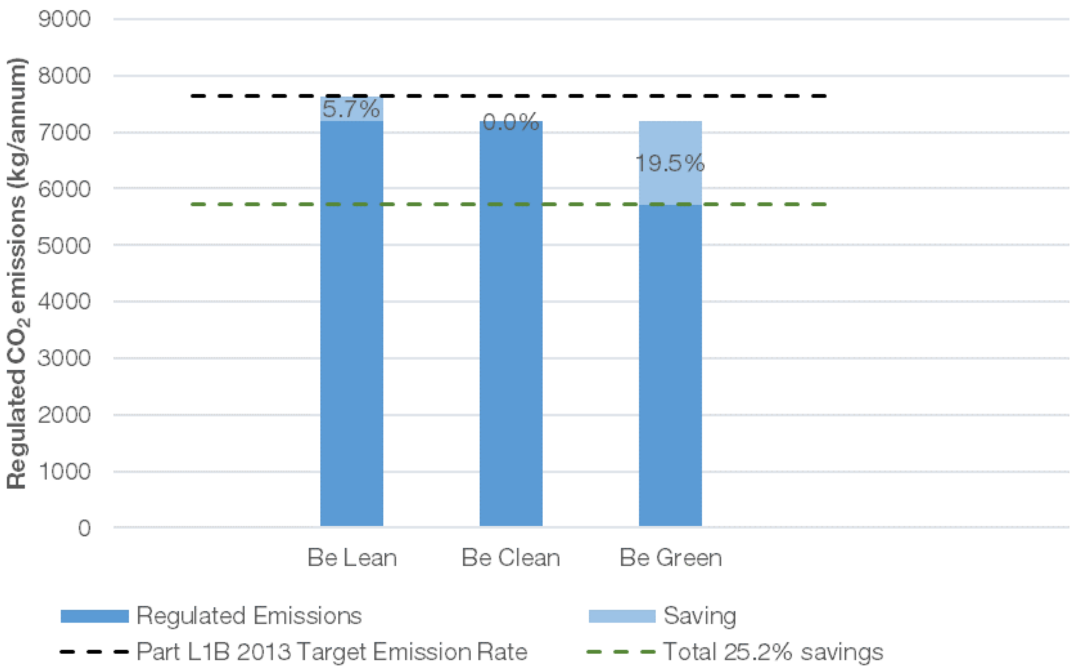


Figure 1: Summary of the scheme's regulated energy use as compared to the CO_2 emission baseline and target

The table below shows the regulated energy use for the residential units.

Location	Carbon dioxide emissions for residential units (Tonnes CO_2 per annum)
Baseline: Part L 2013 (Building Regulations) Compliance	7.64
After "Be Lean" (energy demand reduction)	7.20
After "Be Clean" (heat network / CHP / chiller plant)	7.20
After "Be Green" (renewable energy)	5.71

Table 1: Residential regulated CO2 emissions after each stage of the Energy Hierarchy

This performance can be expressed as savings between each stage in the energy hierarchy.

	Regulated residential carbon dioxide savings	
Location	**(Tonnes CO_2 per annum)**	**(%)**
Savings from "Be Lean" (energy demand reduction)	0.44	5.7%
Savings from "Be Clean" (heat network / CHP / chiller plant)	0.0	0.0%
Savings from "Be Green" (renewable energy)	1.49	19.5%
Cumulative on site savings	1.92	**25.2%**

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

1 INTRODUCTION

Integration Consultancy Limited have been appointed to undertake an energy assessment in support of the full planning application for the proposed development at 5 Denmark Street in London. The report is one of several that accompany the planning application and should be read in conjunction with these documents.

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

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

1. 'Be lean' (energy demand minimisation through 'passive' and 'active' design measures)
2. 'Be clean' (efficient energy supply)
3. 'Be green' (renewable energy generation where feasible)

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

PROPOSED DEVELOPMENT OVERVIEW
The site is located at 5 Denmark Street, London, WC2H 8LP, in the Borough of Camden.

The proposed development involves the refurbishment and extension of a listed early Georgian 4-storey building. The listing includes for the protection of the brick façade and glazing on Denmark Street.

The project includes changing the existing office use (B1) to provide residential units (C3) on upper floors, adding a mansard roof and some minor alterations to the retail areas.

The proposed accommodation is summarised below. The total area for the residential units is 328m^2.

Floor	Existing	Proposed
Third and Fourth	Office	Residential 3-Bedroom including extension
Second	Office	Residential 2-Bedroom including extension
First	Office	Residential 2-Bedroom
Ground	Retail	Retail
Basement	Retail	Retail

Table 3: Summary of the proposed development

ENERGY TARGETS
The scheme will comply with the building regulation but aims to improve on the requirements for Part L1B 2013 where feasible. Approved Document L1B applies to extensions and "where a dwelling is being created on an existing building as the result of a material change of use of all or part of the building."

In terms of local **renewable energy generation**, the target is a reduction of CO_2 emissions from regulated energy demand of **20%** where feasible.

2 POLICY REVIEW

NATIONAL PLANNING POLICY FRAMEWORK (NPPF)
Section 10 of the NPPF relates to the challenge of climate change and flooding. Of particular relevance is paragraph 95 which supports the move to a low carbon future and states that local planning authorities should:

- plan for new development in locations and ways which reduce greenhouse gas emissions;
- actively support energy efficiency improvements to existing buildings; and
- when setting any local requirement for a building's sustainability, do so in a way consistent with the Government's zero carbon buildings policy and adopt nationally described standards. (NB: The Government since withdrew the commitment to zero carbon homes).

The Government introduced an 'optional' housing standard related to water consumption in Building Regulations Part G which requires the consumption of wholesome water in a new dwelling not to exceed 110 litres per person per day.

LONDON PLAN 2016
Regional policy in London is controlled by The Greater London Authority and is set out in The London Plan adopted in March 2016. The Plan sets out policy and guidance in the London context and identifies a number of objectives related to improving London as a workplace and living place. Additional guidance is provided by "Energy Planning, Greater London Authority guidance on preparing energy assessments" (March 2016).

The dominant condition stipulated in terms of energy and sustainability is for all **major** developments to achieve at least a 35% reduction in regulated carbon dioxide emissions beyond the minimum targets stated in Part-L 2013 of the Building Regulation.

Although the proposed scheme is not a major development the policy guidance is important as it sets the direction for all developments.

For residential accommodation, the London Plan has adopted "Zero Carbon" from 1st October 2016. The remaining regulated carbon dioxide emissions to 100% are to be off-set through a cash-in-lieu contribution to the local borough to secure delivery of carbon dioxide savings elsewhere.

In addition, The London Plan states that all major development proposal will seek to reduce carbon dioxide emissions by at least 20 per cent through the use of on-site renewable energy generation wherever feasible.

The concept of sustainable development is cardinal to all policies within the London Plan which covers areas such as Places, People, Economy, Response to Climate Change, Transport, and Living Places and Spaces. Chapter 5 of the London Plan sets out a range of policies in relation to climate change, including climate change mitigation and adaptation, waste, aggregates, contaminated land and hazardous substances.

Key policies within the London Plan applicable to the proposed development are:

POLICY 5.2 -MINIMISING CARBON DIOXIDE EMISSIONS

Planning Decisions

A Development proposals should make the fullest contribution to minimising carbon dioxide emissions in accordance with the following energy hierarchy:

1. Be lean: use less energy
2. Be clean: supply energy efficiently
3. Be green: use renewable energy

B The Mayor will work with boroughs and developers to ensure that major developments meet the following targets for carbon dioxide emissions reduction in buildings. These targets are expressed as minimum improvements over the Target Emission Rate (TER) outlined in the national Building Regulations leading to zero carbon residential buildings from 2016 and zero carbon non-domestic buildings from 2019.

Residential Buildings:

Year	Improvement on 2010 Building Regulations
2016 – 2031	Zero carbon (from 1 October 2016)

C Major development proposals should include a detailed energy assessment to demonstrate how the targets for carbon dioxide emissions reduction outlined above are to be met within the framework of the energy hierarchy.

D As a minimum, the energy assessment should include the following details:

a) calculation of the energy demand and carbon dioxide emissions covered by Building Regulations and, separately, the energy demand and carbon dioxide emissions, that are not covered by the Building Regulations at each stage of the energy hierarchy

b) proposal to reduce carbon dioxide emissions through the energy efficient design of the site, building and services

c) proposals to further reduce carbon dioxide emissions through the use of decentralised energy where feasible, such as district heating and cooling and combined heat and power (CHP).

d) proposals to further reduce carbon dioxide emissions through the use of on-site renewable energy technologies.

E The carbon dioxide reduction targets should be met on-site. Where it is clearly demonstrated that the specific targets cannot be fully achieved on-site, any shortfall may be provided off-site or through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere.

POLICY 5.7 – RENEWABLE ENERGY

5.42 There is a presumption that all major development proposals will seek to reduce carbon dioxide emissions by at least 20 per cent through the use of on-site renewable energy generation wherever feasible.

The London Plan states that “This approach will also help ensure that the development industry in London is prepared for the introduction of ‘Nearly Zero Energy Buildings’ by 2020” (as required by the European Energy Performance of Buildings Regulation which requires periodic review of Building Codes to ensure cost optimal review of energy efficiency standards and that all new buildings are ‘nearly zero energy buildings’ by 2020).

The “Energy Planning, Greater London Authority guidance on preparing energy assessments” (March 2016), provides the definition of Zero Carbon:

ENERGY PLANNING. Greater London Authority guidance on preparing energy assessments (March 2016)

Definition

5.3 ‘Zero carbon’ homes are homes forming part of major development applications where the residential element of the application achieves at least a 35 per cent reduction in regulated carbon dioxide emissions (Beyond Part L 2013) on-site. The remaining regulated carbon dioxide emissions, to 100 per cent, are to be off-set through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere (in line with policy 5.2E).

Other key policies within the London Plan applicable to the proposed development and addressed in this report are:

5.3 – Sustainable Design & Construction

This provides guidance on issues related to air pollution and minimum emission standards for combustion plant.

5.3 – Sustainable Design & Construction

Emissions standards have been developed based on the latest technology, viability and the implication for carbon dioxide emissions of any abatement measures to reduce the NOx and PM10 emissions from the plant. The emission standards are provided in Appendix 7 and are target minimum standards. Plant proposed within developments is to comply with these standards, in addition to the development meeting the overall ‘air quality neutral’ benchmarks.

- 5.6 – Decentralised Energy in Development Proposals
- 5.8 – Innovative Energy Technologies
- 5.9 – Overheating & Cooling

This section states that Major development proposals should reduce potential overheating and reliance on air conditioning systems and demonstrate this in accordance with the cooling hierarchy.

- 5.15 – Water Use & Supplies

This provides additional guidance on water consumption:

5.15 – Water Use & Supplies

Policy 5.15 B “designing residential development so that mains water consumption would meet a target of 105 litres or less per head per day”. (Footnote 24: Excluding an allowance of 5 litres or less per head per day for external water consumption)

LOCAL BOROUGH RELEVANT POLICIES

Camden’s Core Strategy 2010-2015 (Local Development framework) Chapter 13 set out key policy for energy.

CS13. Tackling climate change through promoting higher environmental standards

Ensuring developments use less energy

13.8 A building’s use, design, choice of materials and other measures can minimise its energy needs during both construction and occupation. The Council will encourage all developments to meet the highest feasible environmental standards taking into account the mix of uses, the possibility of reusing buildings and materials and the size and location of the development. In addition to design and materials, a building’s internal heating and cooling design, lighting and source of energy can further reduce energy use. Policy DP22 – Promoting sustainable design and construction in Camden Development Policies provides further guidance on what measures can be implemented to achieve an environmentally sustainable building. The Building Research Establishment’s Environmental Assessment Method (BREEAM) and the Code for Sustainable Homes provide helpful assessment tools for general sustainability. Further details on these assessment tools can be found in Development Policy DP22 and our Camden Planning Guidance supplementary document.

13.9 Camden’s existing dense built form with many conservation areas and other heritage assets means that there are often limits to the contribution that orientation, height and footprint can make towards the energy efficiency of a building. This dense character, along with the varying heights of buildings in central London, can also make the installation of various technologies, including renewable energy technologies more difficult. For example, the efficient use of photovoltaics in Central London can be constrained by overshadowing from taller buildings. We will expect high quality and innovative design to help combat these constraints. Energy efficiency measures relating to heritage assets will be welcomed provided that they do not cause harm to the significance of the heritage asset and its setting. The refurbishment of some existing properties in the borough, such as Camden’s EcoHouse in Camden Town and a home in Chester Road in Highgate have demonstrated how Victorian properties can be upgraded to meet Level 4 of the Code for Sustainable Homes energy performance standards. Given the large proportion of development in the borough that relates to existing buildings, we will expect proportionate measures to be taken to improve their environmental sustainability, where possible. Further details on this can be found in our Camden Planning Guidance supplementary document.

Making use of energy from efficient sources

13.10 Once a development has been designed to minimise its energy consumption in line with the approach above, the development should assess its remaining energy needs and the availability of any local energy networks or its potential to generate its own energy from low carbon technology. The Council’s full approach to local energy generation and local energy networks is set out below (paragraphs 13.16 – 13.22).

Generating renewable energy on-site

13.11 Buildings can also generate energy, for example, by using photovoltaic panels to produce electricity, or solar thermal panels, which produce hot water. Once a building and its services have been designed to make sure energy consumption will be as low as possible and the use of energy efficient sources has been considered, **the Council will expect developments to achieve a reduction in carbon dioxide emissions of 20% from on-site renewable energy generation (which can include sources of site-related decentralised renewable energy) unless it can be demonstrated that such provision is not feasible**. Details on ways to generate renewable energy can be found in our Camden Planning Guidance supplementary document.

Chapter 2 of Camden's Planning Guidance states that developments involving 5 or more dwellings and/or 500sqm (gross internal) or more are required to submit an energy statement which demonstrates how carbon dioxide emissions will be reduced in line with the energy hierarchy.

SUMMARY OF KEY ENERGY POLICY REQUIREMENTS

A reduction in carbon dioxide emissions of 20% from on-site renewable energy generation unless it can be demonstrated that such provision is not feasible.

3 DESIGN APPROACH

Sustainability will be integral to the design, construction, operation and performance of the proposed development.

We adopt the definition of Sustainable Development as defined by the Sustainable Design and Construction Supplementary Planning Guidance (SPG - April 2004): "Development that meets the needs of the present generation without compromising the ability of future generations to meet their own social, economic and environmental needs". Furthermore, we consider the essence of Sustainable Development to be the creation of spaces from which all life can flourish and its full potential realised. This means creating beautiful, functional spaces that support health and well-being as well as social and environmental development whilst at the same time addressing key long-term issues such as those capture by the Mayor's strategic targets as set out below.

The proposal actively addresses each aspect and is summarised as follows:

Mayor's Strategic Targets **(Sustainable Development)**	**Sustainability Strategy** **(How the proposed development contributes to Mayor's Targets)**
CO_2 EMISSIONS An overall reduction in London's carbon dioxide emissions of 60 per cent (below 1990 levels) by 2025	✓ Exceeds CO_2 target of Part L1B 2013 ✓ Beneficial "Crossflow" natural ventilation via the dual aspect nature of the units which facilitate fresh air supply and free night-cooling of exposed thermal mass in summer. ✓ Smart meters for energy monitor with guidance documentation for occupants including energy benchmarks.
DECENTRALISED ENERGY 25% of the heat and power used in London to be generated through the use of localised decentralised energy systems by 2025	✓ Solar PV panels.
BIODIVERSITY Increase the amount of surface area greened in the Central Activities Zone by at least five per cent by 2030, and a further five per cent by 2050 and increase London's tree cover by five per cent by 2025	✓ Areas of greenery can now be created on the new balcony areas.
AIR QUALITY Contribute to the achievement of EU limit values for air pollution	✓ Excellent public transportation links
RECYCLING 95% of construction, demolition and excavation waste is recycled/reused by 2020, and that 80% recycling of that waste as aggregate	✓ Construction, demolition and excavation waste recycling requirement in contractor specification (construction waste management plan).

Table 4: Sustainability strategy in relation to Mayor's Strategic Targets

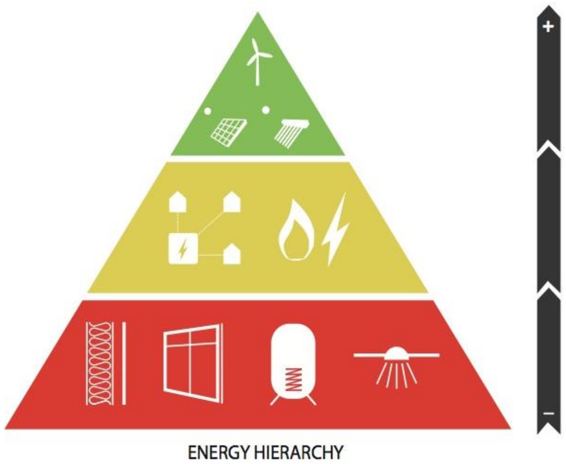
Additional aspects related to sustainable development are summarise below:

Additional sustainable development Issues	Sustainability Strategy
WATER USE On average Londoners use approximately 167 l/p.day (litres of potable water per person per day). This is 14% more than the England and Wales average, despite London already being in one of the driest parts of the country. Part G of building regulation requires 125 l/p.day and 110 l/p.day where required by planning condition such as in London (105 litres or less per head per day excluding an allowance of 5 litres or less per head per day for external water consumption)	✓ Low flow taps, showers, WCs and (where fitted) dishwashers / washing machines as required to meet the target of 105 litres or less per head per day excluding an allowance of 5 litres or less per head per day for external water consumption.
HEAT ISLAND EFFECT AND OVERHEATING The heat island effect in dense urban areas increases discomfort and energy use (for cooling). With continued climate change this is expected to become a significant issue.	✓ Low risk overheating design utilising natural cooling of exposed thermal mass. ✓ SAP 2012 identifies no high risks of overheating. See Appendix A for additional overheating checklists.
FLOOD RESILIENCE When it rains heavily, the sewer interceptors overflow 60 times a year, releasing 39 million cubic metres/tonnes of diluted but untreated sewage into the Thames.	NA

Table 5: Sustainability strategy in relation to additional sustainable development issues

THE ENERGY HIERACHY

The energy hierarchy, as referred to in the London Plan and illustrated below, sets out a three-stage approach to strategic decision-making for the reduction of energy and associated carbon emissions.



BE GREEN - Use Renewable Energy

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

BE CLEAN - Deliver Energy Efficiently

Efficient energy provision for space heating and cooling infrastructure e.g. high efficiency cooling plant, combined heat and power (CHP) or, if available, connection to a district heating/cooling networks.

BE LEAN - Minimise Energy Demand

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

Figure 2: Energy Hierarchy Methodology

This approach aims to reduce the energy consumption and consequent carbon emissions of the development while maintaining quality and without compromising occupant wellbeing and comfort.

This is achieved by developing design strategies that respond to the opportunities and challenges of the site within the context of the local climate and environment as well as implementing a highly-efficient energy infrastructure that integrates on-site renewable energy sources.

Energy demand and annual carbon emissions are calculated using BRE accredited energy compliance Stroma for SAP 2012[1] for the residential areas. The analysis involves calculating CO_2 emissions for the “Be Lean”, “Be Clean” and “Be Green” scenarios relative to the base case (Part L1B) from “regulated” energy (e.g. space heating, hot water, cooling, lighting, pumps and fans).

[1] October 2013 updated June 2014 to include RdSAP 2012 and with minor corrections December 2014.

ENERGY CALCULATION METHODOLOGY

Part L1B compliance can be achieved by following the elemental requirements for:

- Thermal elements (which covers wall, floor or roof)
- Controlled fittings (window, rooflight or door)
- Controlled services (heating and hot water systems, insulation, mechanical ventilation, mechanical cooling and air conditioning, fixed internal and external lighting and renewable energy systems).

Retained thermal elements can meet Part L1B requirements (Table 3) by improving U-values where they are above threshold levels. This is provided it is technically, functionally and economical feasible for example achieving a simple payback of 15 years or less.

Windows that have a U-Value higher than 3.3 $W/m^2.K$ can comply by upgrading in line with Part L requirements. However, as the scheme has listed façade areas of single glazing these will be retained as part of the scheme.

To provide design flexibility, SAP 2012 can be used to demonstrate that the total CO_2 emissions for all the dwelling in the building as it will become are no greater than if each dwelling had been improved following the guidance set out in Part L paragraph 4.15

Therefore SAP 2012 has been used to compare the performance of the proposed scheme to the Part L1B baseline and the calculation carried out in stages according to the Energy Hierarchy.

4 ENERGY - "BE LEAN"

The incorporation of appropriate passive and active energy efficiency measures can significantly reduce energy demands. These measures are often integral to the building form and fabric and cannot be readily remedied or retrofitted once the building has been constructed.

The augmentation of these design strategies begins by identifying site-specific challenges and opportunities, considering the microclimate, location and surroundings and applying them to the building form, façade and orientation.

CLIMATE ANALYSIS

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

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

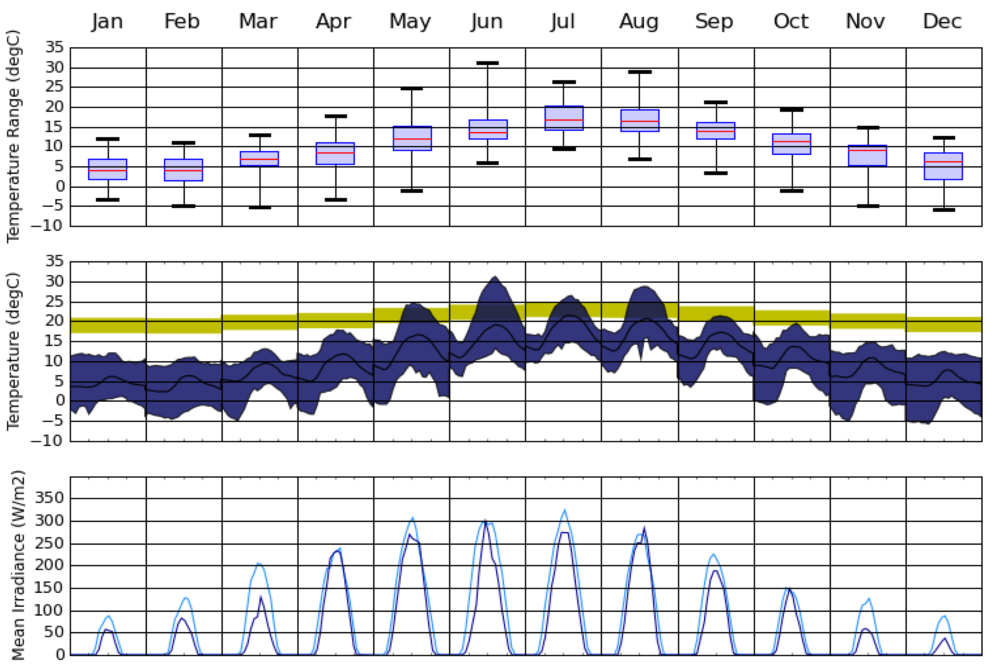


Figure 3: Average historic climate data for London

BUILDING FABRIC PERFORMANCE & INSULATION

High levels of insulation are proposed as summarised later in this section. The thermal performance of all exposed elements equals or exceeds the minimum requirements for Building Regulations 2013. This will significantly reduce energy consumption and ensure optimum occupant comfort all year round by retaining heat in the winter and reducing heat gains in the summer.

AIR TIGHTNESS & INFILTRATION

Air-permeability will comply with Part L standards and testing procedures shall be performed in accordance with the recommendations set out in CIBSE TM 23 and the ATTMA TS1.

THERMAL BRIDGING

Minimising thermal bridging is an important aspect of the design. The approach to limiting thermal bridging is to implement Accredited Details to the extension areas where feasible.

NATURAL VENTILATION & THERMAL MASS

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

During summer, when the building is occupied, windows and patio doors can be opened on both aspects creating beneficial cross-flow ventilation.

SOLAR EXPOSURE AND DAYLIGHT

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

The site has relatively good access to solar energy and natural daylight, as the surrounding buildings are not overly dominating. As such, the roof is suitable for solar energy harvesting.

Fenestration on the facades are sized and located to maximise natural daylight to provide amenity and reduce artificial lighting energy use. Internal shading will be incorporated to minimise the risk of overheating and glare without overly compromising daylight availability.

It is recommended that the glazed areas are kept below 25% of the floor area. The proposed scheme achieves this standard as shown in the table below.

Floor	Accommodation	Glazing Area (m^2)	Glazing Ratio
Fourth	Residential 3 Bedroom (upper level)	17.9	24%
Third	Residential 3 Bedroom (lower level)	14.2	16%
Second	Residential 2 Bedroom	23.2	17%
First	Residential 2 Bedroom	24.0	17%
Ground	Retail	21.4	15%

Table 6: Summary of glazing ratio by floor

ACTIVE BUILDING SERVICES SYSTEMS

All building services systems will be in accordance with, and where possible exceed, the energy minimum requirements of efficiency outlined in the Building Service Compliance Guide 2013.

The heating and hot water distribution will be provided to the residential units via a local high-efficiency gas-fired boilers with full temperature and time control as well as local radiator controls using TRVs.

Each residential unit will be provided with high-efficiency mechanical ventilation.

Low-energy fixed lighting, generally comprising of high efficacy LED fittings will be installed.

As part of the “Be Lean” approach, seeking to minimise energy demand, the building fabric has been specified to meet or exceed the minimum fabric parameters outlined in Part L of the Building Regulation 2013 as per table below.

RESIDENTIAL		
Element	**BASELINE** **Proposed Units using Building Regulations 2013 Part L1B**	**PROPOSED** **Proposed Scheme using Building Regulations 2013 Part L1B for change of use and Part L1A notional building parameters for residential extensions.**
	U Value (W/m²K)	**U Value (W/m²K)**
Existing External Walls	0.3	0.3
Existing Ground Floor	0.25	0.11
Existing Flat Roof	0.18	0.18
Existing Windows	6.0*	6.0*
Existing External Doors	1.8	1.8
New External Walls	0.28	0.18
New Ground Floor	0.22	0.13
New Flat Roof	0.18	0.13
New Windows	1.6	1.4
New Doors	1.8	1.2
Lighting efficiency	75% of fittings	100% of fittings
Combination gas boiler seasonal efficiency SEDBUK 2009	0.88%	0.88%
Gas boiler control	Boiler interlock, time and temperature control and TRVs on radiators	Boiler interlock, time and temperature control and TRVs on radiators
Extractor fan power	0.5 W/l.s for intermittent extract ventilation	0.5 W/l.s for intermittent extract ventilation

Table 7: “Be Lean” Fabric Improvements and Baseline Comparison for Residential Units

* conservative estimate of the performance of the existing single glazing on the listed façade.

The total “Be Lean” CO_2 emission associated with regulated and unregulated energy consumption for the both the residential and commercial units are summarised below.

“BE LEAN” CARBON EMISSIONS SUMMARY

Target	Regulated Carbon Emissions (kg.CO_2/yr.)	Percentage Improvement
Baseline Emissions	7.64	-
Be Lean	7.20	5.7%
Be Clean	-	-
Be Green	-	-

Table 8: Summary of Total “Be Lean” and Baseline Carbon Emissions

5 ENERGY – "BE CLEAN"

GAS FIRED COMBINED HEAT AND POWER (CHP)

Whilst MicroCHP units are available CHP is not generally recommended for small developments. The GLA guidance suggests that the following developments need not install CHP:

- Small-medium residential development (less than 500 apartments)
- Non-domestic developments with a simultaneous demand for heat and power less than 5000 hours per annum (offices/schools)

Therefore, CHP is not considered a viable option for this development.

GAS FIRED COMBINATION BOILERS

The units will benefit from highly efficient combination boiler. Combination boilers are generally deemed more efficient for small dwelling as the water use is relatively low and tank losses are avoided.

"BE CLEAN" CARBON EMISSIONS SUMMARY

Target	Regulated Carbon Emissions (kg.CO_2/yr.)	Percentage Improvement
Baseline Emissions	7.64	-
Be Lean	7.20	5.7%
Be Clean	7.20	0.0%
Be Green	-	-

Table 9: Summary of Total "Be Clean" Carbon Emissions

6 ENERGY – "BE GREEN"

A renewable energy feasibility exercise has been carried out in order to determine the most viable options that would allow the proposal to achieve the renewable energy target of 20% CO_2 reduction relative to the overall energy demand requirements.

The viable technology option(s) are presented below.

PHOTOVOLTAICS

Technical Overview

Solar photovoltaic (PV) modules convert sunlight into electricity. PV is distinct from other renewable energy technologies since it has no moving parts to be maintained and is silent. PV systems can be incorporated into buildings in various ways such as on sloped or flat roofs, in facades, atria and as shading devices.

There has been significant deployment of roof-mounted PV in the UK which has been driven by the government's Feed in Tariff scheme which rewards owners for each unit of electricity produced over 20 years and is available for new schemes until 1st April 2019. Costs have fallen dramatically as a result of growing global uptake and continue to fall. Typical module efficiencies of crystalline PV, which is now the dominate form of PV, are between 15-20% and improve incrementally year on year as manufacturing develops.

Applicability to the Proposed Scheme

Due to the available roof area of the proposed development, solar PV would be a suitable technology for deployment. The extent of the array proposed would be sufficient to meet the 20% renewable energy contribution target.

A particular advantage of solar PV over other types of low and zero carbon technologies, is that the running costs and maintenance requirements are very low.

For the reasons detailed above, solar photovoltaic technology is considered as a viable option for the proposed development. It is proposed that the photovoltaic panels are located on the roof. The panels will be orientated SW in order to maximise the amount of PV that can be deployed and avoid over shading from the adjacent building. They will be installed with a tilt angle of 15-30° to allow for self-cleaning (via rainfall). In total it is proposed to have high efficiency twelve PV modules which equates to an installed capacity of **3.48 kW_{peak}.**

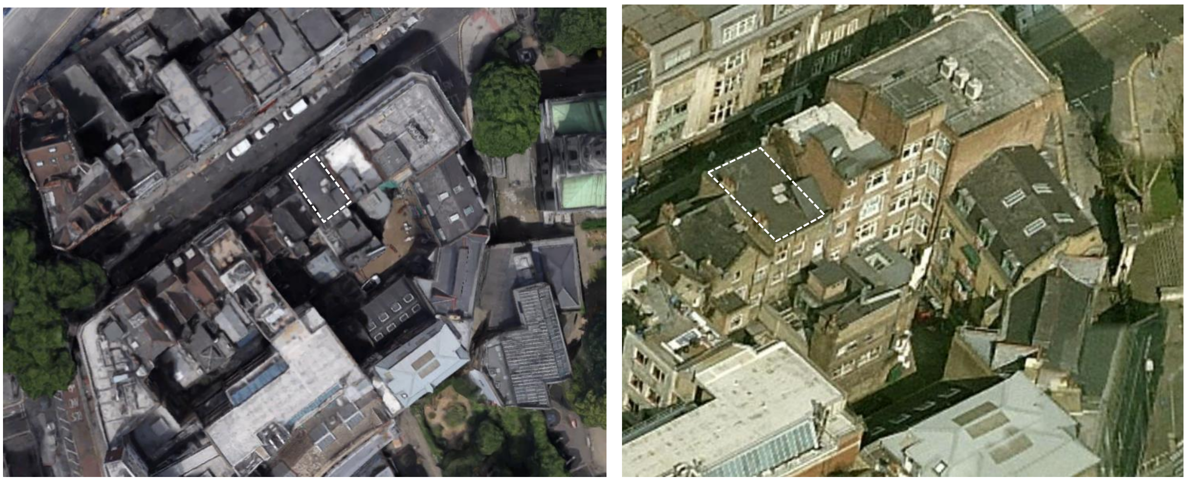


Figure 4: Aerial site images showing little overshadowing risk for the proposed solar PVs

The overall summary of the renewable energy feasibility exercise is presented below.

Technology		Assessment / Viability
Wind Power	Wind turbine installed on the roof of the development.	Due to the proximity to residential areas, the high cost per kW for smaller building-mounted turbines and the impacts in terms of visual noise and shadow flicker, wind turbines are not considered a viable technology for the development. CONCLUSION: NOT CONSIDERED FEASIBLE
Ground Source Heat Pumps	Open or closed loop GSHP system requiring extraction of ground water and / or deep boreholes.	Low maintenance and no external visual or noise impact. However, there are space restrictions. CONCLUSION: NOT CONSIDERED FEASIBLE
Air Source Heat Pumps	Electric powered external plant serving each unit providing heating and cooling	External units will have a negative visual impact if located on the façade. If the units are located on the roof there will be implications for the amount of rooftop PV that can be deployed. CONCLUSION: NOT CONSIDERED FEASIBLE
Solar Thermal Collectors	Roof-mounted solar thermal panels providing hot water heating	Roofs have good potential for solar thermal energy collection. Solar hot water collectors would provide a significant proportion of domestic hot water demand of the development. However, PV modules are favoured due to the low maintenance requirements and the low hot-water demand. CONCLUSION: NOT CONSIDERED FEASIBLE
Solar Photovoltaic Panels	Roof mounted Photovoltaic panels (PV) provide electricity directly to the development, exporting any surplus production to the grid.	Roofs have good potential for solar power generation. PV has low maintenance requirements. PV electricity is clean and zero-carbon and will offset carbon intensive grid power. CONCLUSION: CONSIDERED FEASIBLE
Biomass Heating	Biomass-fired community heating system.	Biomass heating is an established technology but has high maintenance requirements, fuel storage and delivery issues and is a source of increase in pollution, notably particulates (PM10), SO_2 and NO_X emissions. CONCLUSION: NOT CONSIDERED FEASIBLE

Table 10: Summary of Low and Zero Carbon Study Analysis Results

“BE GREEN” CARBON EMISSIONS SUMMARY

Target	Regulated Carbon Emissions (kg.CO_2/yr.)	Percentage Improvement
Baseline Emissions	7.64	-
Be Lean	7.20	5.7%
Be Clean	7.20	0.0%
Be Green	5.71	25.2%

Table 11: Summary of Total “Be Clean” Carbon Emissions

7 Summary of CO_2 Emissions Reduction

Using the approved methodologies, the proposed development has been shown to exceed energy compliance requirement by **25.2%** and exceed the renewable energy target of **20%** in line with local policy.

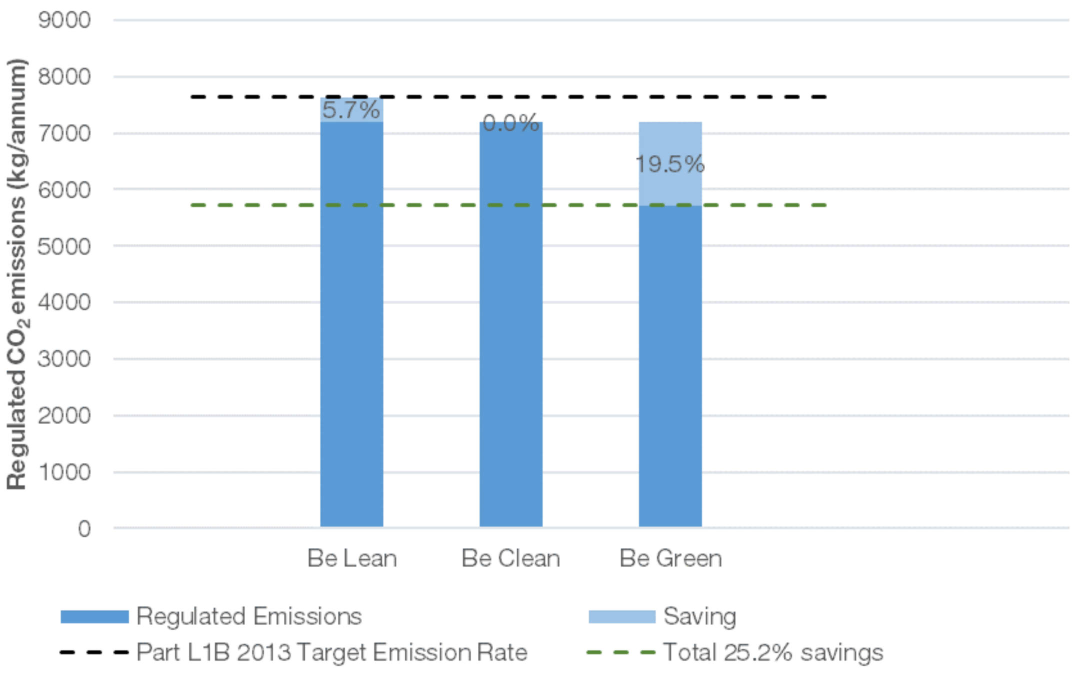


Figure 5: Summary of the scheme's regulated energy use as compared to the CO_2 emission baseline and target

The table below shows the regulated energy use for the residential units.

Location	Carbon dioxide emissions for residential units (Tonnes CO_2 per annum)
Baseline: Part L 2013 (Building Regulations) Compliance	7.64
After "Be Lean" (energy demand reduction)	7.20
After "Be Clean" (heat network / CHP / chiller plant)	7.20
After "Be Green" (renewable energy)	5.71

Table 12: Residential regulated CO2 emissions after each stage of the Energy Hierarchy

This performance can be expressed as savings between each stage in the energy hierarchy.

	Regulated residential carbon dioxide savings	
Location	(Tonnes CO_2 per annum)	(%)
Savings from "Be Lean" (energy demand reduction)	0.44	5.7%
Savings from "Be Clean" (heat network / CHP / chiller plant)	0.0	0.0%
Savings from "Be Green" (renewable energy)	1.49	19.5%
Cumulative on site savings	1.92	**25.2%**

Table 13: Residential regulated CO_2 emissions savings after each stage of the Energy Hierarchy.

APPENDIX A: OVERHEATING CHECKLISTS

Section 1 - Site features affecting vulnerability to overheating		**Yes or No**
Site location	Urban – within central London or in a high-density conurbation	Yes
	Peri-urban – on the suburban fringes of London	No
Air quality and/or Noise sensitivity – are any of the following in the vicinity of buildings?	Busy roads / A roads	Yes
	Railways / Overground / DLR	No
	Airport / Flight path	No
	Industrial uses / waste facility	No
Proposed building use	Will any buildings be occupied by vulnerable people (e.g. elderly, disabled, young children)?	TBC
	Are residents likely to be at home during the day (e.g. students)?	TBC
Dwelling aspect	Are there any single aspect units?	No
Glazing ratio	Is the glazing ratio (glazing: internal floor area) greater than 25%?	No
	If yes, is this to allow acceptable levels of daylighting?	NA
	Single storey ground floor units	No
Security - Are there any security issues that could limit opening of windows for ventilation?	Vulnerable areas identified by the Police Architectural Liaison Officer	TBC
	Other	No

Table A1: Domestic Overheating Checklist Section 1 (GLA Guidance on preparing Overheating Checklist)

Section 2 - Design features implemented to mitigate overheating risk		Response
Landscaping	Will deciduous trees be provided for summer shading (to windows and pedestrian routes)?	NA
	Will green roofs be provided?	No
	Will other green or blue infrastructure be provided around buildings for evaporative cooling?	Greenery can now be deployed on new balcony areas
Materials	Have high albedo (light colour) materials been specified?	NA (refurbishment)
Dwelling aspect	% of total units that are single aspect	0%
	% single aspect with N / NE / NW orientation	0%
	% single aspect with S / SE / SW orientation	0%
	% single aspect with W orientation	0%
Glazing ratio	Glazing; internal floor area	See Table 6
Window opening	Window opening	All windows are openable
Window opening - What is the extent of the opening?	Fully openable	Openings not proposed to be overly restricted
	Limited (e.g. for security, safety, wind loading reasons)	No
Security	Where there are security issues (e.g. ground floor flats) has an alternative night time natural ventilation method been provided (e.g. ventilation grates)?	No ground floor accommodation
Shading	Is there any external shading?	No
	Is there any internal shading?	Yes
Glazing specification	Is there any solar control glazing	Yes, with G-value below 0.6 for new glazing elements
Ventilation - What is the ventilation strategy?	Natural – background	Yes
	Natural – purge	Yes
	Mechanical – background (e.g. MVHR)	Yes
Heating system	Is communal heating present?	No
	What is the flow/return temperature?	Combi boilers provided with adjustable temperature control which can minimise heat output for hot water supply.
	Have horizontal pipe runs been minimised?	Yes, combi boiler specified to limited hot water storage.
	Do the specifications include insulation levels in line with the London Heat Network Manual	NA

Table A2: Domestic Overheating Checklist

APPENDIX B: SAP CALCULATION (BE GREEN) WORKSHEET

DER WorkSheet: New dwelling design stage

User Details:

Assessor Name:		**Stroma Number:**	
Software Name:	Stroma FSAP 2012	**Software Version:**	Version: 1.0.4.5

Property Address: Be GREEN

Address : 5 Denmark Street, London, WC2H 8LU

1. Overall dwelling dimensions:

	Area(m²)		Av. Height(m)		Volume(m³)	
Ground floor	109.37	(1a) x	3.12	(2a) =	341.23	(3a)
First floor	109.97	(1b) x	3.24	(2b) =	356.3	(3b)
Second floor	69.58	(1c) x	3.06	(2c) =	212.57	(3c)
Third floor	63.78	(1d) x	2.9	(2d) =	184.96	(3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	352.7	(4)				
Dwelling volume				(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) =	1095.07	(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)

DRAFT

			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		5	(17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)	0.25	(18)
Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used			
Number of sides sheltered		1	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.92	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.23	(21)

Infiltration rate modified for monthly wind speed

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

Monthly average wind speed from Table 7

(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

0.29	0.29	0.28	0.25	0.25	0.22	0.22	0.21	0.23	0.25	0.26	0.27

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=	0.54	0.54	0.53	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.51	0.52	(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=	0.54	0.54	0.53	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.51	0.52	(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	
Doors			2.1	x	1.2	=	2.52			(26)
Windows Type 1			2.35	x	1/[1/(6)+ 0.04]	=	11.37			(27)
Windows Type 2			3.71	x	1/[1/(1.4)+ 0.04]	=	4.92			(27)
Windows Type 3			7.23	x	1/[1/(1.4)+ 0.04]	=	9.59			(27)
Windows Type 4			2.12	x	1/[1/(6)+ 0.04]	=	10.26			(27)
Windows Type 5			3.71	x	1/[1/(1.4)+ 0.04]	=	4.92			(27)
Windows Type 6			2.01	x	1/[1/(6)+ 0.04]	=	9.73			(27)
Windows Type 7			2.34	x	1/[1/(6)+ 0.04]	=	11.32			(27)
Windows Type 8			3.71	x	1/[1/(1.4)+ 0.04]	=	4.92			(27)
Windows Type 9			2.29	x	1/[1/(1.4)+ 0.04]	=	3.04			(27)
Windows Type 10			5.58	x	1/[1/(1.4)+ 0.04]	=	7.4			(27)
Windows Type 11			3.39	x	1/[1/(1.4)+ 0.04]	=	4.49			(27)
Windows Type 12			7.12	x	1/[1/(1.4)+ 0.04]	=	9.44			(27)
Windows Type 13			10.75	x	1/[1/(1.4)+ 0.04]	=	14.25			(27)

DER WorkSheet: New dwelling design stage

Windows Type 14			4.24	x1/[1/(1.4)+ 0.04] =			5.62			(27)
Windows Type 15			3.68	x1/[1/(1.4)+ 0.04] =			4.88			(27)
Windows Type 16			4.32	x1/[1/(1.4)+ 0.04] =			5.73			(27)
Windows Type 17			0.98	x 1/[1/(6)+ 0.04] =			4.74			(27)
Windows Type 18			1.02	x1/[1/(1.4)+ 0.04] =			1.35			(27)
Windows Type 19			1.02	x1/[1/(1.4)+ 0.04] =			1.35			(27)
Rooflights Type 1			1.26	x1/[1/(1.6) + 0.04] =			2.016			(27b)
Rooflights Type 2			2.21	x1/[1/(1.6) + 0.04] =			3.536			(27b)
Walls Type1	20.9	7.05	13.85	x	0.3	=	4.16			(29)
Walls Type2	21.97	7.42	14.55	x	0.3	=	4.36			(29)
Walls Type3	20.84	7.12	13.72	x	0.3	=	4.12			(29)
Walls Type4	21.38	6.36	15.02	x	0.3	=	4.51			(29)
Walls Type5	22.81	7.42	15.39	x	0.3	=	4.62			(29)
Walls Type6	22.07	10.75	11.32	x	0.3	=	3.4			(29)
Walls Type7	19.98	7.34	12.64	x	0.3	=	3.79			(29)
Walls Type8	27.39	16.72	10.67	x	0.3	=	3.2			(29)
Walls Type9	45.58	0	45.58	x	0.3	=	13.67			(29)
Walls Type10	19.23	4.58	14.65	x	0.18	=	2.64			(29)
Walls Type11	19.23	8.97	10.26	x	0.18	=	1.85			(29)
Walls Type12	34.51	0	34.51	x	0.18	=	6.21			(29)
Walls Type13	2.16	0	2.16	x	0.18	=	0.39			(29)
Walls Type14	32.47	1.02	31.45	x	0.3	=	9.43			(29)
Walls Type15	12.53	0	12.53	x	0.3	=	3.76			(29)
Walls Type16	6.96	0	6.96	x	0.18	=	1.25			(29)
Walls Type17	31.06	1.02	30.04	x	0.3	=	9.01			(29)
Roof Type1	45.89	0	45.89	x	0.13	=	5.97			(30)
Roof Type2	8.23	1.26	6.97	x	0.13	=	0.91			(30)
Roof Type3	74.78	2.21	72.57	x	0.13	=	9.43			(30)
Total area of elements, m²			518.53							(31)

** 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) =	299.58	(33)
Heat capacity Cm = S(A x k)	((28)…(30) + (32) + (32a)…(32e) =	21799.59	(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		56.2	(36)

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

Total fabric heat loss	(33) + (36) =	355.78	(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=	196.89	194.8	192.71	182.27	180.69	180.69	180.69	180.69	180.69	180.69	184.36	188.53	(38)

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

(39)m=	552.67	550.58	548.49	538.04	536.46	536.46	536.46	536.46	536.46	536.46	540.13	544.31	

Average = Sum(39)1…12 /12= 541.08 (39)

DER WorkSheet: New dwelling design stage

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

(40)m=	1.57	1.56	1.56	1.53	1.52	1.52	1.52	1.52	1.52	1.52	1.53	1.54	

Average = Sum(40)$_{1...12}$ /12= 1.53 (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 3.2 (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) + 36 110.21 (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=	121.23	116.82	112.41	108.01	103.6	99.19	99.19	103.6	108.01	112.41	116.82	121.23	

Total = Sum(44)$_{1...12}$ = 1322.53 (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=	179.78	157.24	162.26	141.46	135.73	117.13	108.54	124.55	126.03	146.88	160.33	174.11	

Total = Sum(45)$_{1...12}$ = 1734.04 (45)

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

(46)m=	26.97	23.59	24.34	21.22	20.36	17.57	16.28	18.68	18.91	22.03	24.05	26.12	(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)

DER WorkSheet: New dwelling design stage

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

(61)m=	49.95	45.05	49.73	47.92	49.38	47.59	49.02	49.24	47.72	49.53	48.16	49.88	(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=	229.74	202.29	211.98	189.38	185.11	164.72	157.55	173.78	173.75	196.41	208.5	223.99	(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)

Output from water heater

(64)m=	229.74	202.29	211.98	189.38	185.11	164.72	157.55	173.78	173.75	196.41	208.5	223.99	

Output from water heater (annual)$_{1..12}$ 2317.21 (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=	72.27	63.55	66.38	59.02	57.48	50.84	48.34	53.72	53.84	61.22	65.35	70.36	(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=	160.02	160.02	160.02	160.02	160.02	160.02	160.02	160.02	160.02	160.02	160.02	160.02	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
(67)m=	44.55	39.56	32.18	24.36	18.21	15.37	16.61	21.59	28.98	36.8	42.95	45.78	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
(68)m=	499.66	504.85	491.78	463.97	428.86	395.85	373.81	368.62	381.69	409.5	444.62	477.62	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
(69)m=	39	39	39	39	39	39	39	39	39	39	39	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=	-128.02	-128.02	-128.02	-128.02	-128.02	-128.02	-128.02	-128.02	-128.02	-128.02	-128.02	-128.02	(71)
Water heating gains (Table 5)													
(72)m=	97.13	94.56	89.22	81.97	77.25	70.61	64.98	72.21	74.77	82.28	90.77	94.57	(72)
Total internal gains = (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m													
(73)m=	715.35	712.98	687.19	644.3	598.32	555.85	529.4	536.43	559.45	602.59	652.34	691.98	(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	1.02	x	11.28	x	0.63	x	0.7	=	3.52	(75)
Northeast 0.9x	0.77	x	1.02	x	11.28	x	0.63	x	0.7	=	3.52	(75)
Northeast 0.9x	0.77	x	1.02	x	22.97	x	0.63	x	0.7	=	7.16	(75)
Northeast 0.9x	0.77	x	1.02	x	22.97	x	0.63	x	0.7	=	7.16	(75)
Northeast 0.9x	0.77	x	1.02	x	41.38	x	0.63	x	0.7	=	12.9	(75)

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Northeast	0.9x	0.77	x	1.02	x	41.38	x	0.63	x	0.7	=	12.9	(75)
Northeast	0.9x	0.77	x	1.02	x	67.96	x	0.63	x	0.7	=	21.18	(75)
Northeast	0.9x	0.77	x	1.02	x	67.96	x	0.63	x	0.7	=	21.18	(75)
Northeast	0.9x	0.77	x	1.02	x	91.35	x	0.63	x	0.7	=	28.47	(75)
Northeast	0.9x	0.77	x	1.02	x	91.35	x	0.63	x	0.7	=	28.47	(75)
Northeast	0.9x	0.77	x	1.02	x	97.38	x	0.63	x	0.7	=	30.36	(75)
Northeast	0.9x	0.77	x	1.02	x	97.38	x	0.63	x	0.7	=	30.36	(75)
Northeast	0.9x	0.77	x	1.02	x	91.1	x	0.63	x	0.7	=	28.4	(75)
Northeast	0.9x	0.77	x	1.02	x	91.1	x	0.63	x	0.7	=	28.4	(75)
Northeast	0.9x	0.77	x	1.02	x	72.63	x	0.63	x	0.7	=	22.64	(75)
Northeast	0.9x	0.77	x	1.02	x	72.63	x	0.63	x	0.7	=	22.64	(75)
Northeast	0.9x	0.77	x	1.02	x	50.42	x	0.63	x	0.7	=	15.72	(75)
Northeast	0.9x	0.77	x	1.02	x	50.42	x	0.63	x	0.7	=	15.72	(75)
Northeast	0.9x	0.77	x	1.02	x	28.07	x	0.63	x	0.7	=	8.75	(75)
Northeast	0.9x	0.77	x	1.02	x	28.07	x	0.63	x	0.7	=	8.75	(75)
Northeast	0.9x	0.77	x	1.02	x	14.2	x	0.63	x	0.7	=	4.43	(75)
Northeast	0.9x	0.77	x	1.02	x	14.2	x	0.63	x	0.7	=	4.43	(75)
Northeast	0.9x	0.77	x	1.02	x	9.21	x	0.63	x	0.7	=	2.87	(75)
Northeast	0.9x	0.77	x	1.02	x	9.21	x	0.63	x	0.7	=	2.87	(75)
East	0.9x	0.77	x	7.12	x	19.64	x	0.63	x	0.7	=	42.74	(76)
East	0.9x	0.77	x	10.75	x	19.64	x	0.63	x	0.7	=	64.52	(76)
East	0.9x	0.77	x	7.12	x	38.42	x	0.63	x	0.7	=	83.6	(76)
East	0.9x	0.77	x	10.75	x	38.42	x	0.63	x	0.7	=	126.22	(76)
East	0.9x	0.77	x	7.12	x	63.27	x	0.63	x	0.7	=	137.68	(76)
East	0.9x	0.77	x	10.75	x	63.27	x	0.63	x	0.7	=	207.87	(76)
East	0.9x	0.77	x	7.12	x	92.28	x	0.63	x	0.7	=	200.8	(76)
East	0.9x	0.77	x	10.75	x	92.28	x	0.63	x	0.7	=	303.17	(76)
East	0.9x	0.77	x	7.12	x	113.09	x	0.63	x	0.7	=	246.09	(76)
East	0.9x	0.77	x	10.75	x	113.09	x	0.63	x	0.7	=	371.55	(76)
East	0.9x	0.77	x	7.12	x	115.77	x	0.63	x	0.7	=	251.91	(76)
East	0.9x	0.77	x	10.75	x	115.77	x	0.63	x	0.7	=	380.35	(76)
East	0.9x	0.77	x	7.12	x	110.22	x	0.63	x	0.7	=	239.83	(76)
East	0.9x	0.77	x	10.75	x	110.22	x	0.63	x	0.7	=	362.1	(76)
East	0.9x	0.77	x	7.12	x	94.68	x	0.63	x	0.7	=	206.01	(76)
East	0.9x	0.77	x	10.75	x	94.68	x	0.63	x	0.7	=	311.04	(76)
East	0.9x	0.77	x	7.12	x	73.59	x	0.63	x	0.7	=	160.13	(76)
East	0.9x	0.77	x	10.75	x	73.59	x	0.63	x	0.7	=	241.77	(76)
East	0.9x	0.77	x	7.12	x	45.59	x	0.63	x	0.7	=	99.2	(76)
East	0.9x	0.77	x	10.75	x	45.59	x	0.63	x	0.7	=	149.78	(76)
East	0.9x	0.77	x	7.12	x	24.49	x	0.63	x	0.7	=	53.29	(76)
East	0.9x	0.77	x	10.75	x	24.49	x	0.63	x	0.7	=	80.46	(76)

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East	0.9x	0.77	x	7.12	x	16.15	x	0.63	x	0.7	=	35.14	(76)
East	0.9x	0.77	x	10.75	x	16.15	x	0.63	x	0.7	=	53.06	(76)
Southeast	0.9x	0.77	x	3.71	x	36.79	x	0.63	x	0.7	=	83.44	(77)
Southeast	0.9x	0.77	x	7.23	x	36.79	x	0.63	x	0.7	=	81.3	(77)
Southeast	0.9x	0.77	x	3.71	x	36.79	x	0.63	x	0.7	=	83.44	(77)
Southeast	0.9x	0.77	x	3.71	x	36.79	x	0.63	x	0.7	=	41.72	(77)
Southeast	0.9x	0.77	x	5.58	x	36.79	x	0.63	x	0.7	=	62.75	(77)
Southeast	0.9x	0.77	x	3.39	x	36.79	x	0.63	x	0.7	=	38.12	(77)
Southeast	0.9x	0.77	x	3.68	x	36.79	x	0.63	x	0.7	=	41.38	(77)
Southeast	0.9x	0.77	x	3.71	x	62.67	x	0.63	x	0.7	=	142.12	(77)
Southeast	0.9x	0.77	x	7.23	x	62.67	x	0.63	x	0.7	=	138.48	(77)
Southeast	0.9x	0.77	x	3.71	x	62.67	x	0.63	x	0.7	=	142.12	(77)
Southeast	0.9x	0.77	x	3.71	x	62.67	x	0.63	x	0.7	=	71.06	(77)
Southeast	0.9x	0.77	x	5.58	x	62.67	x	0.63	x	0.7	=	106.88	(77)
Southeast	0.9x	0.77	x	3.39	x	62.67	x	0.63	x	0.7	=	64.93	(77)
Southeast	0.9x	0.77	x	3.68	x	62.67	x	0.63	x	0.7	=	70.49	(77)
Southeast	0.9x	0.77	x	3.71	x	85.75	x	0.63	x	0.7	=	194.46	(77)
Southeast	0.9x	0.77	x	7.23	x	85.75	x	0.63	x	0.7	=	189.48	(77)
Southeast	0.9x	0.77	x	3.71	x	85.75	x	0.63	x	0.7	=	194.46	(77)
Southeast	0.9x	0.77	x	3.71	x	85.75	x	0.63	x	0.7	=	97.23	(77)
Southeast	0.9x	0.77	x	5.58	x	85.75	x	0.63	x	0.7	=	146.24	(77)
Southeast	0.9x	0.77	x	3.39	x	85.75	x	0.63	x	0.7	=	88.84	(77)
Southeast	0.9x	0.77	x	3.68	x	85.75	x	0.63	x	0.7	=	96.44	(77)
Southeast	0.9x	0.77	x	3.71	x	106.25	x	0.63	x	0.7	=	240.94	(77)
Southeast	0.9x	0.77	x	7.23	x	106.25	x	0.63	x	0.7	=	234.77	(77)
Southeast	0.9x	0.77	x	3.71	x	106.25	x	0.63	x	0.7	=	240.94	(77)
Southeast	0.9x	0.77	x	3.71	x	106.25	x	0.63	x	0.7	=	120.47	(77)
Southeast	0.9x	0.77	x	5.58	x	106.25	x	0.63	x	0.7	=	181.19	(77)
Southeast	0.9x	0.77	x	3.39	x	106.25	x	0.63	x	0.7	=	110.08	(77)
Southeast	0.9x	0.77	x	3.68	x	106.25	x	0.63	x	0.7	=	119.5	(77)
Southeast	0.9x	0.77	x	3.71	x	119.01	x	0.63	x	0.7	=	269.87	(77)
Southeast	0.9x	0.77	x	7.23	x	119.01	x	0.63	x	0.7	=	262.96	(77)
Southeast	0.9x	0.77	x	3.71	x	119.01	x	0.63	x	0.7	=	269.87	(77)
Southeast	0.9x	0.77	x	3.71	x	119.01	x	0.63	x	0.7	=	134.94	(77)
Southeast	0.9x	0.77	x	5.58	x	119.01	x	0.63	x	0.7	=	202.95	(77)
Southeast	0.9x	0.77	x	3.39	x	119.01	x	0.63	x	0.7	=	123.3	(77)
Southeast	0.9x	0.77	x	3.68	x	119.01	x	0.63	x	0.7	=	133.85	(77)
Southeast	0.9x	0.77	x	3.71	x	118.15	x	0.63	x	0.7	=	267.92	(77)
Southeast	0.9x	0.77	x	7.23	x	118.15	x	0.63	x	0.7	=	261.06	(77)
Southeast	0.9x	0.77	x	3.71	x	118.15	x	0.63	x	0.7	=	267.92	(77)
Southeast	0.9x	0.77	x	3.71	x	118.15	x	0.63	x	0.7	=	133.96	(77)

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Southeast	0.9x	0.77	x	5.58	x	118.15	x	0.63	x	0.7	=	201.48	(77)
Southeast	0.9x	0.77	x	3.39	x	118.15	x	0.63	x	0.7	=	122.41	(77)
Southeast	0.9x	0.77	x	3.68	x	118.15	x	0.63	x	0.7	=	132.88	(77)
Southeast	0.9x	0.77	x	3.71	x	113.91	x	0.63	x	0.7	=	258.31	(77)
Southeast	0.9x	0.77	x	7.23	x	113.91	x	0.63	x	0.7	=	251.69	(77)
Southeast	0.9x	0.77	x	3.71	x	113.91	x	0.63	x	0.7	=	258.31	(77)
Southeast	0.9x	0.77	x	3.71	x	113.91	x	0.63	x	0.7	=	129.15	(77)
Southeast	0.9x	0.77	x	5.58	x	113.91	x	0.63	x	0.7	=	194.25	(77)
Southeast	0.9x	0.77	x	3.39	x	113.91	x	0.63	x	0.7	=	118.01	(77)
Southeast	0.9x	0.77	x	3.68	x	113.91	x	0.63	x	0.7	=	128.11	(77)
Southeast	0.9x	0.77	x	3.71	x	104.39	x	0.63	x	0.7	=	236.72	(77)
Southeast	0.9x	0.77	x	7.23	x	104.39	x	0.63	x	0.7	=	230.66	(77)
Southeast	0.9x	0.77	x	3.71	x	104.39	x	0.63	x	0.7	=	236.72	(77)
Southeast	0.9x	0.77	x	3.71	x	104.39	x	0.63	x	0.7	=	118.36	(77)
Southeast	0.9x	0.77	x	5.58	x	104.39	x	0.63	x	0.7	=	178.02	(77)
Southeast	0.9x	0.77	x	3.39	x	104.39	x	0.63	x	0.7	=	108.15	(77)
Southeast	0.9x	0.77	x	3.68	x	104.39	x	0.63	x	0.7	=	117.4	(77)
Southeast	0.9x	0.77	x	3.71	x	92.85	x	0.63	x	0.7	=	210.56	(77)
Southeast	0.9x	0.77	x	7.23	x	92.85	x	0.63	x	0.7	=	205.16	(77)
Southeast	0.9x	0.77	x	3.71	x	92.85	x	0.63	x	0.7	=	210.56	(77)
Southeast	0.9x	0.77	x	3.71	x	92.85	x	0.63	x	0.7	=	105.28	(77)
Southeast	0.9x	0.77	x	5.58	x	92.85	x	0.63	x	0.7	=	158.34	(77)
Southeast	0.9x	0.77	x	3.39	x	92.85	x	0.63	x	0.7	=	96.2	(77)
Southeast	0.9x	0.77	x	3.68	x	92.85	x	0.63	x	0.7	=	104.43	(77)
Southeast	0.9x	0.77	x	3.71	x	69.27	x	0.63	x	0.7	=	157.07	(77)
Southeast	0.9x	0.77	x	7.23	x	69.27	x	0.63	x	0.7	=	153.05	(77)
Southeast	0.9x	0.77	x	3.71	x	69.27	x	0.63	x	0.7	=	157.07	(77)
Southeast	0.9x	0.77	x	3.71	x	69.27	x	0.63	x	0.7	=	78.54	(77)
Southeast	0.9x	0.77	x	5.58	x	69.27	x	0.63	x	0.7	=	118.12	(77)
Southeast	0.9x	0.77	x	3.39	x	69.27	x	0.63	x	0.7	=	71.76	(77)
Southeast	0.9x	0.77	x	3.68	x	69.27	x	0.63	x	0.7	=	77.9	(77)
Southeast	0.9x	0.77	x	3.71	x	44.07	x	0.63	x	0.7	=	99.94	(77)
Southeast	0.9x	0.77	x	7.23	x	44.07	x	0.63	x	0.7	=	97.38	(77)
Southeast	0.9x	0.77	x	3.71	x	44.07	x	0.63	x	0.7	=	99.94	(77)
Southeast	0.9x	0.77	x	3.71	x	44.07	x	0.63	x	0.7	=	49.97	(77)
Southeast	0.9x	0.77	x	5.58	x	44.07	x	0.63	x	0.7	=	75.15	(77)
Southeast	0.9x	0.77	x	3.39	x	44.07	x	0.63	x	0.7	=	45.66	(77)
Southeast	0.9x	0.77	x	3.68	x	44.07	x	0.63	x	0.7	=	49.56	(77)
Southeast	0.9x	0.77	x	3.71	x	31.49	x	0.63	x	0.7	=	71.4	(77)
Southeast	0.9x	0.77	x	7.23	x	31.49	x	0.63	x	0.7	=	69.57	(77)
Southeast	0.9x	0.77	x	3.71	x	31.49	x	0.63	x	0.7	=	71.4	(77)

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Southeast	0.9x	0.77	x	3.71	x	31.49	x	0.63	x	0.7	=	35.7	(77)
Southeast	0.9x	0.77	x	5.58	x	31.49	x	0.63	x	0.7	=	53.7	(77)
Southeast	0.9x	0.77	x	3.39	x	31.49	x	0.63	x	0.7	=	32.62	(77)
Southeast	0.9x	0.77	x	3.68	x	31.49	x	0.63	x	0.7	=	35.41	(77)
West	0.9x	0.77	x	4.24	x	19.64	x	0.63	x	0.7	=	25.45	(80)
West	0.9x	0.77	x	4.32	x	19.64	x	0.63	x	0.7	=	25.93	(80)
West	0.9x	0.77	x	4.24	x	38.42	x	0.63	x	0.7	=	49.79	(80)
West	0.9x	0.77	x	4.32	x	38.42	x	0.63	x	0.7	=	50.72	(80)
West	0.9x	0.77	x	4.24	x	63.27	x	0.63	x	0.7	=	81.99	(80)
West	0.9x	0.77	x	4.32	x	63.27	x	0.63	x	0.7	=	83.54	(80)
West	0.9x	0.77	x	4.24	x	92.28	x	0.63	x	0.7	=	119.58	(80)
West	0.9x	0.77	x	4.32	x	92.28	x	0.63	x	0.7	=	121.83	(80)
West	0.9x	0.77	x	4.24	x	113.09	x	0.63	x	0.7	=	146.55	(80)
West	0.9x	0.77	x	4.32	x	113.09	x	0.63	x	0.7	=	149.31	(80)
West	0.9x	0.77	x	4.24	x	115.77	x	0.63	x	0.7	=	150.02	(80)
West	0.9x	0.77	x	4.32	x	115.77	x	0.63	x	0.7	=	152.85	(80)
West	0.9x	0.77	x	4.24	x	110.22	x	0.63	x	0.7	=	142.82	(80)
West	0.9x	0.77	x	4.32	x	110.22	x	0.63	x	0.7	=	145.52	(80)
West	0.9x	0.77	x	4.24	x	94.68	x	0.63	x	0.7	=	122.68	(80)
West	0.9x	0.77	x	4.32	x	94.68	x	0.63	x	0.7	=	125	(80)
West	0.9x	0.77	x	4.24	x	73.59	x	0.63	x	0.7	=	95.36	(80)
West	0.9x	0.77	x	4.32	x	73.59	x	0.63	x	0.7	=	97.16	(80)
West	0.9x	0.77	x	4.24	x	45.59	x	0.63	x	0.7	=	59.07	(80)
West	0.9x	0.77	x	4.32	x	45.59	x	0.63	x	0.7	=	60.19	(80)
West	0.9x	0.77	x	4.24	x	24.49	x	0.63	x	0.7	=	31.73	(80)
West	0.9x	0.77	x	4.32	x	24.49	x	0.63	x	0.7	=	32.33	(80)
West	0.9x	0.77	x	4.24	x	16.15	x	0.63	x	0.7	=	20.93	(80)
West	0.9x	0.77	x	4.32	x	16.15	x	0.63	x	0.7	=	21.32	(80)
Northwest	0.9x	0.77	x	2.35	x	11.28	x	0.63	x	0.7	=	24.31	(81)
Northwest	0.9x	0.77	x	2.12	x	11.28	x	0.63	x	0.7	=	21.93	(81)
Northwest	0.9x	0.77	x	2.01	x	11.28	x	0.63	x	0.7	=	13.86	(81)
Northwest	0.9x	0.77	x	2.34	x	11.28	x	0.63	x	0.7	=	8.07	(81)
Northwest	0.9x	0.77	x	2.29	x	11.28	x	0.63	x	0.7	=	15.79	(81)
Northwest	0.9x	0.77	x	0.98	x	11.28	x	0.63	x	0.7	=	3.38	(81)
Northwest	0.9x	0.77	x	2.35	x	22.97	x	0.63	x	0.7	=	49.48	(81)
Northwest	0.9x	0.77	x	2.12	x	22.97	x	0.63	x	0.7	=	44.64	(81)
Northwest	0.9x	0.77	x	2.01	x	22.97	x	0.63	x	0.7	=	28.22	(81)
Northwest	0.9x	0.77	x	2.34	x	22.97	x	0.63	x	0.7	=	16.42	(81)
Northwest	0.9x	0.77	x	2.29	x	22.97	x	0.63	x	0.7	=	32.15	(81)
Northwest	0.9x	0.77	x	0.98	x	22.97	x	0.63	x	0.7	=	6.88	(81)
Northwest	0.9x	0.77	x	2.35	x	41.38	x	0.63	x	0.7	=	89.15	(81)

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Northwest	0.9x	0.77	x	2.12	x	41.38	x	0.63	x	0.7	=	80.43	(81)
Northwest	0.9x	0.77	x	2.01	x	41.38	x	0.63	x	0.7	=	50.84	(81)
Northwest	0.9x	0.77	x	2.34	x	41.38	x	0.63	x	0.7	=	29.59	(81)
Northwest	0.9x	0.77	x	2.29	x	41.38	x	0.63	x	0.7	=	57.92	(81)
Northwest	0.9x	0.77	x	0.98	x	41.38	x	0.63	x	0.7	=	12.39	(81)
Northwest	0.9x	0.77	x	2.35	x	67.96	x	0.63	x	0.7	=	146.42	(81)
Northwest	0.9x	0.77	x	2.12	x	67.96	x	0.63	x	0.7	=	132.09	(81)
Northwest	0.9x	0.77	x	2.01	x	67.96	x	0.63	x	0.7	=	83.49	(81)
Northwest	0.9x	0.77	x	2.34	x	67.96	x	0.63	x	0.7	=	48.6	(81)
Northwest	0.9x	0.77	x	2.29	x	67.96	x	0.63	x	0.7	=	95.12	(81)
Northwest	0.9x	0.77	x	0.98	x	67.96	x	0.63	x	0.7	=	20.35	(81)
Northwest	0.9x	0.77	x	2.35	x	91.35	x	0.63	x	0.7	=	196.81	(81)
Northwest	0.9x	0.77	x	2.12	x	91.35	x	0.63	x	0.7	=	177.55	(81)
Northwest	0.9x	0.77	x	2.01	x	91.35	x	0.63	x	0.7	=	112.22	(81)
Northwest	0.9x	0.77	x	2.34	x	91.35	x	0.63	x	0.7	=	65.32	(81)
Northwest	0.9x	0.77	x	2.29	x	91.35	x	0.63	x	0.7	=	127.86	(81)
Northwest	0.9x	0.77	x	0.98	x	91.35	x	0.63	x	0.7	=	27.36	(81)
Northwest	0.9x	0.77	x	2.35	x	97.38	x	0.63	x	0.7	=	209.82	(81)
Northwest	0.9x	0.77	x	2.12	x	97.38	x	0.63	x	0.7	=	189.29	(81)
Northwest	0.9x	0.77	x	2.01	x	97.38	x	0.63	x	0.7	=	119.64	(81)
Northwest	0.9x	0.77	x	2.34	x	97.38	x	0.63	x	0.7	=	69.64	(81)
Northwest	0.9x	0.77	x	2.29	x	97.38	x	0.63	x	0.7	=	136.31	(81)
Northwest	0.9x	0.77	x	0.98	x	97.38	x	0.63	x	0.7	=	29.17	(81)
Northwest	0.9x	0.77	x	2.35	x	91.1	x	0.63	x	0.7	=	196.28	(81)
Northwest	0.9x	0.77	x	2.12	x	91.1	x	0.63	x	0.7	=	177.07	(81)
Northwest	0.9x	0.77	x	2.01	x	91.1	x	0.63	x	0.7	=	111.92	(81)
Northwest	0.9x	0.77	x	2.34	x	91.1	x	0.63	x	0.7	=	65.15	(81)
Northwest	0.9x	0.77	x	2.29	x	91.1	x	0.63	x	0.7	=	127.51	(81)
Northwest	0.9x	0.77	x	0.98	x	91.1	x	0.63	x	0.7	=	27.28	(81)
Northwest	0.9x	0.77	x	2.35	x	72.63	x	0.63	x	0.7	=	156.48	(81)
Northwest	0.9x	0.77	x	2.12	x	72.63	x	0.63	x	0.7	=	141.16	(81)
Northwest	0.9x	0.77	x	2.01	x	72.63	x	0.63	x	0.7	=	89.23	(81)
Northwest	0.9x	0.77	x	2.34	x	72.63	x	0.63	x	0.7	=	51.94	(81)
Northwest	0.9x	0.77	x	2.29	x	72.63	x	0.63	x	0.7	=	101.66	(81)
Northwest	0.9x	0.77	x	0.98	x	72.63	x	0.63	x	0.7	=	21.75	(81)
Northwest	0.9x	0.77	x	2.35	x	50.42	x	0.63	x	0.7	=	108.63	(81)
Northwest	0.9x	0.77	x	2.12	x	50.42	x	0.63	x	0.7	=	98	(81)
Northwest	0.9x	0.77	x	2.01	x	50.42	x	0.63	x	0.7	=	61.95	(81)
Northwest	0.9x	0.77	x	2.34	x	50.42	x	0.63	x	0.7	=	36.06	(81)
Northwest	0.9x	0.77	x	2.29	x	50.42	x	0.63	x	0.7	=	70.57	(81)
Northwest	0.9x	0.77	x	0.98	x	50.42	x	0.63	x	0.7	=	15.1	(81)

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Northwest	0.9x	0.77	x	2.35	x	28.07	x	0.63	x	0.7	=	60.47	(81)
Northwest	0.9x	0.77	x	2.12	x	28.07	x	0.63	x	0.7	=	54.55	(81)
Northwest	0.9x	0.77	x	2.01	x	28.07	x	0.63	x	0.7	=	34.48	(81)
Northwest	0.9x	0.77	x	2.34	x	28.07	x	0.63	x	0.7	=	20.07	(81)
Northwest	0.9x	0.77	x	2.29	x	28.07	x	0.63	x	0.7	=	39.29	(81)
Northwest	0.9x	0.77	x	0.98	x	28.07	x	0.63	x	0.7	=	8.41	(81)
Northwest	0.9x	0.77	x	2.35	x	14.2	x	0.63	x	0.7	=	30.59	(81)
Northwest	0.9x	0.77	x	2.12	x	14.2	x	0.63	x	0.7	=	27.59	(81)
Northwest	0.9x	0.77	x	2.01	x	14.2	x	0.63	x	0.7	=	17.44	(81)
Northwest	0.9x	0.77	x	2.34	x	14.2	x	0.63	x	0.7	=	10.15	(81)
Northwest	0.9x	0.77	x	2.29	x	14.2	x	0.63	x	0.7	=	19.87	(81)
Northwest	0.9x	0.77	x	0.98	x	14.2	x	0.63	x	0.7	=	4.25	(81)
Northwest	0.9x	0.77	x	2.35	x	9.21	x	0.63	x	0.7	=	19.85	(81)
Northwest	0.9x	0.77	x	2.12	x	9.21	x	0.63	x	0.7	=	17.91	(81)
Northwest	0.9x	0.77	x	2.01	x	9.21	x	0.63	x	0.7	=	11.32	(81)
Northwest	0.9x	0.77	x	2.34	x	9.21	x	0.63	x	0.7	=	6.59	(81)
Northwest	0.9x	0.77	x	2.29	x	9.21	x	0.63	x	0.7	=	12.9	(81)
Northwest	0.9x	0.77	x	0.98	x	9.21	x	0.63	x	0.7	=	2.76	(81)
Rooflights	0.9x	1	x	1.26	x	26	x	0.63	x	0.7	=	13	(82)
Rooflights	0.9x	1	x	2.21	x	26	x	0.63	x	0.7	=	22.81	(82)
Rooflights	0.9x	1	x	1.26	x	54	x	0.63	x	0.7	=	27.01	(82)
Rooflights	0.9x	1	x	2.21	x	54	x	0.63	x	0.7	=	47.37	(82)
Rooflights	0.9x	1	x	1.26	x	96	x	0.63	x	0.7	=	48.01	(82)
Rooflights	0.9x	1	x	2.21	x	96	x	0.63	x	0.7	=	84.21	(82)
Rooflights	0.9x	1	x	1.26	x	150	x	0.63	x	0.7	=	75.01	(82)
Rooflights	0.9x	1	x	2.21	x	150	x	0.63	x	0.7	=	131.57	(82)
Rooflights	0.9x	1	x	1.26	x	192	x	0.63	x	0.7	=	96.02	(82)
Rooflights	0.9x	1	x	2.21	x	192	x	0.63	x	0.7	=	168.41	(82)
Rooflights	0.9x	1	x	1.26	x	200	x	0.63	x	0.7	=	100.02	(82)
Rooflights	0.9x	1	x	2.21	x	200	x	0.63	x	0.7	=	175.43	(82)
Rooflights	0.9x	1	x	1.26	x	189	x	0.63	x	0.7	=	94.52	(82)
Rooflights	0.9x	1	x	2.21	x	189	x	0.63	x	0.7	=	165.78	(82)
Rooflights	0.9x	1	x	1.26	x	157	x	0.63	x	0.7	=	78.51	(82)
Rooflights	0.9x	1	x	2.21	x	157	x	0.63	x	0.7	=	137.71	(82)
Rooflights	0.9x	1	x	1.26	x	115	x	0.63	x	0.7	=	57.51	(82)
Rooflights	0.9x	1	x	2.21	x	115	x	0.63	x	0.7	=	100.87	(82)
Rooflights	0.9x	1	x	1.26	x	66	x	0.63	x	0.7	=	33.01	(82)
Rooflights	0.9x	1	x	2.21	x	66	x	0.63	x	0.7	=	57.89	(82)
Rooflights	0.9x	1	x	1.26	x	33	x	0.63	x	0.7	=	16.5	(82)
Rooflights	0.9x	1	x	2.21	x	33	x	0.63	x	0.7	=	28.95	(82)
Rooflights	0.9x	1	x	1.26	x	21	x	0.63	x	0.7	=	10.5	(82)

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Rooflights	0.9x	1	x	2.21	x	21	x	0.63	x	0.7	=	18.42	(82)

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

(83)m=	720.96	1312.9	1996.55	2768.28	3339.74	3412.79	3250.43	2814.49	2265.06	1507.44	879.6	606.27	(83)

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

(84)m=	1436.31	2025.88	2683.74	3412.58	3938.06	3968.64	3779.83	3350.92	2824.51	2110.03	1531.94	1298.25	(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=	1	1	0.99	0.96	0.88	0.74	0.59	0.66	0.89	0.99	1	1	(86)

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

(87)m=	19.07	19.3	19.69	20.2	20.62	20.88	20.96	20.94	20.71	20.13	19.51	19.05	(87)

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

(88)m=	19.64	19.64	19.65	19.67	19.67	19.67	19.67	19.67	19.67	19.67	19.66	19.66	(88)

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

(89)m=	1	1	0.99	0.95	0.83	0.63	0.43	0.5	0.82	0.98	1	1	(89)

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

(90)m=	17.09	17.43	17.99	18.73	19.31	19.59	19.66	19.65	19.43	18.65	17.75	17.07	(90)

fLA = Living area ÷ (4) = 0.44 (91)

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

(92)m=	17.97	18.26	18.75	19.39	19.89	20.16	20.24	20.22	20	19.31	18.53	17.95	(92)

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

(93)m=	17.97	18.26	18.75	19.39	19.89	20.16	20.24	20.22	20	19.31	18.53	17.95	(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=	1	1	0.98	0.94	0.84	0.67	0.5	0.58	0.84	0.98	1	1	(94)
Useful gains, hmGm , W = (94)m x (84)m													
(95)m=	1434.67	2017.05	2641.35	3219.84	3320.5	2677.92	1884.98	1931.71	2385.1	2062.65	1527.71	1297.28	(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=	7554.42	7358.04	6716.48	5641.42	4395.61	2984.54	1952.73	2051.05	3163.93	4671.31	6174.89	7483.7	(97)
Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m													
(98)m=	4553.1	3589.14	3031.9	1743.53	799.88	0	0	0	0	1940.84	3345.97	4602.7	

Total per year (kWh/year) = $Sum(98)_{1...5,9...12}$ = 23607.06 (98)

Space heating requirement in kWh/m²/year 66.93 (99)

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

Space heating:

Fraction of space heat from secondary/supplementary system 0 (201)

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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		88.9	(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)	4553.1	3589.14	3031.9	1743.53	799.88	0	0	0	0	1940.84	3345.97	4602.7		
(211)m = {[(98)m x (204)] } x 100 ÷ (206)	5121.59	4037.28	3410.46	1961.23	899.76	0	0	0	0	2183.17	3763.74	5177.39		(211)
Total (kWh/year) =Sum(211)$_{1...5,10...12}$=													26554.63	(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)	229.74	202.29	211.98	189.38	185.11	164.72	157.55	173.78	173.75	196.41	208.5	223.99		
Efficiency of water heater													86.7	(216)
(217)m=	88.79	88.78	88.75	88.68	88.48	86.7	86.7	86.7	86.7	88.69	88.77	88.8		(217)
Fuel for water heating, kWh/month (219)m = (64)m x 100 ÷ (217)m (219)m=	258.74	227.86	238.85	213.55	209.22	189.99	181.72	200.44	200.41	221.45	234.88	252.25		
Total = Sum(219a)$_{1...12}$ =													2629.35	(219)

Annual totals		kWh/year	kWh/year	
Space heating fuel used, main system 1			26554.63	
Water heating fuel used			2629.35	
Electricity for pumps, fans and electric keep-hot				
mechanical ventilation - balanced, extract or positive input from outside		868.39		(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) =		943.39	(231)
Electricity for lighting			786.69	(232)
Electricity generated by PVs			-2865.26	(233)

12a. CO2 emissions – Individual heating systems including micro-CHP

	Energy kWh/year	Emission factor kg CO2/kWh		Emissions kg CO2/year	
Space heating (main system 1)	(211) x	0.216	=	5735.8	(261)
Space heating (secondary)	(215) x	0.519	=	0	(263)
Water heating	(219) x	0.216	=	567.94	(264)
Space and water heating	(261) + (262) + (263) + (264) =			6303.74	(265)

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Electricity for pumps, fans and electric keep-hot	(231) x	0.519	=	489.62	(267)
Electricity for lighting	(232) x	0.519	=	408.29	(268)
Energy saving/generation technologies					
Item 1		0.519	=	-1487.07	(269)
Total CO2, kg/year	sum of (265)...(271) =			5714.58	(272)
Dwelling CO2 Emission Rate	(272) ÷ (4) =			16.2	(273)
EI rating (section 14)				81	(274)

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