ENERGY & SUSTAINABILITY STATEMENT

69 Avenue Road

Produced by XCO2 for N. Goulandris

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EXECUTIVE SUMMARY

The sustainability and energy strategy for the proposed development at 69 Avenue Road has been developed to comply with the relevant policies of the London Plan and the London Borough of Camden's Local Plan. The three step Energy Hierarchy has been implemented and the estimated regulated CO_2 savings on site are 42.9% against a Part L 2013 compliant scheme with SAP10 carbon factors; and 42.9% with SAP2012 carbon factors.

The proposals incorporate a range of sustainable design and construction measures, primarily addressing the sustainable management of resources, the protection and enhancement of the environment and the effective adaptation and mitigation of the development to climate change.

This report presents the sustainability strategy and assesses the predicted energy performance and carbon dioxide emissions of the proposed development at 69 Avenue Road located in the London Borough of Camden.

The proposed development comprises the renovation of the existing dwelling and the addition of a basement and ground floor extension to the west side of the property.

This document is divided into three parts:

1. Planning policies;
2. Proposed sustainability measures; and,
3. Energy Strategy.

The first section on Planning Policy provides an overview of the site and planning policies applicable to this development in accordance with the London Borough of Camden's Local Plan, CPG3 Sustainability and the London Plan.

The second section on proposed sustainability measures outlines the sustainability measures that have been adopted in the team's aim to maximise sustainability within the site.

The third section describes the predicted energy performance and carbon dioxide emissions of the proposed development at 69 Avenue Road. The proposed development, which includes the renovation of the existing dwelling plus an extension, is compared against a baseline dwelling, which includes the existing dwelling as it is plus a notional extension built according to Part L1B requirements. Figure 1 and Figure 2 summarise the regulated CO_2 savings achieved by the proposed development in comparison to the baseline building at each stage of the energy hierarchy, using SAP10 and SAP2012 carbon factors respectively.

The energy strategy outlined in this report has been developed using the SAP2012 emission factors according to the current version of Building Regulations. The results reported in the main body of the report are for SAP10 emission factors. This is representative of the shift towards more sustainable homes and allows for the future proofing of the proposed development.

The energy strategy for the scheme focuses on the efficiency of the fabric and building services, so that the energy demand is reduced to the extent feasible. Energy efficiency is primarily achieved through a highly insulated building envelope, a good air permeability rate in line with the Accredited Construction Details. Highly efficient lighting, space conditioning and hot water systems, as well as appropriate controls further reduce the regulated energy demand and consumption of the development.

In total, the development is expected to achieve regulated CO_2 savings of 42.9% compared to a notional development that meets the minimum Part L 2013 Regulations standards of performance. The proposed development therefore complies with the London Plan CO_2 savings target of 35% overall.

The proposals in their entirety reflect the client and design team's aspirations in delivering a high-quality, energy efficient development that underpins the sustainability of the built environment.

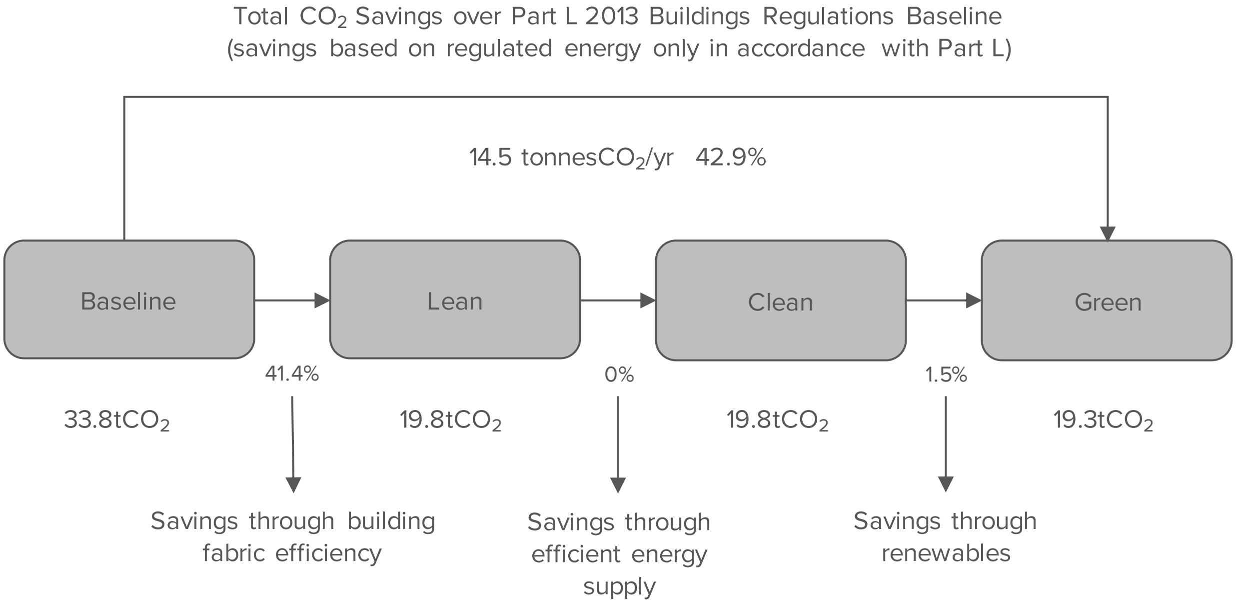

Figure 1: Energy hierarchy with SAP10 carbon factors

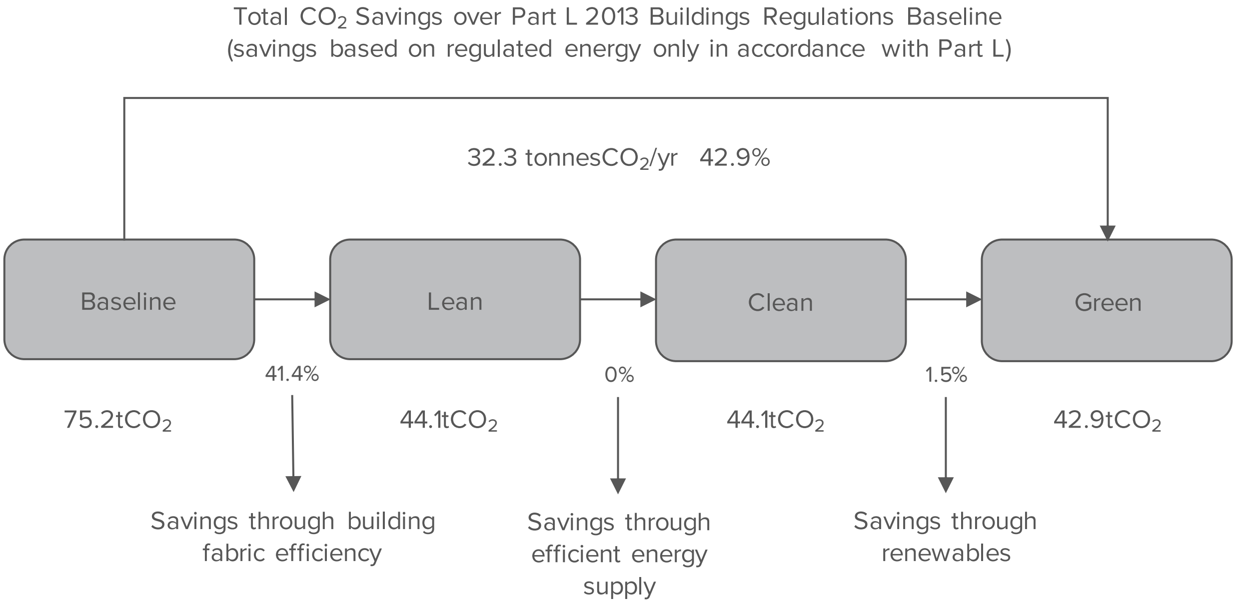

Figure 2: Energy hierarchy with SAP2012 carbon factors

INTRODUCTION

The proposed residential development is located on Avenue Road, within the London Borough of Camden. This section presents the description of the site and the development proposal.

SITE & PROPOSAL

Avenue Road is a residential street that runs south to Regent's Park. The proposed residential development is located at 69 Avenue Road, close to the intersections with Queen's Grove and Elsworthy Road. The site is accessible from Avenue Road, at the front of the property.

The proposed development includes the complete renovation of the existing dwelling and an extension consisting of a basement and a ground floor addition towards the west side of the property.

The location of the development site is shown in Figure 3 below.

Figure 3: Location of the application site.

PLANNING POLICIES

The proposal will seek to respond to the energy and sustainability policies of the London Plan, Camden's Local Plan and CPG3 Sustainability.

The most relevant applicable energy policies in the context of the proposed development are presented below.

THE LONDON PLAN

It is noted that the proposed scheme does not constitute 'major' development, and therefore London Plan policies, intended for major developments, are not applicable in this case.

The London Plan's Energy Hierarchy has however been followed in developing the energy strategy for the proposals, in line with Local Plan guidance. Further details on the Energy Hierarchy can be found in the Energy Strategy Summary section of this report.

The London Plan (2016) is the overall strategic plan for London, setting out an integrated economic, environmental, transport and social framework for the development of London over the next 20–25 years.

The overarching energy and sustainability policies of the London Plan are included in Chapter Five *London's Response to Climate Change* and include:

- Policy 5.2: Minimising carbon dioxide emissions;
- Policy 5.3: Sustainable Design and Construction;
- Policy 5.4: Retrofitting;
- Policy 5.4A: Electricity and gas supply;
- Policy 5.5: Decentralised energy networks;
- Policy 5.6: Decentralised energy in development proposals;
- Policy 5.7: Renewable energy;
- Policy 5.8: Innovative energy technologies;
- Policy 5.9: Overheating and cooling;
- Policy 5.11 Green Roofs and Development Site Environs;
- Policy 5.12 Flood Risk Management;
- Policy 5.13 Sustainable Drainage;
- Policy 5.15 Water use and Supplies; and,
- Policy 5.18 Construction, Excavation and Demolition Waste.

All the above policies have been considered in developing the sustainability strategy for the site. Policies 5.2 and 5.15 are presented below as these set out specific performance requirements for major developments; Policy 5.3 is also presented as it provides the framework of incorporating sustainable design and construction principles in new developments.

The London Plan also consists of a suite of guidance documents, most relevant of which are the Sustainable Design and Construction SPG (April 2014), Housing SPG (2016) & Energy Planning – GLA Guidance on preparing energy assessments (March 2016). These two documents are briefly presented in the sections that follow.

POLICY 5.2 MINIMISING CARBON DIOXIDE EMISSIONS

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

Be lean: use less energy
Be clean: supply energy efficiently
Be green: use renewable energy

B. The Mayor will work with boroughs and developers to ensure 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.

Table 1: CO_2 emissions improvement targets against the current Building Regulations

Residential Buildings	
Year	Minimum improvement over Building Regulations 2013
2016 - 2031	Zero Carbon
Non-domestic Buildings	
Year	Minimum improvement over Building Regulations 2013
2016 - 2019	35%
2019 - 2031	Zero Carbon

POLICY 5.3 SUSTAINABLE DESIGN AND CONSTRUCTION

"Planning decisions:

B. Development proposals should demonstrate that sustainable design standards are integral to the proposal, including its construction and operation, and ensure that they are considered at the beginning of the design process.

C. Major development proposals should meet the minimum standards outlined in the Mayor's supplementary planning guidance and this should be clearly demonstrated within a design and access statement. The standards include measures to achieve other policies in this Plan and the following sustainable design principles:

- a. *minimising carbon dioxide emissions across the site, including the building and services (such as heating and cooling systems)*
- b. *avoiding internal overheating and contributing to the urban heat island effect*
- c. *efficient use of natural resources (including water), including making the most of natural systems both within and around buildings*
- d. *minimising pollution (including noise, air and urban runoff)*
- e. *minimising the generation of waste and maximising reuse or recycling*
- f. *avoiding impacts from natural hazards (including flooding)*
- g. *ensuring developments are comfortable and secure for users, including avoiding the creation of adverse local climatic conditions*
- h. *securing sustainable procurement of materials, using local supplies where feasible, and*
- i. *promoting and protecting biodiversity and green infrastructure."*

POLICY 5.6 DECENTRALISED ENERGY IN DEVELOPMENT PROPOSALS

A. Development proposals should evaluate the feasibility of Combined Heat and Power (CHP) systems, and where a new CHP system is appropriate also examine opportunities to extend the system beyond the site boundary to adjacent sites.

B. Major development proposals should select energy systems in accordance with the following hierarchy:

Connection to existing heating or cooling networks;

Site wide CHP network;

Communal heating and cooling.

C. Potential opportunities to meet the first priority in this hierarchy are outlined in the London Heat Map tool. Where future network opportunities are identified, proposals should be designed to connect to these networks.

POLICY 5.7 RENEWABLE ENERGY

B. Within the framework of the energy hierarchy (see Policy 5.2), major proposals should provide a reduction in expected carbon dioxide emissions through the use of on-site renewable energy generation, where feasible.

D. All renewable energy systems should be located and designed to minimise any potential adverse impacts on biodiversity, the natural environment and historical assets, and to avoid any adverse impacts on air quality.

POLICY 5.9 OVERHEATING AND COOLING

B. Major development proposals should reduce potential overheating and reliance on air conditioning systems and demonstrate this in accordance with the following cooling hierarchy:

1. *Minimise internal heat generation through energy efficient design*

2. *Reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and walls*
3. *Manage the heat within the building through exposed internal thermal mass and high ceilings*
4. *Passive ventilation*
5. *Mechanical ventilation*
6. *Active cooling systems (ensuring they are the lowest carbon options).*

POLICY 5.15 WATER USE AND SUPPLIES

"...setting an upper limit of daily domestic water consumption to 105 litres/head for residential developments (excluding a maximum allowance of 5 litres/head/day for external water consumption)."


MAYOR OF LONDON

THE LONDON PLAN

THE SPATIAL DEVELOPMENT STRATEGY FOR LONDON
CONSOLIDATED WITH ALTERATIONS SINCE 2011

MARCH 2016

EMERGING LONDON PLAN 2018

The current 2016 consolidation Plan is still the adopted Development Plan. However, the Draft London Plan is a material consideration in planning decisions.

The following paragraphs highlight the key changes and additional requirements stemming from emerging policies.

GREENHOUSE GAS EMISSIONS

Policy GG6 (Increasing efficiency and resilience) sets a positive direction for the new draft Plan in terms of ambitious new greenhouse gas emission targets. This policy references London's target to become zero carbon by 2050 and the need to design buildings and infrastructure for a changing climate. To drive this change both residential and non-residential schemes will need to be net zero-carbon (via offset payments). At least 35% of this reduction must be made on site, with residential developments expected to achieve at least a 10% (and non-residential at least a 15%) reduction in emissions through energy efficiency measures alone.

In a major departure from the previous London Plan, calculations will be required to include both regulated and unregulated emissions at each stage of the energy hierarchy. Furthermore, major developments will have to submit details of the method with energy performance and carbon dioxide emissions monitored post-construction for at least the first five years of building operation.

ENERGY INFRASTRUCTURE

In addition to upgrades to the lean and green stages of the energy hierarchy the clean stage has also been enhanced. Most notably, all major developments within Heat Network Priority Areas will need to utilise a communal heating system.

For the first time in UK policy this policy (SE3: Energy infrastructure) recommends fuel cell technology, as step on the heating hierarchy, for selecting communal heating systems. Where developments are utilising CHP this policy also requires them to demonstrate that 'the emissions relating to energy generation will be equivalent or lower than those of an ultra-low NOx gas boiler'.

MATERIALS, WASTE & EMBODIED CARBON

A requirement for Energy Strategies to include proposals to minimise the embodied carbon in construction will be made. This may result in more sustainable material choices at design stage and could lead to straw, bamboo, clay and recycled materials alongside the more widely recognised cross-laminated timber becoming more commonplace in the capital. This section also links with Policy SI7: Reducing waste and supporting the circular economy, whereby materials are retained in use at their highest value for as long as possible. All referable applications will be required to submit a Circular Economy Statement.

AIR QUALITY

The new draft Plan addresses this crucial area by requiring all proposals to utilise 'design solutions to prevent or minimise increased exposure to existing air pollution and make provision to address local problems with air quality.'

In practice this will mean that a preliminary Air Quality Assessment (AQA) will need to be carried out for all major developments prior to any design work taking place, with a full AQA submitted in support of the planning application; these pieces of green infrastructure will also contribute towards the new draft Plan's target to make at least 50% green by 2050.

It should be noted that, as the policies in the draft London Plan are not yet adopted, the following sections demonstrate compliance with the current plan.

GLA GUIDANCE ON PREPARING ENERGY ASSESSMENTS (2018)

This document (last updated in October 2018) provides guidance on preparing energy assessments to accompany strategic planning applications; it contains clarifications on Policy 5.2 carbon reduction targets in the context of zero carbon policy, as well as detailed guidelines on the content of the Energy Assessments undertaken for planning.

The guidance document specifies the emission reduction targets the GLA will apply to applications as follows:

Stage 1 schemes received by the Mayor on or after the 1st October 2016: Zero carbon for residential development and 35% below Part L 2013 for commercial development.

The definition of zero carbon homes is provided on page 45 of the guidance:

Zero carbon homes - homes forming part of major development applications (i.e. those with 10 or more units) 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 offset through a cash in lieu contribution to the relevant borough to be ring fenced to secure delivery of carbon dioxide savings elsewhere.

The new guidance also includes changes to technical requirements relating to presenting carbon information separately for domestic and non-domestic elements of developments and the provision for cooling demand data where active cooling is required.

The structure of this report and the presentation of the carbon emission information for the development follows the guidance in this document.

MAYOR OF LONDON

Energy Assessment Guidance

Greater London Authority guidance on preparing energy assessments as part of planning applications (October 2018)

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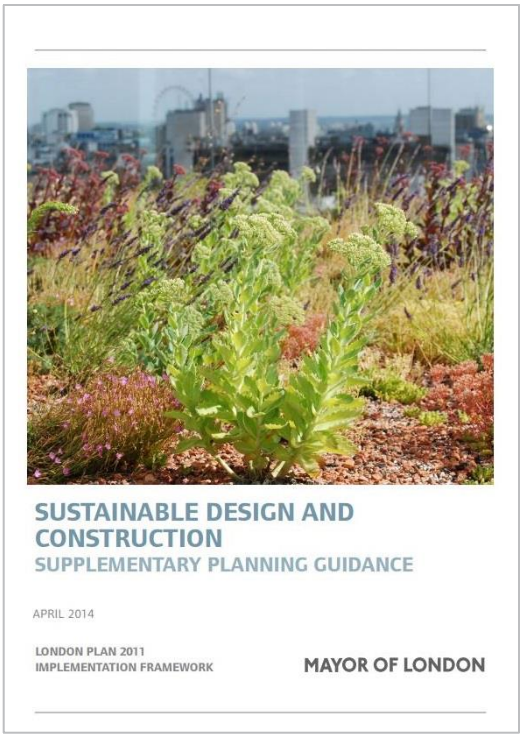
SUSTAINABLE DESIGN AND CONSTRUCTION SPG

The Sustainable Design and Construction SPG, adopted in April 2014, provides additional information and guidance to support the implementation of the Mayor's London Plan. The SPG does not set new policy but explains how policies in the London Plan should be carried through into action.

It is applicable to all major developments and building uses so it is not technically applicable to this development, however, in line with the developer's intention to implement the requirements of the London Plan it has been used to guide the design. It covers the following areas:

- Resource Management;
- Adapting to Climate Change and Greening the City; and,
- Pollution Management.

This SPG provides a basis for sustainable design in London and is used as the overarching structure of this report. Where additional local policies are addressed by these areas this has also been indicated.



HOUSING SPG

This document provides guidance on the implementation of housing policies in the London Plan and it replaces the 2012 Housing SPG.

Part 2 covers housing quality and updates London housing standards to reflect the implementation of the government's new national technical standards through the Minor Alterations to the London Plan (2015-2016).

As design affects the quality of life, health & wellbeing, safety and security of users and neighbours, this guidance is integral to sustainable development and will be cross-referenced as relevant in the subsequent sections.

CAMDEN LOCAL PLAN (2017)

The Camden Local Plan, adopted in 2017, sets out the following policies for energy and sustainability:

Policy CC1: Climate change mitigation

The Council will require all development to minimise the effects of climate change and encourage all developments to meet the highest feasible environmental standards that are financially viable during construction and occupation.

We will:

- *a) promote zero carbon development and require all development to reduce carbon dioxide emissions through following the steps in the energy hierarchy;*
- *b) require all major development to demonstrate how London Plan targets for carbon dioxide emissions have been met;*
- *c) ensure that the location of development and mix of land uses minimise the need to travel by car and help to support decentralised energy networks;*
- *d) support and encourage sensitive energy efficiency improvements to existing buildings;*
- *e) require all proposals that involve substantial demolition to demonstrate that it is not possible to retain and improve the existing building;*
- *f) expect all developments to optimise resource efficiency.*

For decentralised energy networks, we will promote decentralised energy by:

- *g) working with local organisations and developers to implement decentralised energy networks in the parts of Camden most likely to support them;*
- *h) protecting existing decentralised energy networks (e.g. at Gower Street, Bloomsbury, King's Cross, Gospel Oak and Somers Town) and safeguarding potential network routes; and*
- *i) requiring all major developments to assess the feasibility of connecting to an existing decentralised energy network, or where this is not possible establishing a new network.*

To ensure that the Council can monitor the effectiveness of renewable and low carbon technologies, major developments will be required to install appropriate monitoring equipment.

Policy CC2: Adapting to climate change

The Council will require development to be resilient to climate change.

All development should adopt appropriate climate change adaptation measures such as:

- *a) the protection of existing green spaces and promoting new appropriate green infrastructure;*
- *b) not increasing, and wherever possible reducing, surface water runoff through increasing permeable surfaces and use of Sustainable Drainage Systems;*
- *c) incorporating bio-diverse roofs, combination green and blue roofs and green walls where appropriate; and*
- *d) measures to reduce the impact of urban and dwelling overheating, including application of the cooling hierarchy.*

Any development involving 5 or more residential units or 500 sqm or more of any additional floorspace is required to demonstrate the above in a Sustainability Statement.

Sustainable design and construction measures

The Council will promote and measure sustainable design and construction by:

- *e) ensuring development schemes demonstrate how adaptation measures and sustainable development principles have been incorporated into the design and proposed implementation;*
- *f) encourage new build residential development to use the Home Quality Mark and Passivhaus design standards;*
- *g) encouraging conversions and extensions of 500 sqm of residential floorspace or above or five or more dwellings to achieve "excellent" in BREEAM domestic refurbishment; and*

h) expecting non-domestic developments of 500 sqm of floorspace or above to achieve "excellent" in BREEAM assessments and encouraging zero carbon in new development from 2019.

Policy CC3: Water and flooding

The Council will seek to ensure that development does not increase flood risk and reduces the risk of flooding where possible.

We will require development to:

a) incorporate water efficiency measures;

b) avoid harm to the water environment and improve water quality;

c) consider the impact of development in areas at risk of flooding (including drainage);

d) incorporate flood resilient measures in areas prone to flooding;

e) utilise Sustainable Drainage Systems (SuDS) in line with the drainage hierarchy to achieve a greenfield run-off rate where feasible; and

f) not locate vulnerable development in flood-prone areas.

Where an assessment of flood risk is required, developments should consider surface water flooding in detail and groundwater flooding where applicable.

The Council will protect the borough's existing drinking water and foul water infrastructure, including the reservoirs at Barrow Hill, Hampstead Heath, Highgate and Kidderpore.

Policy CC4: Air quality

The Council will ensure that the impact of development on air quality is mitigated and ensure that exposure to poor air quality is reduced in the borough.

The Council will take into account the impact of air quality when assessing development proposals, through the consideration of both the exposure of occupants to air pollution and the effect of the development on air quality. Consideration must be taken to the actions identified in the Council's Air Quality Action Plan.

Air Quality Assessments (AQAs) are required where development is likely to expose residents to high levels of air pollution. Where the AQA shows that a development would cause harm to air quality, the Council will not grant planning permission unless measures are adopted to mitigate the impact. Similarly, developments that introduce sensitive receptors (i.e. housing, schools) in locations of poor air quality will not be acceptable unless designed to mitigate the impact.

Development that involves significant demolition, construction or earthworks will also be required to assess the risk of dust and emissions impacts in an AQA and include appropriate mitigation measures to be secured in a Construction Management Plan.

Policy CC5: Waste

The Council will seek to make Camden a low waste borough.

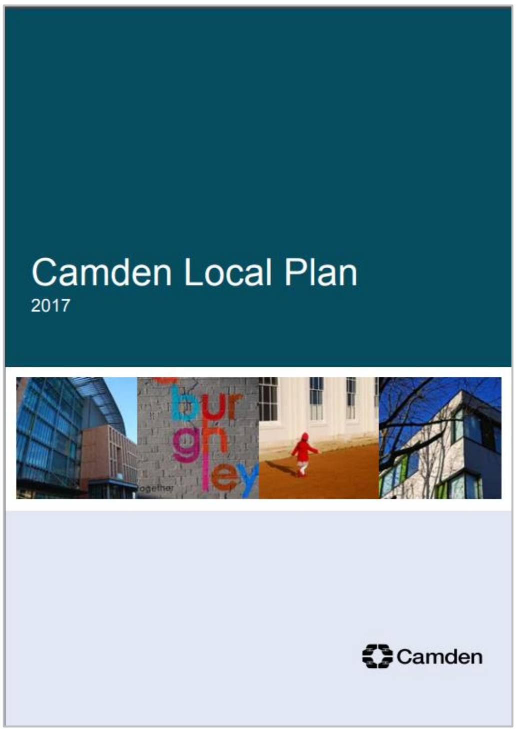
We will:

a) aim to reduce the amount of waste produced in the borough and increase recycling and the reuse of materials to meet the London Plan targets of 50% of household waste recycled/composted by 2020 and aspiring to achieve 60% by 2031;

b) deal with North London's waste by working with our partner boroughs in North London to produce a Waste Plan, which will ensure that sufficient land is allocated to manage the amount of waste apportioned to the area in the London Plan;

c) safeguard Camden's existing waste site at Regis Road unless a suitable compensatory waste site is provided that replaces the maximum throughput achievable at the existing site; and

d) make sure that developments include facilities for the storage and collection of waste and recycling.



CAMDEN PLANNING GUIDANCE – ENERGY EFFICIENCY AND ADAPTION

The Camden Planning Guidance for Energy Efficiency and Adaption has been prepared to support the policies within the Camden Local Plan (2017). The guidance provides most specific information on the key energy and resource issues within the Borough. The document was adopted in March 2019 and replaces the CPG3 Sustainability July 2015 (updated March 2018).

The sections that will be covered by the following sections of this Sustainability Statement are listed below:

The energy hierarchy

- *All developments in Camden is expected to reduce carbon dioxide emissions by following the energy hierarchy in accordance with Local Plan policy CC1.*
- *Energy strategies are to be designed following the steps set out in the energy hierarchy.*

Making buildings more energy efficient

- *Natural 'passive' measures should be prioritised over active measures to reduce energy.*

Decentralised energy

- *All new major developments in Camden are expected to assess the feasibility of decentralised energy network growth.*

Renewable energy technologies

- *There are a variety of renewable energy technologies that can be installed to supplement a development's energy needs.*
- *Developments are to target a 20% reduction in carbon dioxide emissions from on-site renewable energy technologies.*

Energy statements

- *Energy statements are required for all developments involving 5 or more dwellings and/or 500sqm or more of any (gross internal) floorspace.*
- *Energy statements should demonstrate how a development has been designed following the steps in the energy hierarchy.*
- *The energy reductions should accord to those set out in the following chapter 'Energy reduction'.*

Energy reduction

- *All development in Camden is expected to reduce carbon dioxide emissions through the application of the energy hierarchy.*
- *All new build major development to demonstrate compliance with London Plan targets for carbon dioxide emissions.*
- *Deep refurbishments (i.e. refurbishments assessed under Building Regulations Part L1A/L2A) should also meet the London Plan carbon reduction targets for new buildings.*
- *All new build residential development (of 1 – 9 dwellings) must meet 19% carbon dioxide reduction.*
- *Developments of five or more dwellings and/or more than 500sqm of any gross internal floorspace to achieve 20% reduction in carbon dioxide emissions from on-site renewable energy generation.*

Energy efficiency in existing buildings

- *All developments should demonstrate how sustainable design principles have been considered and incorporated.*
- *Sensitive improvements can be made to historic buildings to reduce carbon dioxide emissions.*
- *Warm homes and buildings are key to good health and wellbeing. As a guide, at least 10% of the project cost should be spent on environmental improvements.*
- *The 20% carbon reduction target (using on-site renewable energy technologies) applies for developments of five or more dwellings and/or more than 500sqm of any gross internal floorspace.*

Resource efficiency

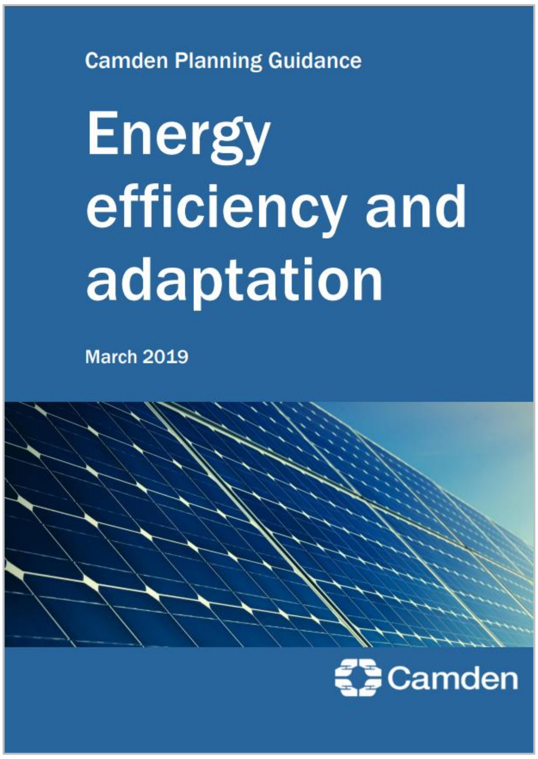
- *Proposals for substantial demolition should be justified in terms of the optimisation of resources and energy use, in comparison with the existing building.*
- *Where demolition cannot be avoided developments are expected to divert 85% of waste from landfill.*

Sustainable design and construction measures

- *All developments of 500 sqm or more should address sustainable design and construction measures (proposed in design and implementation) in a Sustainability Statement (Local Plan policy CC2).*
- *Active cooling (air conditioning) will only be permitted where its need is demonstrated and the steps in the cooling hierarchy are followed (Local Plan policy CC2).*
- *Development is expected to reduce overheating risk through following the steps in the cooling hierarchy. All new development should submit a statement demonstrating how the cooling hierarchy has been followed (Local Plan policy CC2).*
- *All developments should seek opportunities to make a positive contribution to green space provision or greening.*

Sustainability assessment tools

- *BREEAM Excellent is required for all non-residential development of 500sqm or more floorspace.*
- *Other assessment tools such as Home Quality Mark and Passivhaus are encouraged, they can serve to demonstrate the incorporation of sustainable design principles.*



PROPOSED SUSTAINABILITY MEASURES

The proposals incorporate a range of sustainability measures including the reduction in water use, waste and pollution as well as improvements in occupant health & wellbeing and ecology.

The following subsections detail the sustainability measures that will be incorporated into the design of the proposed dwellings.

ENERGY

DWELLING EMISSION RATE AND FABRIC ENERGY EFFICIENCY

The methodology set out by the Department of Energy and Climate Change (DECC) for assessing the energy use of dwellings is the Standard Assessment Procedure (SAP). The current version is SAP 2012.

Preliminary SAP calculations were carried out to assess the potential CO_2 savings achieved through

- Energy efficiency measures
- The efficient supply of energy and
- Renewable systems

The preliminary calculations showed an improvement over Part L Building Regulations 2013, amounting to a 42.9% reduction in regulated CO_2 emissions for the scheme.

The energy demand of the proposed dwelling at 69 Avenue Road will be reduced through the adoption of high levels of insulation, improved thermal bridging details and good levels of air tightness, where feasible. Due to the age of the existing dwelling, the refurbished sections of the building will look to improve upon the leakage rate, where feasible. For the purpose of this assessment the air permeability is assumed as default under SAP, but best-practice measures will be carried out to improve upon this.

DRYING SPACE

The proposed dwelling will include provisions for internal or external clothes drying where appropriate, thereby reducing the amount of electricity consumed through the use of tumble dryers.

ENERGY LABELLED WHITE GOODS

The dwelling will be supplied with energy efficient white goods to help reduce energy consumption.

EXTERNAL LIGHTING

Energy efficient light fittings will be installed throughout the development where appropriate. In addition, external lights will be fitted with controls to reduce the energy consumption of the building during periods of infrequent use:

- External space lighting will include energy efficient fittings
- Security lighting will include daylight cut-off devices, with a maximum wattage of 150W and PIR.

LOW OR ZERO CARBON TECHNOLOGIES

A feasibility study was carried out to determine the energy strategy for the proposed development. The proposed strategy has surpassed Part L Building Regulations due to the reduction in the demand by a highly efficient shell and the use of highly efficient air source heat pumps.

CYCLE STORAGE

Cycle storage space will be provided within the dwelling for use by the occupants to reduce the frequency of short car journeys. The cycle storage will be adequately sized and secure.

WATER

INDOOR WATER USE

The development at 69 Avenue Road aims to reduce water consumption to below 105 litres per person per day, in line with the new target set out within the London Plan (Minor Alterations to the London Plan 2016), through the use of water efficient fittings, and these are listed below.

Table 2: Recommended specification for sanitary fittings

Fitting	Consumption per use
WC (full flush)	6 litres per flush
WC (half flush)	3 litres per flush
Kitchen sink tap	6 litres per min
Wash basin tap	3 litres per min
Bath	180 litres to overflow
Shower	8 litres per min
Washing machine	8.17 litres per kilogram
Dishwasher	1.25 litres per place setting

MATERIALS

Embodied energy is the energy that is used in the manufacture, processing and the transportation of the materials to site.

The construction build-ups for each of the main building elements are rated from A+ to E. Each element to be used in the building has been rated according to the BRE Green Guide to Specification whereby:

- A+ rated elements are least likely to affect the environment
- E rated elements are most likely to affect the environment

It is assumed that most of the main building elements within this development will achieve between an A+ to C rating where possible.

All timber used during site preparation and construction to be FSC certified, and all non-timber materials to be certified with Environmental Management Systems (ISO 14001 OR BES 6001) where possible.

WASTE

HOUSEHOLD WASTE

Dedicated external waste storage for the dwelling will be provided to meet the Local Authority requirements.

Adequate internal storage for recyclable waste will be provided to the dwelling in a dedicated position. The Local Authority provides recyclable household waste collection and sorting.

CONSTRUCTION SITE WASTE MANAGEMENT

The development will minimise the impact of construction waste on the environment through a Resource Management Plan or Strategy. This plan will include information such as:

- Benchmarks for resource efficiency
- Procedures and commitments to reduce hazardous and non-hazardous waste
- Monitoring hazardous and non-hazardous waste

POLLUTION

GLOBAL WARMING POTENTIAL (GWP) OF INSULANTS

Global warming potential (GWP) is a measure of how effective a gas is at preventing the passage of infrared radiation. Blowing agents, used in the production of insulation, are a common source of gases with high GWPs.

The development will aim to specify insulation materials that have a low Global Warming Potential (GWP).

NO_x EMISSIONS

Space heating and hot water requirements are to be met through high efficiency ASHP systems with inherently low NOx emissions.

HEALTH AND WELLBEING

DAYLIGHTING

The existing dwelling already provides large areas of glazing to maximise daylight to internal spaces. The extension to this dwelling has been designed with daylight in mind and large areas of glazing have been provided to further maximise daylight and sunlight in all habitable spaces. A large south facing garden and terrace are also provided where light and sunlight will be abundant.

The proposed extension to the existing dwelling will have no adverse effects on access to daylight and sunlight of neighbouring properties.

SOUND INSULATION

The development proposes that airborne sound insulation will comply or exceed current Building Regulations Part E standards.

The development will incorporate design and building fabric measures to mitigate potential noise levels from the proposed development and ensure the impact of any external sources on internal ambient noise levels are within acceptable limits.

Further details can be found in the Noise Impact Assessment prepared by Noise Solutions Ltd submitted in support of the planning application.

PRIVATE SPACE

A large private garden and terrace are provided to the rear of the dwelling, with a south orientation. External spaces to the front of the property are also private due to the cover provided by the many large mature trees. These private external spaces in the proposed dwelling aim to improve the quality of life of the occupants.

SURFACE WATER RUN-OFF

The Environment Agency flood map below shows the proposed development to be located in Flood Zone 1, therefore, within an area at low risk of flooding.

However, sustainable urban drainage systems (SuDS) will be incorporated on site, such as an extent of green roof, and the buildings' fabric and structure will be designed to minimise risk of infiltration and damage via flooding, where possible. Landscaped areas and the private garden have been maximised to reduce the amount of surface water runoff from the site.

Further details for this scheme can be found in the Flood Risk Assessment prepared by Water Environment submitted in support of the planning application.

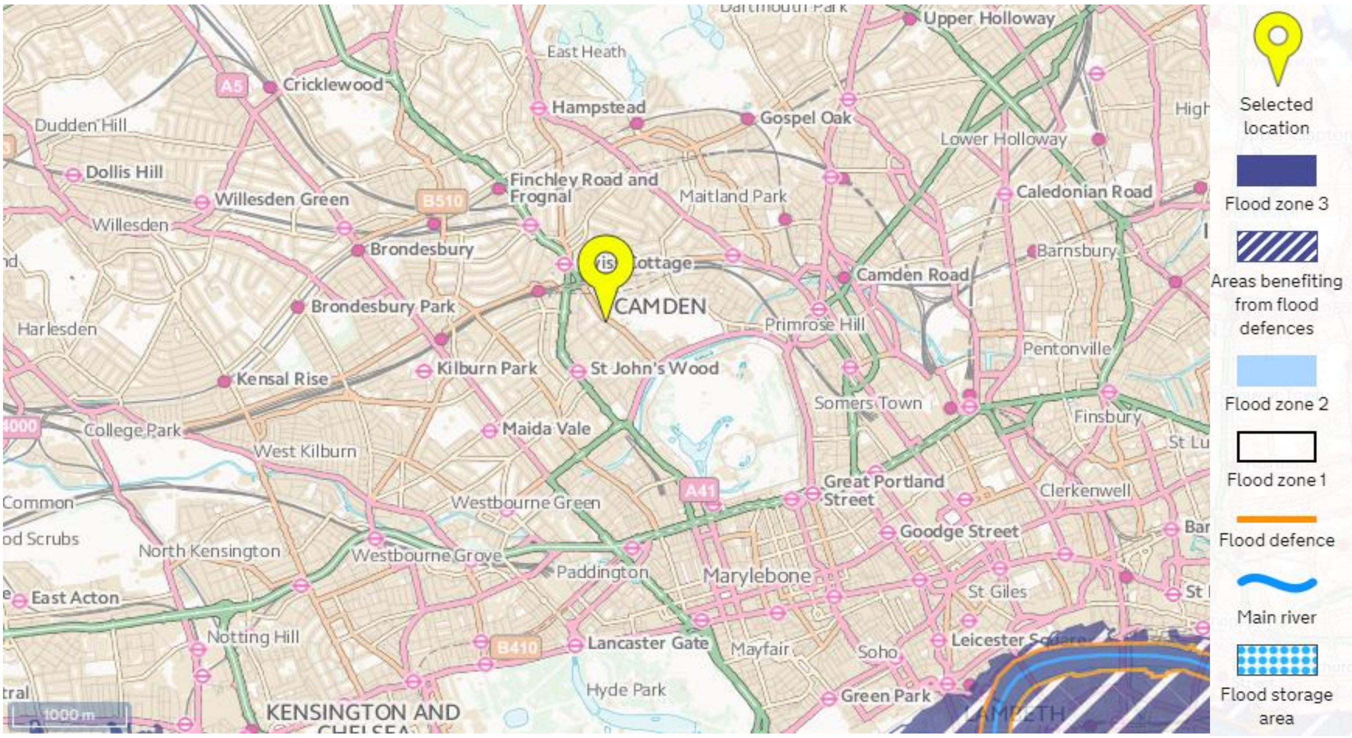


Figure 4: Flood map for local area

MANAGEMENT

CONSTRUCTION SITE IMPACTS

Where feasible, to minimise the construction impacts of the site, the contractor will strive to monitor, report and set targets for:

- The production of CO_2 arising from site activities
- Water consumption from site activities

In addition, contractors will strive to adopt best practice policies for air (dust) and water (ground and surface) pollution occurring on site. All timber will be sourced following the Government's Timber Procurement Policy.

ECOLOGY

ECOLOGICAL VALUE OF SITE & PROTECTION OF ECOLOGICAL FEATURES

Where possible, the large mature trees that encompass the current site will be kept ensuring the retention of the existing biodiversity of the site. The development will also introduce further landscaped areas within the existing private gardens and a green roof over the extension roof to increase the biodiversity of the post-developed site. Native species will be incorporated within the landscaped area, where possible, to maximise ecological improvement on site. The introduction of this further flora will help to attract invertebrates, birds and other fauna to the area.

Further details for this scheme can be found in the Arboriculture Impact Assessment prepared by Landmark Trees submitted in support of the planning application.

BUILDING FOOTPRINT

Although the proposed development will increase the density of the site, it has been designed in line with the surrounding architecture. This will ensure that the land is used efficiently whilst maximising the building area and maintaining the characteristics of the neighbourhood and the existing dwelling.

Further information can be found in the Heritage Statement prepared by Dorain Crone and the Design and Access Statement by KSR Architects submitted in support of the planning application.

MINIMISING OVERHEATING

The potential risk of overheating will be mitigated by incorporating passive and active design measures, in line with the London Plan Policy 5.9 and the Cooling Hierarchy, as follows.

THE COOLING HIERARCHY

MINIMISING INTERNAL HEAT GENERATION THROUGH ENERGY EFFICIENT DESIGN

The development will be served by high efficiency ASHP space heating and hot water system, therefore, heat losses from distribution pipework will be minimised. Heat sources and pipework will be sufficiently insulated to reduce heat dissipation in occupied spaces.

Efficient lighting will be used to further minimise internal heat gains and reduce energy expenditure.

REDUCING THE AMOUNT OF HEAT ENTERING THE BUILDING IN SUMMER

The openings across the development have been appropriately designed to offer satisfactory daylight and views to occupied spaces, without disproportionately increasing solar gains and overheating risks.

MECHANICAL VENTILATION

Mechanical ventilation is proposed as the primary strategy for the dwelling. The MVHR will be capable of operating in summer bypass mode allowing for the dissipation of any heat build-up during peak summer conditions.

PASSIVE VENTILATION

The development has allowed for passive ventilation as the secondary strategy for providing fresh air and dissipating heat that builds up within the building. The passive ventilation strategy includes single-sided ventilation, cross ventilation and night purge ventilation through openable windows and doors, operated by the occupants.

OVERHEATING RISK ASSESSMENT

The potential risk of overheating was assessed via the Part L Building Regulation compliance tool SAP.

An overheating risk classified as ‘Not Significant’ was found for the dwelling modelled in SAP.

ENERGY STRATEGY

This section describes the predicted energy performance and carbon dioxide emissions of the proposed 69 Avenue Road development based on the information provided by the design team.

The overall regulated CO_2 savings *on site* against a Part L 2013 compliant scheme are estimated at 42.9% with SAP10 carbon factors, and 42.9% with SAP2012 carbon factors

METHODOLOGY - BE LEAN, BE CLEAN, BE GREEN

The methodology used to determine CO_2 emissions is in accordance with the London Plan's three-step Energy Hierarchy (Policy 5.2A).

The proposed development, which includes the renovation of the existing dwelling plus an extension, is compared against a baseline dwelling, which includes the existing dwelling as it is with existing construction plus a notional extension built according to Part L1B requirements.

Since the current systems used within the dwelling are unknown, a baseline dwelling with electric ASHP has been adopted. Considering the scheme includes both new build and refurbishment developments, this baseline dwelling enables a comparison to be carried out on the improvement of the building fabric alone.

The regulated CO_2 savings that are presented within this section are achieved by the proposed development compared to this baseline building at each stage of the energy hierarchy.

BE LEAN – USE LESS ENERGY

The proposals incorporate a range of passive and active design measures that will reduce the energy demand for space conditioning, hot water and lighting. Measures will also be put in place to reduce the risk of overheating.

PASSIVE DESIGN MEASURES

ENHANCED U-VALUES

The heat loss of different building fabric elements is dependent upon their U-value, which is a measure of the thermal transmittance through the element. An element with low U-value provides better levels of insulation and reduced heating demand.

The proposed development will incorporate high levels of insulation for existing and new-build elements and high-performance glazing beyond Part L 2013 targets and notional building specifications, in order to reduce the demand for space conditioning (heating and/or cooling). Different U-values are used for the new-build elements of the extension and the refurbished elements of the existing dwelling. The U-values used for the extension are more stringent than the Building Regulation specifications; the refurbishment U-values will be upgraded based on guidance provided in Part L1B.

Table 3 demonstrates the improved performance of these proposed building elements beyond the Building Regulations requirements, for both the extension and the refurbishment. The assumed values for the existing building elements are based on guidance for a 1930's dwelling as outlined in SAP Conventions Appendix S.

Table 3: Thermal Envelope U-values

Extension (U-values in W/m².K)			
Element	Building Regulations	Proposed	Improvement
Walls	0.30	0.15	50%
Floor	0.25	0.10	60%
Roof	0.20	0.10	50%
Windows	2.00	1.30	35%
Refurbishment (U-values in W/m².K)			
Element	Existing	Proposed	Improvement
Walls	2.10	0.25	88%
Floor	1.20	0.25	79%
Roof	2.30	0.18	92%
Windows	4.80	1.30	73%

AIR TIGHTNESS IMPROVEMENT

Heat loss may also occur due to air infiltration. Although this cannot be eliminated altogether, good construction detailing, and the use of best practice construction techniques can minimise the amount of air infiltration.

Due to the age of the existing dwelling, the air permeability has been taken as default. However, the air permeability rate is intended to be improved upon during construction.

REDUCING THE NEED FOR ARTIFICIAL LIGHTING

The design of the development incorporates large areas of glazing across all building elevations, to optimise daylight in occupied spaces. Good internal daylight levels will translate to less dependency on artificial lighting and will indirectly deliver energy and carbon savings, together with pleasant, healthy spaces for occupants.

ACTIVE DESIGN MEASURES

HIGH EFFICACY LIGHTING

The development intends to incorporate low energy lighting fittings throughout the dwelling. All light fittings will be specified as low energy lighting and will primarily accommodate LEDs.

HEAT GENERATION

Space heating and domestic hot water will be provided in the dwelling by individual highly efficient air source heat pumps. To accommodate consistency between the Baseline and Be Lean stage, the gross efficiency of the air source heat pumps has been assumed as 170%. The final efficiency may be improved upon and is considered at the Be Green stage.

CONTROLS

Advanced lighting and space conditioning controls will be incorporated, specifically, heating controls in dwellings will comprise of time and temperature zone controls.

MONITORING

Apart from the above design measures, the development will incorporate monitoring equipment and systems to enable occupiers to monitor and reduce their energy use.

Smart meters will be installed to monitor the heat and electricity consumption of the dwelling; the display board will demonstrate real-time and historical energy use data and will be installed at an accessible location within the dwelling.

ENERGY USE

Table 4 and Table 5 show a breakdown of carbon dioxide emissions associated with the proposed development's fossil fuel and electricity consumption for the different uses. The figures provide a comparison between the baseline condition and the proposed development once energy efficiency measures (Lean) have been applied.

The tables demonstrate the energy savings achieved through energy efficiency measures only (Lean stage of the Energy Hierarchy).

Table 4: Breakdown of energy consumption and CO_2 emissions for the baseline and the proposed schemes after 'Lean' measures are implemented using SAP10 carbon factors

	Baseline			Lean		
	Energy (kWh/yr.)	**$kgCO_2$ /yr.**	**$kgCO_2/m^2$**	**Energy (kWh/yr.)**	**$kgCO_2$ /yr.**	**$kgCO_2/m^2$**
Hot Water	3,540	824	0.5	1,870	435	0.3
Space Heating	138,450	32,260	19.7	74,750	17,417	10.7
Cooling	0	0	0.0	0	0	0.0
Auxiliary	120	28	0.0	6,160	1,435	0.9
Lighting	2,770	647	0.4	2,170	505	0.3
Equipment	14,830	3,455	2.1	14,830	3,455	2.1
Total Part L	**144,890**	**33,758**	**20.7**	**84,950**	**19,791**	**12.1**
Total (incl. equipment)	**159,710**	**37,214**	**22.8**	**99,780**	**23,247**	**14.2**

Table 5: Breakdown of energy consumption and CO_2 emissions for the baseline and the proposed schemes after 'Lean' measures are implemented using SAP2012 carbon factors

	Baseline			Lean		
	Energy (kWh/yr.)	**$kgCO_2$ /yr.**	**$kgCO_2/m^2$**	**Energy (kWh/yr.)**	**$kgCO_2$ /yr.**	**$kgCO_2/m^2$**
Hot Water	3,540	1,840	1.1	1,870	970	0.6
Space Heating	138,450	71,860	44.0	74,750	38,800	23.7
Cooling	0	0	0.0	0	0	0.0
Auxiliary	120	60	0.0	6,160	3,200	2.0
Lighting	2,770	1,440	0.9	2,170	1,120	0.7
Equipment	14,830	7,700	4.7	14,830	7,700	4.7
Total Part L	**144,890**	**75,200**	**46.0**	**84,950**	**44,080**	**27.0**
Total (incl. equipment)	**159,710**	**82,890**	**50.7**	**99,780**	**51,780**	**31.7**

BE LEAN CO_2 EMISSIONS & SAVINGS

By means of energy efficiency measures alone, regulated CO_2 emissions are shown to reduce by 41.4% (14.0 tonnes per annum) using SAP10 factors, and by 41.4% (31.1 tonnes per annum) using SAP2012 carbon factors.

BE CLEAN – SUPPLY ENERGY EFFICIENTLY

The application site is in an area where district heating is not expected to be implemented in the near future. In addition, a site heating network is not considered feasible due to the size of the proposed development. Therefore, high efficiency air source heat pumps have been proposed.

No carbon savings have been achieved in this step of the Energy Hierarchy.

ENERGY SYSTEM HIERARCHY

The energy system for the development has been selected in accordance with the London Plan decentralised energy hierarchy. The hierarchy listed in Policy 5.6 states that energy systems should consider:

- Connection to existing heating and cooling networks;
- Site wide CHP network; and,
- Communal heating and cooling.

Local heat and power sources minimise distribution losses and achieve greater efficiencies when compared to separate energy systems, thus reducing CO_2 emissions.

In a communal energy system, energy in the form of heat, cooling, and/or electricity is generated from a central source and distributed via a network of insulated pipes to surrounding residences.

CONNECTION TO AN EXISTING NETWORK

The London Heat Map identifies existing and potential opportunities for decentralised energy projects in London. It builds on the 2005 London Community Heating Development Study.

An excerpt from the London Heat Map can be seen in the following figure. The map also highlights any existing and proposed district heating networks within the vicinity of the development.

A review of the map shows that there are no existing or proposed district heating networks close to the development site.

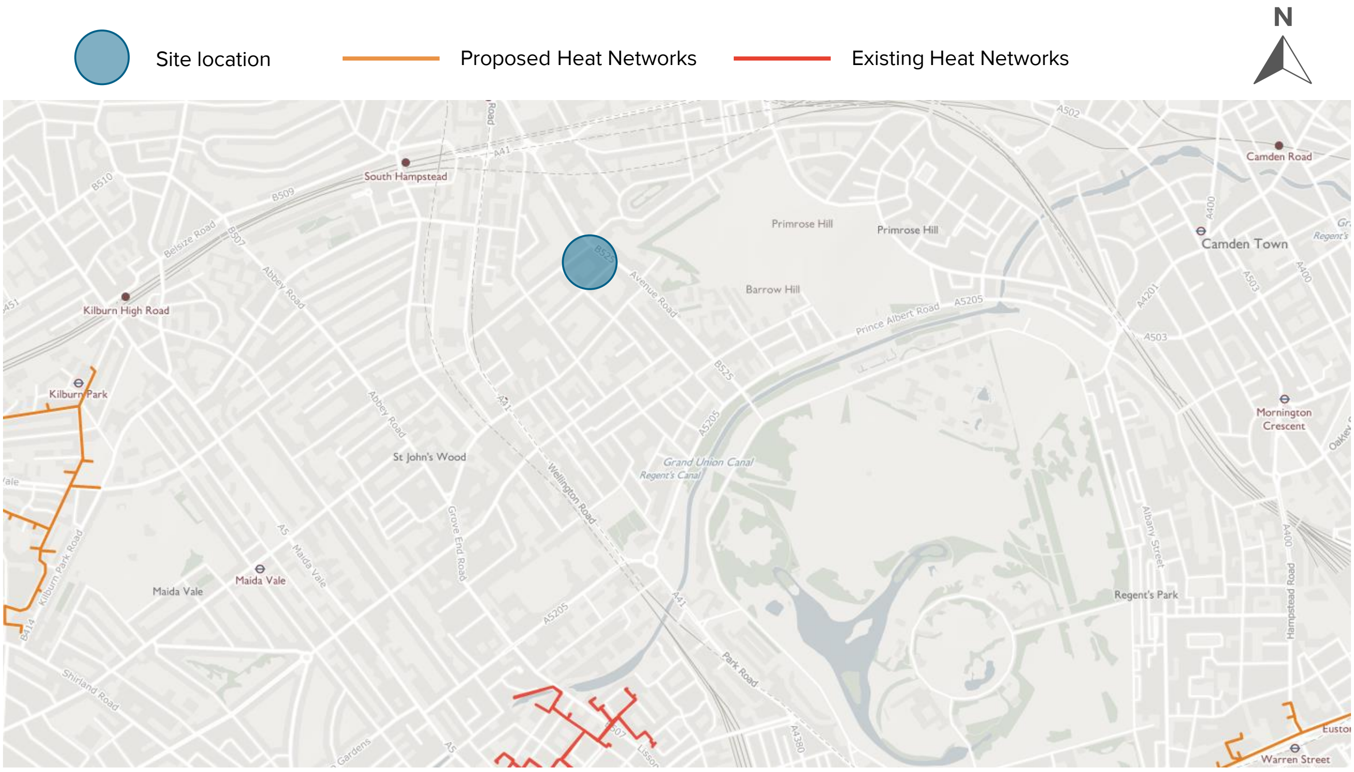


Figure 5: Excerpt from the London Heat Map. Existing district networks outlined in red, proposed networks in orange.

COMBINED HEAT & POWER

A CHP system is not viable for the proposed development as it does not provide high carbon savings under the new SAP10 carbon factors.

INDIVIDUAL HEATING

Space heating and hot water for the proposed development will therefore be provided by individual high efficiency air source heat pumps.

BE CLEAN CO_2 EMISSIONS & SAVINGS

Given that it has not been found feasible or viable for the proposed development to incorporate the supply of low carbon heating, no carbon savings are achieved for this step of the Energy Hierarchy.

BE GREEN – USE RENEWABLE ENERGY

The renewable technologies feasibility study carried out for the development identified air source heat pumps as a suitable technology for the development. The regulated carbon saving achieved in this step of the Energy Hierarchy is 1.5% over the site wide baseline level with SAP10 factors and 1.5% with SAP2012 factors.

RENEWABLE TECHNOLOGIES FEASIBILITY STUDY

Methods of generating on-site renewable energy (Green) were assessed, once Lean and Clean measures were taken into account.

The development of 69 Avenue Road will benefit from an energy efficient building fabric which will reduce the energy consumption of the proposed development in the first instance. A range of renewable technologies were subsequently considered including:

- Biomass;
- Ground/water source heat pumps;
- Air source heat pump;
- Wind energy;
- Photovoltaic panels, and,
- Solar thermal panels.

In determining the appropriate renewable technology for the site, the following factors were considered:

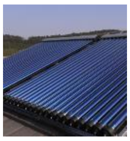
- CO_2 savings achieved;
- Site constraints;
- Any potential visual impacts, and,
- Compatibility with the 'Clean' stage proposals where applicable.

RENEWABLE ENERGY APPRAISAL SUMMARY

The table below summarises the factors taken into account in determining the appropriate renewable technologies for this project. This includes estimated capital cost, lifetime, level of maintenance and level of impact on external appearance. The final column indicates the feasibility of the technology in relation to the site conditions (10 being the most feasible and 0 being infeasible). It is important to note that the information provided is indicative and based upon early project stage estimates.

The feasibility study demonstrates that ASHP is the most feasible renewable technology for the proposed development. As the proposed development is located in a sensitive location between two areas of conservation, to preserve the character and architectural quality of the proposed development and the neighbourhood of heritage asset, PV systems or solar thermal panels are not considered feasible due to the significant visual impact associated with these technologies. Further information can be found within the accompanied Heritage Report prepared by Dorian Crone. A detailed assessment for the proposed ASHP technology can be found in the following sections.

Table 6: Summary of renewable technologies feasibility study

		Comments	Lifetime	Maintenance	Impact on external appearance	Site feasibility
Biomass		Not adopted -burning of wood pellets releases high NOx emissions and there are limitations for their storage and delivery within an urban location.	20 yrs.	High	High	2
PV		Not adopted - PV panels placed on the dwelling roof would create significant visual impact within areas of conservation.	25 yrs.	Low	Med	5
Solar thermal		Not adopted - fSolar thermal technology would also create significant visual impact within areas of conservation.	25 yrs.	Low	Med	5
GSHP		Not adopted -the installation of ground loops requires significant space, additional time at the beginning of the construction process and very high capital costs.	20 yrs.	Med	Low	4
ASHP		Adopted - ASHP evaporator units provide highly efficient space conditioning and hot water.	20 yrs.	Med	Med	9
Wind		Not adopted - Wind turbines located at the site will have a significant visual impact on the dwelling.	25 yrs.	Med	High	2

DETAILED ASSESSMENT OF AIR SOURCE HEAT PUMPS

Air source heat pumps (ASHPs) employ the same technology as ground source heat pump (GSHPs). However, instead of using heat exchangers buried in the ground, heat is extracted from the external ambient air.

The efficiency of heat pumps is very much dependent on the temperature difference between the heat source and the space required to be heated. As a result, ASHPs tend to have a lower COP than GSHPs. This is due to the varying levels of air temperature throughout the year when compared to the relatively stable ground temperature. The lower the difference between internal and external air temperature, the more efficient the system.

ASHP is considered a suitable technology for the development for the following reasons:

- It is a high efficiency system that can cater for the space heating and cooling of the most energy-intensive areas of the proposed development;
- Requires less capital cost than GSHP and other renewable technologies;
- It can be integrated with the proposed ventilation strategy; and,
- It is simple to install when compared to other renewable technologies.

The table opposite summarises the technical data for the proposed ASHP and estimated CO_2 savings from the application of this technology based on SAP10 carbon factors. In total, the ASHP technology would produce regulated CO_2 savings of 1.5% for the development. As the baseline for the proposed development was set to an electric system in order to reflect the significant savings from energy efficiency measures, the savings obtained from ASHP are lower.

Table 7: Summary of technical/operational data and estimated CO_2 savings for ASHP with SAP10 carbon factors

ASHP		
Efficiency	170%	
Carbon intensity of electricity	0.233	$kgCO_2/kWh$
Proportion of space heating and hot water met by ASHP	100	%
Total CO_2 savings	0.5	t/yr.
Regulated baseline CO_2 emissions	33.8	t/yr.
Total baseline CO_2 emissions	37.2	t/yr.
% Regulated CO_2 reduction*	1.5	%
% Total CO_2 reduction*	1.3	%

* % reduction from site baseline

Figure 6: Outdoor unit of an ASHP

BE GREEN CO_2 EMISSIONS & SAVINGS

The incorporation of renewable technologies will further reduce CO_2 emissions by a further 1.5% (0.5 tonnes per annum), with SAP10 carbon factors and by 1.5% (1.2 tonnes per annum), with SAP2012 carbon factors.

CONCLUSIONS

The sustainability strategy for the scheme at 69 Avenue Road has been developed in line with the relevant policies of the London Plan and of the London Borough of Camden's Local Plan and aims at the efficient management of resources, environmental protection and the effective adaptation and mitigation of the development to climate change.

The energy strategy has been developed in line with the three-step Energy Hierarchy and the cumulative CO_2 savings on site are 42.9% against a Part L 2013 compliant scheme with SAP10 carbon factors; and 42.9% with SAP2012 carbon factors.

SUSTAINABILITY

The proposed residential development will meet the targets set out by Camden Council and the Greater London Authority (GLA).

Key sustainability features of the proposed dwelling include:

- Effective renovation to the existing dwelling in response to the neighbouring context;
- Efficient design of the proposed extension so that habitable spaces across the site benefit from abundant daylight and sunlight levels, whilst impacts to neighbouring dwellings are kept to a minimum;
- The use of energy efficient lighting and appliances to further reduce the energy consumption of the site;
- The specification of water efficient fittings to limit water consumption to less than 105 litres per person per day for domestic uses;
- The protection of natural features of ecological value, such as exiting mature trees, and the implementation of further landscaped spaces to encourage biodiversity;
- Effective pollution management and control: the development is not expected to have any significant adverse effects to air, noise, land or watercourses.

The sustainability measures incorporated reflect the client and design team's aspirations in integrating sustainability measures and demonstrates that the project is designed to exceed the planning policy sustainability requirements.

ENERGY STRATEGY

By implementing the three step Energy Hierarchy as detailed in the previous sections, the Regulated CO_2 emissions for the development have been reduced against a Part L 2013 compliant scheme through on-site measures alone by 42.9% (14.5 tonnes per annum) with SAP10 carbon factors, and by 42.9% (32.3 tonnes per annum) with SAP2012 carbon factors.

The tables in the following pages summarise the implementation of the Energy Hierarchy for the proposed scheme and detail the CO_2 emissions and savings against the baseline scheme for each step of the hierarchy; as well as the savings achieved through carbon offset.

Separate tables are presented for the results obtained using SAP10 and SAP2012 carbon factors.

Overall, the proposed development at 69 Avenue Road has been designed to meet energy policies set out by the GLA and the London Borough of Camden, which demonstrates the client and the design team's commitment to enhancing sustainability of the scheme.

Table 8: CO_2 emissions after each step of the Energy Hierarchy for SAP10 carbon factors

	Carbon dioxide emissions for the domestic building (tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline	33.8	3.5
After energy demand reduction	19.8	3.5
After heat network/CHP	19.8	3.5
After renewable energy	19.3	3.5

Table 9: Regulated CO_2 savings from each stage of the Energy Hierarchy for SAP10 carbon factors

	Regulated domestic carbon dioxide savings	
	Tonnes CO_2 per annum	% over baseline
Savings from energy demand reduction	14.0	41.4%
Savings from heat network/CHP	0.0	0.0%
Savings from renewable energy	1.8	1.5%
Cumulative on-site savings	14.5	42.9%
Cumulative for offset payments	578.1 tonnes over 30 years	

Table 10: Summary of regulated CO_2 emissions and savings for SAP10 carbon factors

	Total regulated emissions (tonnes CO_2/year)	Regulated CO_2 savings (tonnes CO_2/year)	Percentage saving (%)
Baseline	33.8		
Be Lean	19.8	14.0	41.4%
Be Clean	19.8	0.0	0.0%
Be Green	19.3	0.5	1.5%
Total		14.5	42.9%
Offset to zero carbon for domestic		578.1 tonnes over 30 years	

Table 11: CO_2 emissions after each step of the Energy Hierarchy for SAP2012 carbon factors

	Carbon dioxide emissions for the domestic building (tonnes CO2 per annum)	
	Regulated	Unregulated
Baseline	75.2	7.7
After energy demand reduction	44.1	7.7
After heat network/CHP	44.1	7.7
After renewable energy	42.9	7.7

Table 12: Regulated CO_2 savings from each stage of the Energy Hierarchy for SAP2012 carbon factors

	Regulated domestic carbon dioxide savings	
	Tonnes CO_2 per annum	% over baseline
Savings from energy demand reduction	31.1	41.4%
Savings from heat network/CHP	0.0	0.0%
Savings from renewable energy	1.2	1.5%
Cumulative on-site savings	32.3	42.9%
Cumulative for offset payments	1,288 tonnes over 30 years	

Table 13: Summary of regulated CO_2 emissions and savings for SAP2012 carbon factors

	Total regulated emissions (tonnes CO_2/year)	Regulated CO_2 savings (tonnes CO_2/year)	Percentage saving (%)
Baseline	75.2		
Be Lean	44.1	31.1	41.4%
Be Clean	44.1	0.0	0.0%
Be Green	42.9	1.2	1.5%
Total		32.3	42.9%
Offset to zero carbon for domestic		1,288tonnes over 30 years	

APPENDIX A – SAP RESULTS

The following pages show the DER/TER FSAP2012 worksheets for the dwelling.

DER WorkSheet: New dwelling design stage

User Details:

Assessor Name: | **Stroma Number:**
Software Name: Stroma FSAP 2012 | **Software Version:** Version: 1.0.4.23

Property Address: Proposed (ASHP Be Green - MCS ASHP)

Address : 69, Avenue Road, LONDON, NW8 6HP

1. Overall dwelling dimensions:

	Area(m²)			Av. Height(m)			Volume(m³)	
Basement	544	(1a)	x	3.52	(2a)	=	1914.88	(3a)
Ground floor	547	(1b)	x	3.08	(2b)	=	1684.76	(3b)
First floor	326	(1c)	x	2.71	(2c)	=	883.46	(3c)
Second floor	217	(1d)	x	2.49	(2d)	=	540.33	(3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	1634	(4)						
Dwelling volume				(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n)		=	5023.43	(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		15	(17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)	0.75	(18)

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

Number of sides sheltered		2	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.64	(21)

Infiltration rate modified for monthly wind speed

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

DER WorkSheet: New dwelling design stage

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

0.81	0.8	0.78	0.7	0.69	0.61	0.61	0.59	0.64	0.69	0.72	0.75

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) = 75.65 (23c)

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

(24a)m=	0.93	0.92	0.9	0.82	0.81	0.73	0.73	0.71	0.76	0.81	0.84	0.87	(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	0	0	0	0	0	0	0	0	0	0	0	(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=	0.93	0.92	0.9	0.82	0.81	0.73	0.73	0.71	0.76	0.81	0.84	0.87	(25)

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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			2.52	x	3	=	7.56			(26)
Windows Type 1			1.9		x1/[1/(1.3)+ 0.04]	=	2.35			(27)
Windows Type 2			1.8		x1/[1/(1.3)+ 0.04]	=	2.22			(27)
Windows Type 3			37.89		x1/[1/(1.3)+ 0.04]	=	46.82			(27)
Windows Type 4			4.9		x1/[1/(1.3)+ 0.04]	=	6.06			(27)
Windows Type 5			12.64		x1/[1/(1.3)+ 0.04]	=	15.62			(27)
Windows Type 6			2.14		x1/[1/(1.3)+ 0.04]	=	2.64			(27)
Windows Type 7			8.54		x1/[1/(1.3)+ 0.04]	=	10.55			(27)
Windows Type 8			4.57		x1/[1/(1.3)+ 0.04]	=	5.65			(27)
Windows Type 9			1.8		x1/[1/(1.3)+ 0.04]	=	2.22			(27)
Windows Type 10			7.97		x1/[1/(1.3)+ 0.04]	=	9.85			(27)
Windows Type 11			8.77		x1/[1/(1.3)+ 0.04]	=	10.84			(27)
Windows Type 12			4.53		x1/[1/(1.3)+ 0.04]	=	5.6			(27)
Windows Type 13			3.5		x1/[1/(1.3)+ 0.04]	=	4.33			(27)

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Windows Type 14			5.45	x1/[1/(1.3)+ 0.04]		=	6.73			(27)
Windows Type 15			1.8	x1/[1/(1.3)+ 0.04]		=	2.22			(27)
Windows Type 16			2.14	x1/[1/(1.3)+ 0.04]		=	2.64			(27)
Windows Type 17			3.71	x1/[1/(1.3)+ 0.04]		=	4.58			(27)
Windows Type 18			1.8	x1/[1/(1.3)+ 0.04]		=	2.22			(27)
Windows Type 19			1.96	x1/[1/(1.3)+ 0.04]		=	2.42			(27)
Windows Type 20			2.33	x1/[1/(1.3)+ 0.04]		=	2.88			(27)
Windows Type 21			2.65	x1/[1/(1.3)+ 0.04]		=	3.27			(27)
Windows Type 22			3.97	x1/[1/(1.3)+ 0.04]		=	4.91			(27)
Windows Type 23			1.61	x1/[1/(1.3)+ 0.04]		=	1.99			(27)
Floor Type 1			544	x	0.1	=	54.4			(28)
Floor Type 2			81.8	x	0.1	=	8.18			(28)
Floor Type 3			49.3	x	0.25	=	12.325			(28)
Walls Type1	450.56	7.6	442.96	x	0.15	=	66.44			(29)
Walls Type2	214.97	85.89	129.08	x	0.15	=	19.36			(29)
Walls Type3	224.21	59.44	164.77	x	0.25	=	41.19			(29)
Walls Type4	238.48	43.13	195.35	x	0.25	=	48.84			(29)
Walls Type5	199.2	13.21	185.99	x	0.25	=	46.5			(29)
Roof Type1	221	0	221	x	0.1	=	22.1			(30)
Roof Type2	376.4	0	376.4	x	0.18	=	67.75			(30)
Total area of elements, m²			2599.92							(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) =	650.14	(33)
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		389.99	(36)

if details of thermal bridging are not known (36) = 0.05 x (31)

Total fabric heat loss	(33) + (36) =	1040.13	(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=	1549.25	1522.83	1496.41	1364.31	1337.89	1205.79	1205.79	1179.37	1258.63	1337.89	1390.73	1443.57	(38)

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

(39)m=	2589.38	2562.96	2536.54	2404.44	2378.02	2245.92	2245.92	2219.5	2298.76	2378.02	2430.86	2483.7	

Average = Sum(39)$_{1…12}$ /12= 2397.84 (39)

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

(40)m=	1.58	1.57	1.55	1.47	1.46	1.37	1.37	1.36	1.41	1.46	1.49	1.52	

Average = Sum(40)$_{1…12}$ /12= 1.47 (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)

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DER WorkSheet: New dwelling design stage

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N | 4.87 | (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 | 149.77 | (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=	164.75	158.76	152.77	146.78	140.78	134.79	134.79	140.78	146.78	152.77	158.76	164.75		
										Total = Sum(44)$_{1...12}$ =			1797.25	(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=	244.32	213.68	220.5	192.24	184.46	159.17	147.5	169.25	171.27	199.6	217.88	236.61		
										Total = Sum(45)$_{1...12}$ =			2356.47	(45)
If instantaneous water heating at point of use (no hot water storage), enter 0 in boxes (46) to (61)														
(46)m=	36.65	32.05	33.07	28.84	27.67	23.88	22.12	25.39	25.69	29.94	32.68	35.49		(46)

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel | 300 | (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) = | 300 | (50)

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

Hot water storage loss factor from Table 2 (kWh/litre/day) | 0.01 | (51)

If community heating see section 4.3

Volume factor from Table 2a | 0.74 | (52)

Temperature factor from Table 2b | 0.54 | (53)

Energy lost from water storage, kWh/year (47) x (51) x (52) x (53) = | 1.48 | (54)

Enter (50) or (54) in (55) | 1.48 | (55)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(56)m=	46	41.55	46	44.52	46	44.52	46	46	44.52	46	44.52	46	(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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(57)m=	46	41.55	46	44.52	46	44.52	46	46	44.52	46	44.52	46	(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)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(59)m=	23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(61)m=	0	0	0	0	0	0	0	0	0	0	0	0	(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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(62)m=	313.58	276.24	289.76	259.27	253.72	226.2	216.76	238.52	238.31	268.87	284.91	305.87	(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)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)

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Output from water heater

(64)m=	313.58	276.24	289.76	259.27	253.72	226.2	216.76	238.52	238.31	268.87	284.91	305.87		
								Output from water heater (annual)1…12					3172.02	(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=	136.65	121.1	128.73	117.54	116.74	106.55	104.45	111.69	110.57	121.78	126.07	134.08	(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=	243.31	243.31	243.31	243.31	243.31	243.31	243.31	243.31	243.31	243.31	243.31	243.31	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
(67)m=	122.65	108.94	88.59	67.07	50.14	42.33	45.74	59.45	79.79	101.32	118.25	126.06	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
(68)m=	1254.13	1267.14	1234.34	1164.53	1076.4	993.57	938.23	925.22	958.01	1027.83	1115.96	1198.79	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
(69)m=	47.33	47.33	47.33	47.33	47.33	47.33	47.33	47.33	47.33	47.33	47.33	47.33	(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=	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	(71)
Water heating gains (Table 5)													
(72)m=	183.67	180.21	173.02	163.25	156.91	147.98	140.4	150.12	153.57	163.68	175.1	180.22	(72)
Total internal gains =						(66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m							
(73)m=	1659.43	1655.27	1594.95	1493.85	1382.44	1282.87	1223.36	1233.78	1290.37	1391.82	1508.3	1604.06	(73)

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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)	
North	0.9x	0.77	x	1.8	x	10.63	x	0.63	x	0.7	=	23.4	(74)
North	0.9x	0.77	x	1.8	x	10.63	x	0.63	x	0.7	=	29.25	(74)
North	0.9x	0.77	x	1.8	x	20.32	x	0.63	x	0.7	=	44.71	(74)
North	0.9x	0.77	x	1.8	x	20.32	x	0.63	x	0.7	=	55.89	(74)
North	0.9x	0.77	x	1.8	x	34.53	x	0.63	x	0.7	=	75.98	(74)
North	0.9x	0.77	x	1.8	x	34.53	x	0.63	x	0.7	=	94.98	(74)
North	0.9x	0.77	x	1.8	x	55.46	x	0.63	x	0.7	=	122.04	(74)
North	0.9x	0.77	x	1.8	x	55.46	x	0.63	x	0.7	=	152.56	(74)
North	0.9x	0.77	x	1.8	x	74.72	x	0.63	x	0.7	=	164.41	(74)
North	0.9x	0.77	x	1.8	x	74.72	x	0.63	x	0.7	=	205.51	(74)
North	0.9x	0.77	x	1.8	x	79.99	x	0.63	x	0.7	=	176	(74)
North	0.9x	0.77	x	1.8	x	79.99	x	0.63	x	0.7	=	220	(74)

North	0.9x	0.77	x	1.8	x	74.68	x	0.63	x	0.7	=	164.32	(74)
North	0.9x	0.77	x	1.8	x	74.68	x	0.63	x	0.7	=	205.4	(74)
North	0.9x	0.77	x	1.8	x	59.25	x	0.63	x	0.7	=	130.37	(74)
North	0.9x	0.77	x	1.8	x	59.25	x	0.63	x	0.7	=	162.96	(74)
North	0.9x	0.77	x	1.8	x	41.52	x	0.63	x	0.7	=	91.35	(74)
North	0.9x	0.77	x	1.8	x	41.52	x	0.63	x	0.7	=	114.19	(74)
North	0.9x	0.77	x	1.8	x	24.19	x	0.63	x	0.7	=	53.23	(74)
North	0.9x	0.77	x	1.8	x	24.19	x	0.63	x	0.7	=	66.53	(74)
North	0.9x	0.77	x	1.8	x	13.12	x	0.63	x	0.7	=	28.86	(74)
North	0.9x	0.77	x	1.8	x	13.12	x	0.63	x	0.7	=	36.08	(74)
North	0.9x	0.77	x	1.8	x	8.86	x	0.63	x	0.7	=	19.51	(74)
North	0.9x	0.77	x	1.8	x	8.86	x	0.63	x	0.7	=	24.38	(74)
Northeast	0.9x	0.77	x	4.9	x	11.28	x	0.63	x	0.7	=	16.9	(75)
Northeast	0.9x	0.77	x	12.64	x	11.28	x	0.63	x	0.7	=	43.59	(75)
Northeast	0.9x	0.77	x	4.9	x	22.97	x	0.63	x	0.7	=	34.39	(75)
Northeast	0.9x	0.77	x	12.64	x	22.97	x	0.63	x	0.7	=	88.72	(75)
Northeast	0.9x	0.77	x	4.9	x	41.38	x	0.63	x	0.7	=	61.96	(75)
Northeast	0.9x	0.77	x	12.64	x	41.38	x	0.63	x	0.7	=	159.84	(75)
Northeast	0.9x	0.77	x	4.9	x	67.96	x	0.63	x	0.7	=	101.76	(75)
Northeast	0.9x	0.77	x	12.64	x	67.96	x	0.63	x	0.7	=	262.51	(75)
Northeast	0.9x	0.77	x	4.9	x	91.35	x	0.63	x	0.7	=	136.79	(75)
Northeast	0.9x	0.77	x	12.64	x	91.35	x	0.63	x	0.7	=	352.86	(75)
Northeast	0.9x	0.77	x	4.9	x	97.38	x	0.63	x	0.7	=	145.83	(75)
Northeast	0.9x	0.77	x	12.64	x	97.38	x	0.63	x	0.7	=	376.19	(75)
Northeast	0.9x	0.77	x	4.9	x	91.1	x	0.63	x	0.7	=	136.42	(75)
Northeast	0.9x	0.77	x	12.64	x	91.1	x	0.63	x	0.7	=	351.92	(75)
Northeast	0.9x	0.77	x	4.9	x	72.63	x	0.63	x	0.7	=	108.76	(75)
Northeast	0.9x	0.77	x	12.64	x	72.63	x	0.63	x	0.7	=	280.55	(75)
Northeast	0.9x	0.77	x	4.9	x	50.42	x	0.63	x	0.7	=	75.51	(75)
Northeast	0.9x	0.77	x	12.64	x	50.42	x	0.63	x	0.7	=	194.77	(75)
Northeast	0.9x	0.77	x	4.9	x	28.07	x	0.63	x	0.7	=	42.03	(75)
Northeast	0.9x	0.77	x	12.64	x	28.07	x	0.63	x	0.7	=	108.42	(75)
Northeast	0.9x	0.77	x	4.9	x	14.2	x	0.63	x	0.7	=	21.26	(75)
Northeast	0.9x	0.77	x	12.64	x	14.2	x	0.63	x	0.7	=	54.84	(75)
Northeast	0.9x	0.77	x	4.9	x	9.21	x	0.63	x	0.7	=	13.8	(75)
Northeast	0.9x	0.77	x	12.64	x	9.21	x	0.63	x	0.7	=	35.59	(75)
Southeast	0.9x	0.77	x	1.9	x	36.79	x	0.63	x	0.7	=	85.46	(77)
Southeast	0.9x	0.77	x	1.8	x	36.79	x	0.63	x	0.7	=	121.44	(77)
Southeast	0.9x	0.77	x	37.89	x	36.79	x	0.63	x	0.7	=	426.06	(77)
Southeast	0.9x	0.77	x	1.8	x	36.79	x	0.63	x	0.7	=	141.68	(77)
Southeast	0.9x	0.77	x	2.33	x	36.79	x	0.63	x	0.7	=	26.2	(77)

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Southeast	0.9x	0.77	x	1.9	x	62.67	x	0.63	x	0.7	=	145.57	(77)
Southeast	0.9x	0.77	x	1.8	x	62.67	x	0.63	x	0.7	=	206.86	(77)
Southeast	0.9x	0.77	x	37.89	x	62.67	x	0.63	x	0.7	=	725.74	(77)
Southeast	0.9x	0.77	x	1.8	x	62.67	x	0.63	x	0.7	=	241.34	(77)
Southeast	0.9x	0.77	x	2.33	x	62.67	x	0.63	x	0.7	=	44.63	(77)
Southeast	0.9x	0.77	x	1.9	x	85.75	x	0.63	x	0.7	=	199.17	(77)
Southeast	0.9x	0.77	x	1.8	x	85.75	x	0.63	x	0.7	=	283.04	(77)
Southeast	0.9x	0.77	x	37.89	x	85.75	x	0.63	x	0.7	=	992.99	(77)
Southeast	0.9x	0.77	x	1.8	x	85.75	x	0.63	x	0.7	=	330.21	(77)
Southeast	0.9x	0.77	x	2.33	x	85.75	x	0.63	x	0.7	=	61.06	(77)
Southeast	0.9x	0.77	x	1.9	x	106.25	x	0.63	x	0.7	=	246.79	(77)
Southeast	0.9x	0.77	x	1.8	x	106.25	x	0.63	x	0.7	=	350.7	(77)
Southeast	0.9x	0.77	x	37.89	x	106.25	x	0.63	x	0.7	=	1230.36	(77)
Southeast	0.9x	0.77	x	1.8	x	106.25	x	0.63	x	0.7	=	409.15	(77)
Southeast	0.9x	0.77	x	2.33	x	106.25	x	0.63	x	0.7	=	75.66	(77)
Southeast	0.9x	0.77	x	1.9	x	119.01	x	0.63	x	0.7	=	276.42	(77)
Southeast	0.9x	0.77	x	1.8	x	119.01	x	0.63	x	0.7	=	392.81	(77)
Southeast	0.9x	0.77	x	37.89	x	119.01	x	0.63	x	0.7	=	1378.1	(77)
Southeast	0.9x	0.77	x	1.8	x	119.01	x	0.63	x	0.7	=	458.28	(77)
Southeast	0.9x	0.77	x	2.33	x	119.01	x	0.63	x	0.7	=	84.74	(77)
Southeast	0.9x	0.77	x	1.9	x	118.15	x	0.63	x	0.7	=	274.42	(77)
Southeast	0.9x	0.77	x	1.8	x	118.15	x	0.63	x	0.7	=	389.97	(77)
Southeast	0.9x	0.77	x	37.89	x	118.15	x	0.63	x	0.7	=	1368.14	(77)
Southeast	0.9x	0.77	x	1.8	x	118.15	x	0.63	x	0.7	=	454.96	(77)
Southeast	0.9x	0.77	x	2.33	x	118.15	x	0.63	x	0.7	=	84.13	(77)
Southeast	0.9x	0.77	x	1.9	x	113.91	x	0.63	x	0.7	=	264.57	(77)
Southeast	0.9x	0.77	x	1.8	x	113.91	x	0.63	x	0.7	=	375.97	(77)
Southeast	0.9x	0.77	x	37.89	x	113.91	x	0.63	x	0.7	=	1319.03	(77)
Southeast	0.9x	0.77	x	1.8	x	113.91	x	0.63	x	0.7	=	438.63	(77)
Southeast	0.9x	0.77	x	2.33	x	113.91	x	0.63	x	0.7	=	81.11	(77)
Southeast	0.9x	0.77	x	1.9	x	104.39	x	0.63	x	0.7	=	242.46	(77)
Southeast	0.9x	0.77	x	1.8	x	104.39	x	0.63	x	0.7	=	344.55	(77)
Southeast	0.9x	0.77	x	37.89	x	104.39	x	0.63	x	0.7	=	1208.81	(77)
Southeast	0.9x	0.77	x	1.8	x	104.39	x	0.63	x	0.7	=	401.98	(77)
Southeast	0.9x	0.77	x	2.33	x	104.39	x	0.63	x	0.7	=	74.33	(77)
Southeast	0.9x	0.77	x	1.9	x	92.85	x	0.63	x	0.7	=	215.66	(77)
Southeast	0.9x	0.77	x	1.8	x	92.85	x	0.63	x	0.7	=	306.47	(77)
Southeast	0.9x	0.77	x	37.89	x	92.85	x	0.63	x	0.7	=	1075.2	(77)
Southeast	0.9x	0.77	x	1.8	x	92.85	x	0.63	x	0.7	=	357.55	(77)
Southeast	0.9x	0.77	x	2.33	x	92.85	x	0.63	x	0.7	=	66.12	(77)
Southeast	0.9x	0.77	x	1.9	x	69.27	x	0.63	x	0.7	=	160.88	(77)

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Southeast	0.9x	0.77	x	1.8	x	69.27	x	0.63	x	0.7	=	228.63	(77)
Southeast	0.9x	0.77	x	37.89	x	69.27	x	0.63	x	0.7	=	802.1	(77)
Southeast	0.9x	0.77	x	1.8	x	69.27	x	0.63	x	0.7	=	266.73	(77)
Southeast	0.9x	0.77	x	2.33	x	69.27	x	0.63	x	0.7	=	49.32	(77)
Southeast	0.9x	0.77	x	1.9	x	44.07	x	0.63	x	0.7	=	102.36	(77)
Southeast	0.9x	0.77	x	1.8	x	44.07	x	0.63	x	0.7	=	145.46	(77)
Southeast	0.9x	0.77	x	37.89	x	44.07	x	0.63	x	0.7	=	510.32	(77)
Southeast	0.9x	0.77	x	1.8	x	44.07	x	0.63	x	0.7	=	169.7	(77)
Southeast	0.9x	0.77	x	2.33	x	44.07	x	0.63	x	0.7	=	31.38	(77)
Southeast	0.9x	0.77	x	1.9	x	31.49	x	0.63	x	0.7	=	73.14	(77)
Southeast	0.9x	0.77	x	1.8	x	31.49	x	0.63	x	0.7	=	103.93	(77)
Southeast	0.9x	0.77	x	37.89	x	31.49	x	0.63	x	0.7	=	364.62	(77)
Southeast	0.9x	0.77	x	1.8	x	31.49	x	0.63	x	0.7	=	121.25	(77)
Southeast	0.9x	0.77	x	2.33	x	31.49	x	0.63	x	0.7	=	22.42	(77)
Southwest	0.9x	0.77	x	7.97	x	36.79		0.63	x	0.7	=	358.48	(79)
Southwest	0.9x	0.77	x	8.77	x	36.79		0.63	x	0.7	=	98.62	(79)
Southwest	0.9x	0.77	x	4.53	x	36.79		0.63	x	0.7	=	50.94	(79)
Southwest	0.9x	0.77	x	3.5	x	36.79		0.63	x	0.7	=	39.36	(79)
Southwest	0.9x	0.77	x	5.45	x	36.79		0.63	x	0.7	=	61.28	(79)
Southwest	0.9x	0.77	x	1.96	x	36.79		0.63	x	0.7	=	176.32	(79)
Southwest	0.9x	0.77	x	2.65	x	36.79		0.63	x	0.7	=	59.6	(79)
Southwest	0.9x	0.77	x	3.97	x	36.79		0.63	x	0.7	=	44.64	(79)
Southwest	0.9x	0.77	x	7.97	x	62.67		0.63	x	0.7	=	610.62	(79)
Southwest	0.9x	0.77	x	8.77	x	62.67		0.63	x	0.7	=	167.98	(79)
Southwest	0.9x	0.77	x	4.53	x	62.67		0.63	x	0.7	=	86.77	(79)
Southwest	0.9x	0.77	x	3.5	x	62.67		0.63	x	0.7	=	67.04	(79)
Southwest	0.9x	0.77	x	5.45	x	62.67		0.63	x	0.7	=	104.39	(79)
Southwest	0.9x	0.77	x	1.96	x	62.67		0.63	x	0.7	=	300.33	(79)
Southwest	0.9x	0.77	x	2.65	x	62.67		0.63	x	0.7	=	101.52	(79)
Southwest	0.9x	0.77	x	3.97	x	62.67		0.63	x	0.7	=	76.04	(79)
Southwest	0.9x	0.77	x	7.97	x	85.75		0.63	x	0.7	=	835.48	(79)
Southwest	0.9x	0.77	x	8.77	x	85.75		0.63	x	0.7	=	229.84	(79)
Southwest	0.9x	0.77	x	4.53	x	85.75		0.63	x	0.7	=	118.72	(79)
Southwest	0.9x	0.77	x	3.5	x	85.75		0.63	x	0.7	=	91.72	(79)
Southwest	0.9x	0.77	x	5.45	x	85.75		0.63	x	0.7	=	142.83	(79)
Southwest	0.9x	0.77	x	1.96	x	85.75		0.63	x	0.7	=	410.93	(79)
Southwest	0.9x	0.77	x	2.65	x	85.75		0.63	x	0.7	=	138.9	(79)
Southwest	0.9x	0.77	x	3.97	x	85.75		0.63	x	0.7	=	104.04	(79)
Southwest	0.9x	0.77	x	7.97	x	106.25		0.63	x	0.7	=	1035.2	(79)
Southwest	0.9x	0.77	x	8.77	x	106.25		0.63	x	0.7	=	284.78	(79)
Southwest	0.9x	0.77	x	4.53	x	106.25		0.63	x	0.7	=	147.1	(79)

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DER WorkSheet: New dwelling design stage

Southwest	0.9x	0.77	x	3.5	x	106.25		0.63	x	0.7	=	113.65	(79)
Southwest	0.9x	0.77	x	5.45	x	106.25		0.63	x	0.7	=	176.97	(79)
Southwest	0.9x	0.77	x	1.96	x	106.25		0.63	x	0.7	=	509.16	(79)
Southwest	0.9x	0.77	x	2.65	x	106.25		0.63	x	0.7	=	172.1	(79)
Southwest	0.9x	0.77	x	3.97	x	106.25		0.63	x	0.7	=	128.91	(79)
Southwest	0.9x	0.77	x	7.97	x	119.01		0.63	x	0.7	=	1159.51	(79)
Southwest	0.9x	0.77	x	8.77	x	119.01		0.63	x	0.7	=	318.98	(79)
Southwest	0.9x	0.77	x	4.53	x	119.01		0.63	x	0.7	=	164.76	(79)
Southwest	0.9x	0.77	x	3.5	x	119.01		0.63	x	0.7	=	127.3	(79)
Southwest	0.9x	0.77	x	5.45	x	119.01		0.63	x	0.7	=	198.22	(79)
Southwest	0.9x	0.77	x	1.96	x	119.01		0.63	x	0.7	=	570.3	(79)
Southwest	0.9x	0.77	x	2.65	x	119.01		0.63	x	0.7	=	192.77	(79)
Southwest	0.9x	0.77	x	3.97	x	119.01		0.63	x	0.7	=	144.39	(79)
Southwest	0.9x	0.77	x	7.97	x	118.15		0.63	x	0.7	=	1151.13	(79)
Southwest	0.9x	0.77	x	8.77	x	118.15		0.63	x	0.7	=	316.67	(79)
Southwest	0.9x	0.77	x	4.53	x	118.15		0.63	x	0.7	=	163.57	(79)
Southwest	0.9x	0.77	x	3.5	x	118.15		0.63	x	0.7	=	126.38	(79)
Southwest	0.9x	0.77	x	5.45	x	118.15		0.63	x	0.7	=	196.79	(79)
Southwest	0.9x	0.77	x	1.96	x	118.15		0.63	x	0.7	=	566.18	(79)
Southwest	0.9x	0.77	x	2.65	x	118.15		0.63	x	0.7	=	191.37	(79)
Southwest	0.9x	0.77	x	3.97	x	118.15		0.63	x	0.7	=	143.35	(79)
Southwest	0.9x	0.77	x	7.97	x	113.91		0.63	x	0.7	=	1109.81	(79)
Southwest	0.9x	0.77	x	8.77	x	113.91		0.63	x	0.7	=	305.3	(79)
Southwest	0.9x	0.77	x	4.53	x	113.91		0.63	x	0.7	=	157.7	(79)
Southwest	0.9x	0.77	x	3.5	x	113.91		0.63	x	0.7	=	121.84	(79)
Southwest	0.9x	0.77	x	5.45	x	113.91		0.63	x	0.7	=	189.73	(79)
Southwest	0.9x	0.77	x	1.96	x	113.91		0.63	x	0.7	=	545.85	(79)
Southwest	0.9x	0.77	x	2.65	x	113.91		0.63	x	0.7	=	184.5	(79)
Southwest	0.9x	0.77	x	3.97	x	113.91		0.63	x	0.7	=	138.2	(79)
Southwest	0.9x	0.77	x	7.97	x	104.39		0.63	x	0.7	=	1017.07	(79)
Southwest	0.9x	0.77	x	8.77	x	104.39		0.63	x	0.7	=	279.79	(79)
Southwest	0.9x	0.77	x	4.53	x	104.39		0.63	x	0.7	=	144.52	(79)
Southwest	0.9x	0.77	x	3.5	x	104.39		0.63	x	0.7	=	111.66	(79)
Southwest	0.9x	0.77	x	5.45	x	104.39		0.63	x	0.7	=	173.87	(79)
Southwest	0.9x	0.77	x	1.96	x	104.39		0.63	x	0.7	=	500.24	(79)
Southwest	0.9x	0.77	x	2.65	x	104.39		0.63	x	0.7	=	169.09	(79)
Southwest	0.9x	0.77	x	3.97	x	104.39		0.63	x	0.7	=	126.66	(79)
Southwest	0.9x	0.77	x	7.97	x	92.85		0.63	x	0.7	=	904.65	(79)
Southwest	0.9x	0.77	x	8.77	x	92.85		0.63	x	0.7	=	248.86	(79)
Southwest	0.9x	0.77	x	4.53	x	92.85		0.63	x	0.7	=	128.55	(79)
Southwest	0.9x	0.77	x	3.5	x	92.85		0.63	x	0.7	=	99.32	(79)

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Southwest	0.9x	0.77	x	5.45	x	92.85		0.63	x	0.7	=	154.65	(79)
Southwest	0.9x	0.77	x	1.96	x	92.85		0.63	x	0.7	=	444.95	(79)
Southwest	0.9x	0.77	x	2.65	x	92.85		0.63	x	0.7	=	150.4	(79)
Southwest	0.9x	0.77	x	3.97	x	92.85		0.63	x	0.7	=	112.66	(79)
Southwest	0.9x	0.77	x	7.97	x	69.27		0.63	x	0.7	=	674.87	(79)
Southwest	0.9x	0.77	x	8.77	x	69.27		0.63	x	0.7	=	185.65	(79)
Southwest	0.9x	0.77	x	4.53	x	69.27		0.63	x	0.7	=	95.9	(79)
Southwest	0.9x	0.77	x	3.5	x	69.27		0.63	x	0.7	=	74.09	(79)
Southwest	0.9x	0.77	x	5.45	x	69.27		0.63	x	0.7	=	115.37	(79)
Southwest	0.9x	0.77	x	1.96	x	69.27		0.63	x	0.7	=	331.93	(79)
Southwest	0.9x	0.77	x	2.65	x	69.27		0.63	x	0.7	=	112.2	(79)
Southwest	0.9x	0.77	x	3.97	x	69.27		0.63	x	0.7	=	84.04	(79)
Southwest	0.9x	0.77	x	7.97	x	44.07		0.63	x	0.7	=	429.38	(79)
Southwest	0.9x	0.77	x	8.77	x	44.07		0.63	x	0.7	=	118.12	(79)
Southwest	0.9x	0.77	x	4.53	x	44.07		0.63	x	0.7	=	61.01	(79)
Southwest	0.9x	0.77	x	3.5	x	44.07		0.63	x	0.7	=	47.14	(79)
Southwest	0.9x	0.77	x	5.45	x	44.07		0.63	x	0.7	=	73.4	(79)
Southwest	0.9x	0.77	x	1.96	x	44.07		0.63	x	0.7	=	211.19	(79)
Southwest	0.9x	0.77	x	2.65	x	44.07		0.63	x	0.7	=	71.38	(79)
Southwest	0.9x	0.77	x	3.97	x	44.07		0.63	x	0.7	=	53.47	(79)
Southwest	0.9x	0.77	x	7.97	x	31.49		0.63	x	0.7	=	306.78	(79)
Southwest	0.9x	0.77	x	8.77	x	31.49		0.63	x	0.7	=	84.39	(79)
Southwest	0.9x	0.77	x	4.53	x	31.49		0.63	x	0.7	=	43.59	(79)
Southwest	0.9x	0.77	x	3.5	x	31.49		0.63	x	0.7	=	33.68	(79)
Southwest	0.9x	0.77	x	5.45	x	31.49		0.63	x	0.7	=	52.45	(79)
Southwest	0.9x	0.77	x	1.96	x	31.49		0.63	x	0.7	=	150.89	(79)
Southwest	0.9x	0.77	x	2.65	x	31.49		0.63	x	0.7	=	51	(79)
Southwest	0.9x	0.77	x	3.97	x	31.49		0.63	x	0.7	=	38.2	(79)
Northwest	0.9x	0.77	x	2.14	x	11.28	x	0.63	x	0.7	=	7.38	(81)
Northwest	0.9x	0.77	x	8.54	x	11.28	x	0.63	x	0.7	=	29.45	(81)
Northwest	0.9x	0.77	x	4.57	x	11.28	x	0.63	x	0.7	=	15.76	(81)
Northwest	0.9x	0.77	x	2.14	x	11.28	x	0.63	x	0.7	=	7.38	(81)
Northwest	0.9x	0.77	x	3.71	x	11.28	x	0.63	x	0.7	=	12.79	(81)
Northwest	0.9x	0.77	x	1.61	x	11.28	x	0.63	x	0.7	=	5.55	(81)
Northwest	0.9x	0.77	x	2.14	x	22.97	x	0.63	x	0.7	=	15.02	(81)
Northwest	0.9x	0.77	x	8.54	x	22.97	x	0.63	x	0.7	=	59.94	(81)
Northwest	0.9x	0.77	x	4.57	x	22.97	x	0.63	x	0.7	=	32.08	(81)
Northwest	0.9x	0.77	x	2.14	x	22.97	x	0.63	x	0.7	=	15.02	(81)
Northwest	0.9x	0.77	x	3.71	x	22.97	x	0.63	x	0.7	=	26.04	(81)
Northwest	0.9x	0.77	x	1.61	x	22.97	x	0.63	x	0.7	=	11.3	(81)
Northwest	0.9x	0.77	x	2.14	x	41.38	x	0.63	x	0.7	=	27.06	(81)

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DER WorkSheet: New dwelling design stage

Northwest	0.9x	0.77	x	8.54	x	41.38	x	0.63	x	0.7	=	108	(81)
Northwest	0.9x	0.77	x	4.57	x	41.38	x	0.63	x	0.7	=	57.79	(81)
Northwest	0.9x	0.77	x	2.14	x	41.38	x	0.63	x	0.7	=	27.06	(81)
Northwest	0.9x	0.77	x	3.71	x	41.38	x	0.63	x	0.7	=	46.92	(81)
Northwest	0.9x	0.77	x	1.61	x	41.38	x	0.63	x	0.7	=	20.36	(81)
Northwest	0.9x	0.77	x	2.14	x	67.96	x	0.63	x	0.7	=	44.44	(81)
Northwest	0.9x	0.77	x	8.54	x	67.96	x	0.63	x	0.7	=	177.36	(81)
Northwest	0.9x	0.77	x	4.57	x	67.96	x	0.63	x	0.7	=	94.91	(81)
Northwest	0.9x	0.77	x	2.14	x	67.96	x	0.63	x	0.7	=	44.44	(81)
Northwest	0.9x	0.77	x	3.71	x	67.96	x	0.63	x	0.7	=	77.05	(81)
Northwest	0.9x	0.77	x	1.61	x	67.96	x	0.63	x	0.7	=	33.44	(81)
Northwest	0.9x	0.77	x	2.14	x	91.35	x	0.63	x	0.7	=	59.74	(81)
Northwest	0.9x	0.77	x	8.54	x	91.35	x	0.63	x	0.7	=	238.41	(81)
Northwest	0.9x	0.77	x	4.57	x	91.35	x	0.63	x	0.7	=	127.58	(81)
Northwest	0.9x	0.77	x	2.14	x	91.35	x	0.63	x	0.7	=	59.74	(81)
Northwest	0.9x	0.77	x	3.71	x	91.35	x	0.63	x	0.7	=	103.57	(81)
Northwest	0.9x	0.77	x	1.61	x	91.35	x	0.63	x	0.7	=	44.95	(81)
Northwest	0.9x	0.77	x	2.14	x	97.38	x	0.63	x	0.7	=	63.69	(81)
Northwest	0.9x	0.77	x	8.54	x	97.38	x	0.63	x	0.7	=	254.17	(81)
Northwest	0.9x	0.77	x	4.57	x	97.38	x	0.63	x	0.7	=	136.01	(81)
Northwest	0.9x	0.77	x	2.14	x	97.38	x	0.63	x	0.7	=	63.69	(81)
Northwest	0.9x	0.77	x	3.71	x	97.38	x	0.63	x	0.7	=	110.42	(81)
Northwest	0.9x	0.77	x	1.61	x	97.38	x	0.63	x	0.7	=	47.92	(81)
Northwest	0.9x	0.77	x	2.14	x	91.1	x	0.63	x	0.7	=	59.58	(81)
Northwest	0.9x	0.77	x	8.54	x	91.1	x	0.63	x	0.7	=	237.77	(81)
Northwest	0.9x	0.77	x	4.57	x	91.1	x	0.63	x	0.7	=	127.24	(81)
Northwest	0.9x	0.77	x	2.14	x	91.1	x	0.63	x	0.7	=	59.58	(81)
Northwest	0.9x	0.77	x	3.71	x	91.1	x	0.63	x	0.7	=	103.29	(81)
Northwest	0.9x	0.77	x	1.61	x	91.1	x	0.63	x	0.7	=	44.83	(81)
Northwest	0.9x	0.77	x	2.14	x	72.63	x	0.63	x	0.7	=	47.5	(81)
Northwest	0.9x	0.77	x	8.54	x	72.63	x	0.63	x	0.7	=	189.55	(81)
Northwest	0.9x	0.77	x	4.57	x	72.63	x	0.63	x	0.7	=	101.43	(81)
Northwest	0.9x	0.77	x	2.14	x	72.63	x	0.63	x	0.7	=	47.5	(81)
Northwest	0.9x	0.77	x	3.71	x	72.63	x	0.63	x	0.7	=	82.35	(81)
Northwest	0.9x	0.77	x	1.61	x	72.63	x	0.63	x	0.7	=	35.74	(81)
Northwest	0.9x	0.77	x	2.14	x	50.42	x	0.63	x	0.7	=	32.98	(81)
Northwest	0.9x	0.77	x	8.54	x	50.42	x	0.63	x	0.7	=	131.59	(81)
Northwest	0.9x	0.77	x	4.57	x	50.42	x	0.63	x	0.7	=	70.42	(81)
Northwest	0.9x	0.77	x	2.14	x	50.42	x	0.63	x	0.7	=	32.98	(81)
Northwest	0.9x	0.77	x	3.71	x	50.42	x	0.63	x	0.7	=	57.17	(81)
Northwest	0.9x	0.77	x	1.61	x	50.42	x	0.63	x	0.7	=	24.81	(81)

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Northwest	0.9x	0.77	x	2.14	x	28.07	x	0.63	x	0.7	=	18.36	(81)
Northwest	0.9x	0.77	x	8.54	x	28.07	x	0.63	x	0.7	=	73.25	(81)
Northwest	0.9x	0.77	x	4.57	x	28.07	x	0.63	x	0.7	=	39.2	(81)
Northwest	0.9x	0.77	x	2.14	x	28.07	x	0.63	x	0.7	=	18.36	(81)
Northwest	0.9x	0.77	x	3.71	x	28.07	x	0.63	x	0.7	=	31.82	(81)
Northwest	0.9x	0.77	x	1.61	x	28.07	x	0.63	x	0.7	=	13.81	(81)
Northwest	0.9x	0.77	x	2.14	x	14.2	x	0.63	x	0.7	=	9.28	(81)
Northwest	0.9x	0.77	x	8.54	x	14.2	x	0.63	x	0.7	=	37.05	(81)
Northwest	0.9x	0.77	x	4.57	x	14.2	x	0.63	x	0.7	=	19.83	(81)
Northwest	0.9x	0.77	x	2.14	x	14.2	x	0.63	x	0.7	=	9.28	(81)
Northwest	0.9x	0.77	x	3.71	x	14.2	x	0.63	x	0.7	=	16.1	(81)
Northwest	0.9x	0.77	x	1.61	x	14.2	x	0.63	x	0.7	=	6.99	(81)
Northwest	0.9x	0.77	x	2.14	x	9.21	x	0.63	x	0.7	=	6.03	(81)
Northwest	0.9x	0.77	x	8.54	x	9.21	x	0.63	x	0.7	=	24.05	(81)
Northwest	0.9x	0.77	x	4.57	x	9.21	x	0.63	x	0.7	=	12.87	(81)
Northwest	0.9x	0.77	x	2.14	x	9.21	x	0.63	x	0.7	=	6.03	(81)
Northwest	0.9x	0.77	x	3.71	x	9.21	x	0.63	x	0.7	=	10.45	(81)
Northwest	0.9x	0.77	x	1.61	x	9.21	x	0.63	x	0.7	=	4.53	(81)

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

(83)m=	1881.51	3261.94	4618.88	5991.04	6960.14	7020.98	6722.61	5981.73	5090.79	3646.72	2263.9	1603.58	(83)

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

(84)m=	3540.94	4917.22	6213.83	7484.89	8342.58	8303.85	7945.97	7215.52	6381.17	5038.55	3772.2	3207.64	(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	1	1	0.99	0.96	0.89	0.93	0.99	1	1	1	(86)

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

(87)m=	19.35	19.48	19.7	20.05	20.37	20.67	20.82	20.79	20.54	20.13	19.72	19.38	(87)

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

(88)m=	19.62	19.64	19.65	19.71	19.72	19.78	19.78	19.8	19.76	19.72	19.7	19.67	(88)

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

(89)m=	1	1	1	1	0.98	0.92	0.77	0.83	0.98	1	1	1	(89)

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

(90)m=	17.41	17.61	17.95	18.51	18.98	19.45	19.63	19.61	19.26	18.63	18	17.49	(90)

fLA = Living area ÷ (4) = | 0.07 | (91)

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

(92)m=	17.55	17.74	18.08	18.62	19.08	19.54	19.71	19.7	19.35	18.74	18.13	17.63	(92)

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

(93)m=	17.55	17.74	18.08	18.62	19.08	19.54	19.71	19.7	19.35	18.74	18.13	17.63	(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

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Utilisation factor for gains, hm:

(94)m=	1	1	1	0.99	0.98	0.91	0.76	0.82	0.97	1	1	1	(94)

Useful gains, hmGm , W = (94)m x (84)m

(95)m=	3540.51	4914.93	6203.74	7439.43	8142.67	7556.48	6027.47	5922.84	6178.88	5025.11	3771.18	3207.42	(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=	34306.74	32918.04	29369.97	23369.9	17540.63	11091.61	6996	7318.84	12067.39	19352.98	26805.17	33349.75	(97)

Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m

(98)m=	22890.08	18818.09	17235.68	11469.94	6992.08	0	0	0	0	10659.93	16584.47	22425.89

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 127076.16 (98)

Space heating requirement in kWh/m²/year 77.77 (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		175.1	(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)														
	22890.08	18818.09	17235.68	11469.94	6992.08	0	0	0	0	10659.93	16584.47	22425.89		
(211)m = {[(98)m x (204)] } x 100 ÷ (206)														(211)
	13072.57	10747.05	9843.33	6550.51	3993.19	0	0	0	0	6087.91	9471.43	12807.47		

Total (kWh/year) =Sum(211)$_{1...5,10....12}$= 72573.48 (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

Output from water heater (calculated above)

313.58	276.24	289.76	259.27	253.72	226.2	216.76	238.52	238.31	268.87	284.91	305.87

Efficiency of water heater 175.1 (216)

(217)m=	175.1	175.1	175.1	175.1	175.1	175.1	175.1	175.1	175.1	175.1	175.1	175.1	(217)

Fuel for water heating, kWh/month

(219)m = (64)m x 100 ÷ (217)m

(219)m=	179.09	157.76	165.49	148.07	144.9	129.18	123.79	136.22	136.1	153.55	162.72	174.68

Total = Sum(219a)$_{1...12}$ = 1811.55 (219)

Annual totals	**kWh/year**	**kWh/year**
Space heating fuel used, main system 1		72573.48
Water heating fuel used		1811.55
Electricity for pumps, fans and electric keep-hot		

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mechanical ventilation - balanced, extract or positive input from outside		6128.58		(230a)
central heating pump:		30		(230c)
Total electricity for the above, kWh/year	sum of (230a)…(230g) =		6158.58	(231)
Electricity for lighting			2166.06	(232)

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	0.519	=	37665.63	(261)
Space heating (secondary)	(215) x	0.519	=	0	(263)
Water heating	(219) x	0.519	=	940.19	(264)
Space and water heating	(261) + (262) + (263) + (264) =			38605.83	(265)
Electricity for pumps, fans and electric keep-hot	(231) x	0.519	=	3196.31	(267)
Electricity for lighting	(232) x	0.519	=	1124.18	(268)
Total CO2, kg/year		sum of (265)…(271) =		42926.32	(272)
Dwelling CO2 Emission Rate		(272) ÷ (4) =		26.27	(273)
EI rating (section 14)				66	(274)

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User Details:

Assessor Name: | **Stroma Number:**
Software Name: Stroma FSAP 2012 | **Software Version:** Version: 1.0.4.23

Property Address: Proposed (ASHP Be Green - MCS ASHP)

Address : 69, Avenue Road, LONDON, NW8 6HP

1. Overall dwelling dimensions:

	Area(m²)		Av. Height(m)		Volume(m³)	
Basement	544	(1a) x	3.52	(2a) =	1914.88	(3a)
Ground floor	547	(1b) x	3.08	(2b) =	1684.76	(3b)
First floor	326	(1c) x	2.71	(2c) =	883.46	(3c)
Second floor	217	(1d) x	2.49	(2d) =	540.33	(3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	1634	(4)				
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) =		5023.43	(5)

2. Ventilation rate:

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	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							4	x 10 =	40	(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) =	40	÷ (5) =	0.01	(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 *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*		0	(11)
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)	0.26	(18)

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

Number of sides sheltered		2	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.85	(20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =	0.22	(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

0.28	0.27	0.27	0.24	0.24	0.21	0.21	0.2	0.22	0.24	0.25	0.26

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0 (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	0	0	0	0	0	0	0	0	0	0	0	(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=	0.54	0.54	0.54	0.53	0.53	0.52	0.52	0.52	0.52	0.53	0.53	0.53	(24d)

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

(25)m=	0.54	0.54	0.54	0.53	0.53	0.52	0.52	0.52	0.52	0.53	0.53	0.53	(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			2.52	x 1	=	2.52			(26)
Windows Type 1			1.9	x1/[1/(1.4)+ 0.04]	=	2.52			(27)
Windows Type 2			1.8	x1/[1/(1.4)+ 0.04]	=	2.39			(27)
Windows Type 3			37.89	x1/[1/(1.4)+ 0.04]	=	50.23			(27)
Windows Type 4			4.9	x1/[1/(1.4)+ 0.04]	=	6.5			(27)
Windows Type 5			12.64	x1/[1/(1.4)+ 0.04]	=	16.76			(27)
Windows Type 6			2.14	x1/[1/(1.4)+ 0.04]	=	2.84			(27)
Windows Type 7			8.54	x1/[1/(1.4)+ 0.04]	=	11.32			(27)
Windows Type 8			4.57	x1/[1/(1.4)+ 0.04]	=	6.06			(27)
Windows Type 9			1.8	x1/[1/(1.4)+ 0.04]	=	2.39			(27)
Windows Type 10			7.97	x1/[1/(1.4)+ 0.04]	=	10.57			(27)
Windows Type 11			8.77	x1/[1/(1.4)+ 0.04]	=	11.63			(27)
Windows Type 12			4.53	x1/[1/(1.4)+ 0.04]	=	6.01			(27)
Windows Type 13			3.5	x1/[1/(1.4)+ 0.04]	=	4.64			(27)

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Windows Type 14			5.45	x1/[1/(1.4)+ 0.04]	=	7.23				(27)
Windows Type 15			1.8	x1/[1/(1.4)+ 0.04]	=	2.39				(27)
Windows Type 16			2.14	x1/[1/(1.4)+ 0.04]	=	2.84				(27)
Windows Type 17			3.71	x1/[1/(1.4)+ 0.04]	=	4.92				(27)
Windows Type 18			1.8	x1/[1/(1.4)+ 0.04]	=	2.39				(27)
Windows Type 19			1.96	x1/[1/(1.4)+ 0.04]	=	2.6				(27)
Windows Type 20			2.33	x1/[1/(1.4)+ 0.04]	=	3.09				(27)
Windows Type 21			2.65	x1/[1/(1.4)+ 0.04]	=	3.51				(27)
Windows Type 22			3.97	x1/[1/(1.4)+ 0.04]	=	5.26				(27)
Windows Type 23			1.61	x1/[1/(1.4)+ 0.04]	=	2.13				(27)
Floor Type 1			544	x 0.13	=	70.72				(28)
Floor Type 2			81.8	x 0.13	=	10.634				(28)
Floor Type 3			49.3	x 0.13	=	6.408999				(28)
Walls Type1	450.56	7.6	442.96	x 0.18	=	79.73				(29)
Walls Type2	214.97	85.89	129.08	x 0.18	=	23.23				(29)
Walls Type3	224.21	59.44	164.77	x 0.18	=	29.66				(29)
Walls Type4	238.48	43.13	195.35	x 0.18	=	35.16				(29)
Walls Type5	199.2	13.21	185.99	x 0.18	=	33.48				(29)
Roof Type1	221	0	221	x 0.13	=	28.73				(30)
Roof Type2	376.4	0	376.4	x 0.13	=	48.93				(30)
Total area of elements, m²			2599.92							(31)

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** 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) =	643.31	(33)
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		130	(36)

if details of thermal bridging are not known (36) = 0.05 x (31)

Total fabric heat loss	(33) + (36) =	773.31	(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=	893.65	891.13	888.67	877.09	874.92	864.83	864.83	862.96	868.72	874.92	879.3	883.88	(38)

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

(39)m=	1666.96	1664.44	1661.98	1650.39	1648.23	1638.14	1638.14	1636.27	1642.03	1648.23	1652.61	1657.19	

Average = Sum(39)$_{1…12}$ /12= 1650.38 (39)

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

(40)m=	1.02	1.02	1.02	1.01	1.01	1	1	1	1	1.01	1.01	1.01	

Average = Sum(40)$_{1…12}$ /12= 1.01 (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)

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4. Water heating energy requirement: kWh/year:

Assumed occupancy, N | 4.87 | (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 | 149.77 | (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)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(44)m=	164.75	158.76	152.77	146.78	140.78	134.79	134.79	140.78	146.78	152.77	158.76	164.75	

Total = Sum(44)$_{1...12}$ = | 1797.25 | (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=	244.32	213.68	220.5	192.24	184.46	159.17	147.5	169.25	171.27	199.6	217.88	236.61	

Total = Sum(45)$_{1...12}$ = | 2356.47 | (45)

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

(46)m=	36.65	32.05	33.07	28.84	27.67	23.88	22.12	25.39	25.69	29.94	32.68	35.49	(46)

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel | 150 | (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): | 2.11 | (48)

Temperature factor from Table 2b | 0.54 | (49)

Energy lost from water storage, kWh/year (48) x (49) = | 1.14 | (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) | 1.14 | (55)

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

(56)m=	35.37	31.94	35.37	34.23	35.37	34.23	35.37	35.37	34.23	35.37	34.23	35.37	(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=	35.37	31.94	35.37	34.23	35.37	34.23	35.37	35.37	34.23	35.37	34.23	35.37	(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=	23.26	21.01	23.26	22.51	23.26	22.51	23.26	23.26	22.51	23.26	22.51	23.26	(59)

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

(61)m=	0	0	0	0	0	0	0	0	0	0	0	0	(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=	302.94	266.64	279.13	248.97	243.08	215.91	206.12	227.88	228.01	258.23	274.62	295.24	(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)

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Output from water heater

(64)m=	302.94	266.64	279.13	248.97	243.08	215.91	206.12	227.88	228.01	258.23	274.62	295.24	

Output from water heater (annual)$_{1...12}$ 3046.78 (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=	128.14	113.41	120.22	109.31	108.23	98.31	95.95	103.18	102.34	113.27	117.84	125.57	(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=	243.31	243.31	243.31	243.31	243.31	243.31	243.31	243.31	243.31	243.31	243.31	243.31	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
(67)m=	122.65	108.94	88.59	67.07	50.14	42.33	45.74	59.45	79.79	101.32	118.25	126.06	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
(68)m=	1254.13	1267.14	1234.34	1164.53	1076.4	993.57	938.23	925.22	958.01	1027.83	1115.96	1198.79	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
(69)m=	47.33	47.33	47.33	47.33	47.33	47.33	47.33	47.33	47.33	47.33	47.33	47.33	(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=	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	-194.65	(71)
Water heating gains (Table 5)													
(72)m=	172.23	168.77	161.58	151.82	145.48	136.55	128.96	138.68	142.14	152.25	163.66	168.78	(72)
Total internal gains = (66)m + (67)m + (68)m + (69)m + (70)m + (71)m + (72)m													
(73)m=	1648	1643.84	1583.52	1482.41	1371	1271.44	1211.92	1222.34	1278.94	1380.38	1496.86	1592.63	(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)	
North	0.9x	0.77	x	1.8	x	10.63	x	0.63	x	0.7	=	23.4	(74)
North	0.9x	0.77	x	1.8	x	10.63	x	0.63	x	0.7	=	29.25	(74)
North	0.9x	0.77	x	1.8	x	20.32	x	0.63	x	0.7	=	44.71	(74)
North	0.9x	0.77	x	1.8	x	20.32	x	0.63	x	0.7	=	55.89	(74)
North	0.9x	0.77	x	1.8	x	34.53	x	0.63	x	0.7	=	75.98	(74)
North	0.9x	0.77	x	1.8	x	34.53	x	0.63	x	0.7	=	94.98	(74)
North	0.9x	0.77	x	1.8	x	55.46	x	0.63	x	0.7	=	122.04	(74)
North	0.9x	0.77	x	1.8	x	55.46	x	0.63	x	0.7	=	152.56	(74)
North	0.9x	0.77	x	1.8	x	74.72	x	0.63	x	0.7	=	164.41	(74)
North	0.9x	0.77	x	1.8	x	74.72	x	0.63	x	0.7	=	205.51	(74)
North	0.9x	0.77	x	1.8	x	79.99	x	0.63	x	0.7	=	176	(74)
North	0.9x	0.77	x	1.8	x	79.99	x	0.63	x	0.7	=	220	(74)

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North	0.9x	0.77	x	1.8	x	74.68	x	0.63	x	0.7	=	164.32	(74)
North	0.9x	0.77	x	1.8	x	74.68	x	0.63	x	0.7	=	205.4	(74)
North	0.9x	0.77	x	1.8	x	59.25	x	0.63	x	0.7	=	130.37	(74)
North	0.9x	0.77	x	1.8	x	59.25	x	0.63	x	0.7	=	162.96	(74)
North	0.9x	0.77	x	1.8	x	41.52	x	0.63	x	0.7	=	91.35	(74)
North	0.9x	0.77	x	1.8	x	41.52	x	0.63	x	0.7	=	114.19	(74)
North	0.9x	0.77	x	1.8	x	24.19	x	0.63	x	0.7	=	53.23	(74)
North	0.9x	0.77	x	1.8	x	24.19	x	0.63	x	0.7	=	66.53	(74)
North	0.9x	0.77	x	1.8	x	13.12	x	0.63	x	0.7	=	28.86	(74)
North	0.9x	0.77	x	1.8	x	13.12	x	0.63	x	0.7	=	36.08	(74)
North	0.9x	0.77	x	1.8	x	8.86	x	0.63	x	0.7	=	19.51	(74)
North	0.9x	0.77	x	1.8	x	8.86	x	0.63	x	0.7	=	24.38	(74)
Northeast	0.9x	0.77	x	4.9	x	11.28	x	0.63	x	0.7	=	16.9	(75)
Northeast	0.9x	0.77	x	12.64	x	11.28	x	0.63	x	0.7	=	43.59	(75)
Northeast	0.9x	0.77	x	4.9	x	22.97	x	0.63	x	0.7	=	34.39	(75)
Northeast	0.9x	0.77	x	12.64	x	22.97	x	0.63	x	0.7	=	88.72	(75)
Northeast	0.9x	0.77	x	4.9	x	41.38	x	0.63	x	0.7	=	61.96	(75)
Northeast	0.9x	0.77	x	12.64	x	41.38	x	0.63	x	0.7	=	159.84	(75)
Northeast	0.9x	0.77	x	4.9	x	67.96	x	0.63	x	0.7	=	101.76	(75)
Northeast	0.9x	0.77	x	12.64	x	67.96	x	0.63	x	0.7	=	262.51	(75)
Northeast	0.9x	0.77	x	4.9	x	91.35	x	0.63	x	0.7	=	136.79	(75)
Northeast	0.9x	0.77	x	12.64	x	91.35	x	0.63	x	0.7	=	352.86	(75)
Northeast	0.9x	0.77	x	4.9	x	97.38	x	0.63	x	0.7	=	145.83	(75)
Northeast	0.9x	0.77	x	12.64	x	97.38	x	0.63	x	0.7	=	376.19	(75)
Northeast	0.9x	0.77	x	4.9	x	91.1	x	0.63	x	0.7	=	136.42	(75)
Northeast	0.9x	0.77	x	12.64	x	91.1	x	0.63	x	0.7	=	351.92	(75)
Northeast	0.9x	0.77	x	4.9	x	72.63	x	0.63	x	0.7	=	108.76	(75)
Northeast	0.9x	0.77	x	12.64	x	72.63	x	0.63	x	0.7	=	280.55	(75)
Northeast	0.9x	0.77	x	4.9	x	50.42	x	0.63	x	0.7	=	75.51	(75)
Northeast	0.9x	0.77	x	12.64	x	50.42	x	0.63	x	0.7	=	194.77	(75)
Northeast	0.9x	0.77	x	4.9	x	28.07	x	0.63	x	0.7	=	42.03	(75)
Northeast	0.9x	0.77	x	12.64	x	28.07	x	0.63	x	0.7	=	108.42	(75)
Northeast	0.9x	0.77	x	4.9	x	14.2	x	0.63	x	0.7	=	21.26	(75)
Northeast	0.9x	0.77	x	12.64	x	14.2	x	0.63	x	0.7	=	54.84	(75)
Northeast	0.9x	0.77	x	4.9	x	9.21	x	0.63	x	0.7	=	13.8	(75)
Northeast	0.9x	0.77	x	12.64	x	9.21	x	0.63	x	0.7	=	35.59	(75)
Southeast	0.9x	0.77	x	1.9	x	36.79	x	0.63	x	0.7	=	85.46	(77)
Southeast	0.9x	0.77	x	1.8	x	36.79	x	0.63	x	0.7	=	121.44	(77)
Southeast	0.9x	0.77	x	37.89	x	36.79	x	0.63	x	0.7	=	426.06	(77)
Southeast	0.9x	0.77	x	1.8	x	36.79	x	0.63	x	0.7	=	141.68	(77)
Southeast	0.9x	0.77	x	2.33	x	36.79	x	0.63	x	0.7	=	26.2	(77)

Southeast	0.9x	0.77	x	1.9	x	62.67	x	0.63	x	0.7	=	145.57	(77)
Southeast	0.9x	0.77	x	1.8	x	62.67	x	0.63	x	0.7	=	206.86	(77)
Southeast	0.9x	0.77	x	37.89	x	62.67	x	0.63	x	0.7	=	725.74	(77)
Southeast	0.9x	0.77	x	1.8	x	62.67	x	0.63	x	0.7	=	241.34	(77)
Southeast	0.9x	0.77	x	2.33	x	62.67	x	0.63	x	0.7	=	44.63	(77)
Southeast	0.9x	0.77	x	1.9	x	85.75	x	0.63	x	0.7	=	199.17	(77)
Southeast	0.9x	0.77	x	1.8	x	85.75	x	0.63	x	0.7	=	283.04	(77)
Southeast	0.9x	0.77	x	37.89	x	85.75	x	0.63	x	0.7	=	992.99	(77)
Southeast	0.9x	0.77	x	1.8	x	85.75	x	0.63	x	0.7	=	330.21	(77)
Southeast	0.9x	0.77	x	2.33	x	85.75	x	0.63	x	0.7	=	61.06	(77)
Southeast	0.9x	0.77	x	1.9	x	106.25	x	0.63	x	0.7	=	246.79	(77)
Southeast	0.9x	0.77	x	1.8	x	106.25	x	0.63	x	0.7	=	350.7	(77)
Southeast	0.9x	0.77	x	37.89	x	106.25	x	0.63	x	0.7	=	1230.36	(77)
Southeast	0.9x	0.77	x	1.8	x	106.25	x	0.63	x	0.7	=	409.15	(77)
Southeast	0.9x	0.77	x	2.33	x	106.25	x	0.63	x	0.7	=	75.66	(77)
Southeast	0.9x	0.77	x	1.9	x	119.01	x	0.63	x	0.7	=	276.42	(77)
Southeast	0.9x	0.77	x	1.8	x	119.01	x	0.63	x	0.7	=	392.81	(77)
Southeast	0.9x	0.77	x	37.89	x	119.01	x	0.63	x	0.7	=	1378.1	(77)
Southeast	0.9x	0.77	x	1.8	x	119.01	x	0.63	x	0.7	=	458.28	(77)
Southeast	0.9x	0.77	x	2.33	x	119.01	x	0.63	x	0.7	=	84.74	(77)
Southeast	0.9x	0.77	x	1.9	x	118.15	x	0.63	x	0.7	=	274.42	(77)
Southeast	0.9x	0.77	x	1.8	x	118.15	x	0.63	x	0.7	=	389.97	(77)
Southeast	0.9x	0.77	x	37.89	x	118.15	x	0.63	x	0.7	=	1368.14	(77)
Southeast	0.9x	0.77	x	1.8	x	118.15	x	0.63	x	0.7	=	454.96	(77)
Southeast	0.9x	0.77	x	2.33	x	118.15	x	0.63	x	0.7	=	84.13	(77)
Southeast	0.9x	0.77	x	1.9	x	113.91	x	0.63	x	0.7	=	264.57	(77)
Southeast	0.9x	0.77	x	1.8	x	113.91	x	0.63	x	0.7	=	375.97	(77)
Southeast	0.9x	0.77	x	37.89	x	113.91	x	0.63	x	0.7	=	1319.03	(77)
Southeast	0.9x	0.77	x	1.8	x	113.91	x	0.63	x	0.7	=	438.63	(77)
Southeast	0.9x	0.77	x	2.33	x	113.91	x	0.63	x	0.7	=	81.11	(77)
Southeast	0.9x	0.77	x	1.9	x	104.39	x	0.63	x	0.7	=	242.46	(77)
Southeast	0.9x	0.77	x	1.8	x	104.39	x	0.63	x	0.7	=	344.55	(77)
Southeast	0.9x	0.77	x	37.89	x	104.39	x	0.63	x	0.7	=	1208.81	(77)
Southeast	0.9x	0.77	x	1.8	x	104.39	x	0.63	x	0.7	=	401.98	(77)
Southeast	0.9x	0.77	x	2.33	x	104.39	x	0.63	x	0.7	=	74.33	(77)
Southeast	0.9x	0.77	x	1.9	x	92.85	x	0.63	x	0.7	=	215.66	(77)
Southeast	0.9x	0.77	x	1.8	x	92.85	x	0.63	x	0.7	=	306.47	(77)
Southeast	0.9x	0.77	x	37.89	x	92.85	x	0.63	x	0.7	=	1075.2	(77)
Southeast	0.9x	0.77	x	1.8	x	92.85	x	0.63	x	0.7	=	357.55	(77)
Southeast	0.9x	0.77	x	2.33	x	92.85	x	0.63	x	0.7	=	66.12	(77)
Southeast	0.9x	0.77	x	1.9	x	69.27	x	0.63	x	0.7	=	160.88	(77)

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Southeast	0.9x	0.77	x	1.8	x	69.27	x	0.63	x	0.7	=	228.63	(77)
Southeast	0.9x	0.77	x	37.89	x	69.27	x	0.63	x	0.7	=	802.1	(77)
Southeast	0.9x	0.77	x	1.8	x	69.27	x	0.63	x	0.7	=	266.73	(77)
Southeast	0.9x	0.77	x	2.33	x	69.27	x	0.63	x	0.7	=	49.32	(77)
Southeast	0.9x	0.77	x	1.9	x	44.07	x	0.63	x	0.7	=	102.36	(77)
Southeast	0.9x	0.77	x	1.8	x	44.07	x	0.63	x	0.7	=	145.46	(77)
Southeast	0.9x	0.77	x	37.89	x	44.07	x	0.63	x	0.7	=	510.32	(77)
Southeast	0.9x	0.77	x	1.8	x	44.07	x	0.63	x	0.7	=	169.7	(77)
Southeast	0.9x	0.77	x	2.33	x	44.07	x	0.63	x	0.7	=	31.38	(77)
Southeast	0.9x	0.77	x	1.9	x	31.49	x	0.63	x	0.7	=	73.14	(77)
Southeast	0.9x	0.77	x	1.8	x	31.49	x	0.63	x	0.7	=	103.93	(77)
Southeast	0.9x	0.77	x	37.89	x	31.49	x	0.63	x	0.7	=	364.62	(77)
Southeast	0.9x	0.77	x	1.8	x	31.49	x	0.63	x	0.7	=	121.25	(77)
Southeast	0.9x	0.77	x	2.33	x	31.49	x	0.63	x	0.7	=	22.42	(77)
Southwest	0.9x	0.77	x	7.97	x	36.79		0.63	x	0.7	=	358.48	(79)
Southwest	0.9x	0.77	x	8.77	x	36.79		0.63	x	0.7	=	98.62	(79)
Southwest	0.9x	0.77	x	4.53	x	36.79		0.63	x	0.7	=	50.94	(79)
Southwest	0.9x	0.77	x	3.5	x	36.79		0.63	x	0.7	=	39.36	(79)
Southwest	0.9x	0.77	x	5.45	x	36.79		0.63	x	0.7	=	61.28	(79)
Southwest	0.9x	0.77	x	1.96	x	36.79		0.63	x	0.7	=	176.32	(79)
Southwest	0.9x	0.77	x	2.65	x	36.79		0.63	x	0.7	=	59.6	(79)
Southwest	0.9x	0.77	x	3.97	x	36.79		0.63	x	0.7	=	44.64	(79)
Southwest	0.9x	0.77	x	7.97	x	62.67		0.63	x	0.7	=	610.62	(79)
Southwest	0.9x	0.77	x	8.77	x	62.67		0.63	x	0.7	=	167.98	(79)
Southwest	0.9x	0.77	x	4.53	x	62.67		0.63	x	0.7	=	86.77	(79)
Southwest	0.9x	0.77	x	3.5	x	62.67		0.63	x	0.7	=	67.04	(79)
Southwest	0.9x	0.77	x	5.45	x	62.67		0.63	x	0.7	=	104.39	(79)
Southwest	0.9x	0.77	x	1.96	x	62.67		0.63	x	0.7	=	300.33	(79)
Southwest	0.9x	0.77	x	2.65	x	62.67		0.63	x	0.7	=	101.52	(79)
Southwest	0.9x	0.77	x	3.97	x	62.67		0.63	x	0.7	=	76.04	(79)
Southwest	0.9x	0.77	x	7.97	x	85.75		0.63	x	0.7	=	835.48	(79)
Southwest	0.9x	0.77	x	8.77	x	85.75		0.63	x	0.7	=	229.84	(79)
Southwest	0.9x	0.77	x	4.53	x	85.75		0.63	x	0.7	=	118.72	(79)
Southwest	0.9x	0.77	x	3.5	x	85.75		0.63	x	0.7	=	91.72	(79)
Southwest	0.9x	0.77	x	5.45	x	85.75		0.63	x	0.7	=	142.83	(79)
Southwest	0.9x	0.77	x	1.96	x	85.75		0.63	x	0.7	=	410.93	(79)
Southwest	0.9x	0.77	x	2.65	x	85.75		0.63	x	0.7	=	138.9	(79)
Southwest	0.9x	0.77	x	3.97	x	85.75		0.63	x	0.7	=	104.04	(79)
Southwest	0.9x	0.77	x	7.97	x	106.25		0.63	x	0.7	=	1035.2	(79)
Southwest	0.9x	0.77	x	8.77	x	106.25		0.63	x	0.7	=	284.78	(79)
Southwest	0.9x	0.77	x	4.53	x	106.25		0.63	x	0.7	=	147.1	(79)

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Southwest	0.9x	0.77	x	3.5	x	106.25	0.63	x	0.7	=	113.65	(79)
Southwest	0.9x	0.77	x	5.45	x	106.25	0.63	x	0.7	=	176.97	(79)
Southwest	0.9x	0.77	x	1.96	x	106.25	0.63	x	0.7	=	509.16	(79)
Southwest	0.9x	0.77	x	2.65	x	106.25	0.63	x	0.7	=	172.1	(79)
Southwest	0.9x	0.77	x	3.97	x	106.25	0.63	x	0.7	=	128.91	(79)
Southwest	0.9x	0.77	x	7.97	x	119.01	0.63	x	0.7	=	1159.51	(79)
Southwest	0.9x	0.77	x	8.77	x	119.01	0.63	x	0.7	=	318.98	(79)
Southwest	0.9x	0.77	x	4.53	x	119.01	0.63	x	0.7	=	164.76	(79)
Southwest	0.9x	0.77	x	3.5	x	119.01	0.63	x	0.7	=	127.3	(79)
Southwest	0.9x	0.77	x	5.45	x	119.01	0.63	x	0.7	=	198.22	(79)
Southwest	0.9x	0.77	x	1.96	x	119.01	0.63	x	0.7	=	570.3	(79)
Southwest	0.9x	0.77	x	2.65	x	119.01	0.63	x	0.7	=	192.77	(79)
Southwest	0.9x	0.77	x	3.97	x	119.01	0.63	x	0.7	=	144.39	(79)
Southwest	0.9x	0.77	x	7.97	x	118.15	0.63	x	0.7	=	1151.13	(79)
Southwest	0.9x	0.77	x	8.77	x	118.15	0.63	x	0.7	=	316.67	(79)
Southwest	0.9x	0.77	x	4.53	x	118.15	0.63	x	0.7	=	163.57	(79)
Southwest	0.9x	0.77	x	3.5	x	118.15	0.63	x	0.7	=	126.38	(79)
Southwest	0.9x	0.77	x	5.45	x	118.15	0.63	x	0.7	=	196.79	(79)
Southwest	0.9x	0.77	x	1.96	x	118.15	0.63	x	0.7	=	566.18	(79)
Southwest	0.9x	0.77	x	2.65	x	118.15	0.63	x	0.7	=	191.37	(79)
Southwest	0.9x	0.77	x	3.97	x	118.15	0.63	x	0.7	=	143.35	(79)
Southwest	0.9x	0.77	x	7.97	x	113.91	0.63	x	0.7	=	1109.81	(79)
Southwest	0.9x	0.77	x	8.77	x	113.91	0.63	x	0.7	=	305.3	(79)
Southwest	0.9x	0.77	x	4.53	x	113.91	0.63	x	0.7	=	157.7	(79)
Southwest	0.9x	0.77	x	3.5	x	113.91	0.63	x	0.7	=	121.84	(79)
Southwest	0.9x	0.77	x	5.45	x	113.91	0.63	x	0.7	=	189.73	(79)
Southwest	0.9x	0.77	x	1.96	x	113.91	0.63	x	0.7	=	545.85	(79)
Southwest	0.9x	0.77	x	2.65	x	113.91	0.63	x	0.7	=	184.5	(79)
Southwest	0.9x	0.77	x	3.97	x	113.91	0.63	x	0.7	=	138.2	(79)
Southwest	0.9x	0.77	x	7.97	x	104.39	0.63	x	0.7	=	1017.07	(79)
Southwest	0.9x	0.77	x	8.77	x	104.39	0.63	x	0.7	=	279.79	(79)
Southwest	0.9x	0.77	x	4.53	x	104.39	0.63	x	0.7	=	144.52	(79)
Southwest	0.9x	0.77	x	3.5	x	104.39	0.63	x	0.7	=	111.66	(79)
Southwest	0.9x	0.77	x	5.45	x	104.39	0.63	x	0.7	=	173.87	(79)
Southwest	0.9x	0.77	x	1.96	x	104.39	0.63	x	0.7	=	500.24	(79)
Southwest	0.9x	0.77	x	2.65	x	104.39	0.63	x	0.7	=	169.09	(79)
Southwest	0.9x	0.77	x	3.97	x	104.39	0.63	x	0.7	=	126.66	(79)
Southwest	0.9x	0.77	x	7.97	x	92.85	0.63	x	0.7	=	904.65	(79)
Southwest	0.9x	0.77	x	8.77	x	92.85	0.63	x	0.7	=	248.86	(79)
Southwest	0.9x	0.77	x	4.53	x	92.85	0.63	x	0.7	=	128.55	(79)
Southwest	0.9x	0.77	x	3.5	x	92.85	0.63	x	0.7	=	99.32	(79)

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Southwest	0.9x	0.77	x	5.45	x	92.85		0.63	x	0.7	=	154.65	(79)
Southwest	0.9x	0.77	x	1.96	x	92.85		0.63	x	0.7	=	444.95	(79)
Southwest	0.9x	0.77	x	2.65	x	92.85		0.63	x	0.7	=	150.4	(79)
Southwest	0.9x	0.77	x	3.97	x	92.85		0.63	x	0.7	=	112.66	(79)
Southwest	0.9x	0.77	x	7.97	x	69.27		0.63	x	0.7	=	674.87	(79)
Southwest	0.9x	0.77	x	8.77	x	69.27		0.63	x	0.7	=	185.65	(79)
Southwest	0.9x	0.77	x	4.53	x	69.27		0.63	x	0.7	=	95.9	(79)
Southwest	0.9x	0.77	x	3.5	x	69.27		0.63	x	0.7	=	74.09	(79)
Southwest	0.9x	0.77	x	5.45	x	69.27		0.63	x	0.7	=	115.37	(79)
Southwest	0.9x	0.77	x	1.96	x	69.27		0.63	x	0.7	=	331.93	(79)
Southwest	0.9x	0.77	x	2.65	x	69.27		0.63	x	0.7	=	112.2	(79)
Southwest	0.9x	0.77	x	3.97	x	69.27		0.63	x	0.7	=	84.04	(79)
Southwest	0.9x	0.77	x	7.97	x	44.07		0.63	x	0.7	=	429.38	(79)
Southwest	0.9x	0.77	x	8.77	x	44.07		0.63	x	0.7	=	118.12	(79)
Southwest	0.9x	0.77	x	4.53	x	44.07		0.63	x	0.7	=	61.01	(79)
Southwest	0.9x	0.77	x	3.5	x	44.07		0.63	x	0.7	=	47.14	(79)
Southwest	0.9x	0.77	x	5.45	x	44.07		0.63	x	0.7	=	73.4	(79)
Southwest	0.9x	0.77	x	1.96	x	44.07		0.63	x	0.7	=	211.19	(79)
Southwest	0.9x	0.77	x	2.65	x	44.07		0.63	x	0.7	=	71.38	(79)
Southwest	0.9x	0.77	x	3.97	x	44.07		0.63	x	0.7	=	53.47	(79)
Southwest	0.9x	0.77	x	7.97	x	31.49		0.63	x	0.7	=	306.78	(79)
Southwest	0.9x	0.77	x	8.77	x	31.49		0.63	x	0.7	=	84.39	(79)
Southwest	0.9x	0.77	x	4.53	x	31.49		0.63	x	0.7	=	43.59	(79)
Southwest	0.9x	0.77	x	3.5	x	31.49		0.63	x	0.7	=	33.68	(79)
Southwest	0.9x	0.77	x	5.45	x	31.49		0.63	x	0.7	=	52.45	(79)
Southwest	0.9x	0.77	x	1.96	x	31.49		0.63	x	0.7	=	150.89	(79)
Southwest	0.9x	0.77	x	2.65	x	31.49		0.63	x	0.7	=	51	(79)
Southwest	0.9x	0.77	x	3.97	x	31.49		0.63	x	0.7	=	38.2	(79)
Northwest	0.9x	0.77	x	2.14	x	11.28	x	0.63	x	0.7	=	7.38	(81)
Northwest	0.9x	0.77	x	8.54	x	11.28	x	0.63	x	0.7	=	29.45	(81)
Northwest	0.9x	0.77	x	4.57	x	11.28	x	0.63	x	0.7	=	15.76	(81)
Northwest	0.9x	0.77	x	2.14	x	11.28	x	0.63	x	0.7	=	7.38	(81)
Northwest	0.9x	0.77	x	3.71	x	11.28	x	0.63	x	0.7	=	12.79	(81)
Northwest	0.9x	0.77	x	1.61	x	11.28	x	0.63	x	0.7	=	5.55	(81)
Northwest	0.9x	0.77	x	2.14	x	22.97	x	0.63	x	0.7	=	15.02	(81)
Northwest	0.9x	0.77	x	8.54	x	22.97	x	0.63	x	0.7	=	59.94	(81)
Northwest	0.9x	0.77	x	4.57	x	22.97	x	0.63	x	0.7	=	32.08	(81)
Northwest	0.9x	0.77	x	2.14	x	22.97	x	0.63	x	0.7	=	15.02	(81)
Northwest	0.9x	0.77	x	3.71	x	22.97	x	0.63	x	0.7	=	26.04	(81)
Northwest	0.9x	0.77	x	1.61	x	22.97	x	0.63	x	0.7	=	11.3	(81)
Northwest	0.9x	0.77	x	2.14	x	41.38	x	0.63	x	0.7	=	27.06	(81)

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Northwest	0.9x	0.77	x	8.54	x	41.38	x	0.63	x	0.7	= 108	(81)
Northwest	0.9x	0.77	x	4.57	x	41.38	x	0.63	x	0.7	= 57.79	(81)
Northwest	0.9x	0.77	x	2.14	x	41.38	x	0.63	x	0.7	= 27.06	(81)
Northwest	0.9x	0.77	x	3.71	x	41.38	x	0.63	x	0.7	= 46.92	(81)
Northwest	0.9x	0.77	x	1.61	x	41.38	x	0.63	x	0.7	= 20.36	(81)
Northwest	0.9x	0.77	x	2.14	x	67.96	x	0.63	x	0.7	= 44.44	(81)
Northwest	0.9x	0.77	x	8.54	x	67.96	x	0.63	x	0.7	= 177.36	(81)
Northwest	0.9x	0.77	x	4.57	x	67.96	x	0.63	x	0.7	= 94.91	(81)
Northwest	0.9x	0.77	x	2.14	x	67.96	x	0.63	x	0.7	= 44.44	(81)
Northwest	0.9x	0.77	x	3.71	x	67.96	x	0.63	x	0.7	= 77.05	(81)
Northwest	0.9x	0.77	x	1.61	x	67.96	x	0.63	x	0.7	= 33.44	(81)
Northwest	0.9x	0.77	x	2.14	x	91.35	x	0.63	x	0.7	= 59.74	(81)
Northwest	0.9x	0.77	x	8.54	x	91.35	x	0.63	x	0.7	= 238.41	(81)
Northwest	0.9x	0.77	x	4.57	x	91.35	x	0.63	x	0.7	= 127.58	(81)
Northwest	0.9x	0.77	x	2.14	x	91.35	x	0.63	x	0.7	= 59.74	(81)
Northwest	0.9x	0.77	x	3.71	x	91.35	x	0.63	x	0.7	= 103.57	(81)
Northwest	0.9x	0.77	x	1.61	x	91.35	x	0.63	x	0.7	= 44.95	(81)
Northwest	0.9x	0.77	x	2.14	x	97.38	x	0.63	x	0.7	= 63.69	(81)
Northwest	0.9x	0.77	x	8.54	x	97.38	x	0.63	x	0.7	= 254.17	(81)
Northwest	0.9x	0.77	x	4.57	x	97.38	x	0.63	x	0.7	= 136.01	(81)
Northwest	0.9x	0.77	x	2.14	x	97.38	x	0.63	x	0.7	= 63.69	(81)
Northwest	0.9x	0.77	x	3.71	x	97.38	x	0.63	x	0.7	= 110.42	(81)
Northwest	0.9x	0.77	x	1.61	x	97.38	x	0.63	x	0.7	= 47.92	(81)
Northwest	0.9x	0.77	x	2.14	x	91.1	x	0.63	x	0.7	= 59.58	(81)
Northwest	0.9x	0.77	x	8.54	x	91.1	x	0.63	x	0.7	= 237.77	(81)
Northwest	0.9x	0.77	x	4.57	x	91.1	x	0.63	x	0.7	= 127.24	(81)
Northwest	0.9x	0.77	x	2.14	x	91.1	x	0.63	x	0.7	= 59.58	(81)
Northwest	0.9x	0.77	x	3.71	x	91.1	x	0.63	x	0.7	= 103.29	(81)
Northwest	0.9x	0.77	x	1.61	x	91.1	x	0.63	x	0.7	= 44.83	(81)
Northwest	0.9x	0.77	x	2.14	x	72.63	x	0.63	x	0.7	= 47.5	(81)
Northwest	0.9x	0.77	x	8.54	x	72.63	x	0.63	x	0.7	= 189.55	(81)
Northwest	0.9x	0.77	x	4.57	x	72.63	x	0.63	x	0.7	= 101.43	(81)
Northwest	0.9x	0.77	x	2.14	x	72.63	x	0.63	x	0.7	= 47.5	(81)
Northwest	0.9x	0.77	x	3.71	x	72.63	x	0.63	x	0.7	= 82.35	(81)
Northwest	0.9x	0.77	x	1.61	x	72.63	x	0.63	x	0.7	= 35.74	(81)
Northwest	0.9x	0.77	x	2.14	x	50.42	x	0.63	x	0.7	= 32.98	(81)
Northwest	0.9x	0.77	x	8.54	x	50.42	x	0.63	x	0.7	= 131.59	(81)
Northwest	0.9x	0.77	x	4.57	x	50.42	x	0.63	x	0.7	= 70.42	(81)
Northwest	0.9x	0.77	x	2.14	x	50.42	x	0.63	x	0.7	= 32.98	(81)
Northwest	0.9x	0.77	x	3.71	x	50.42	x	0.63	x	0.7	= 57.17	(81)
Northwest	0.9x	0.77	x	1.61	x	50.42	x	0.63	x	0.7	= 24.81	(81)

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Northwest	0.9x	0.77	x	2.14	x	28.07	x	0.63	x	0.7	=	18.36	(81)
Northwest	0.9x	0.77	x	8.54	x	28.07	x	0.63	x	0.7	=	73.25	(81)
Northwest	0.9x	0.77	x	4.57	x	28.07	x	0.63	x	0.7	=	39.2	(81)
Northwest	0.9x	0.77	x	2.14	x	28.07	x	0.63	x	0.7	=	18.36	(81)
Northwest	0.9x	0.77	x	3.71	x	28.07	x	0.63	x	0.7	=	31.82	(81)
Northwest	0.9x	0.77	x	1.61	x	28.07	x	0.63	x	0.7	=	13.81	(81)
Northwest	0.9x	0.77	x	2.14	x	14.2	x	0.63	x	0.7	=	9.28	(81)
Northwest	0.9x	0.77	x	8.54	x	14.2	x	0.63	x	0.7	=	37.05	(81)
Northwest	0.9x	0.77	x	4.57	x	14.2	x	0.63	x	0.7	=	19.83	(81)
Northwest	0.9x	0.77	x	2.14	x	14.2	x	0.63	x	0.7	=	9.28	(81)
Northwest	0.9x	0.77	x	3.71	x	14.2	x	0.63	x	0.7	=	16.1	(81)
Northwest	0.9x	0.77	x	1.61	x	14.2	x	0.63	x	0.7	=	6.99	(81)
Northwest	0.9x	0.77	x	2.14	x	9.21	x	0.63	x	0.7	=	6.03	(81)
Northwest	0.9x	0.77	x	8.54	x	9.21	x	0.63	x	0.7	=	24.05	(81)
Northwest	0.9x	0.77	x	4.57	x	9.21	x	0.63	x	0.7	=	12.87	(81)
Northwest	0.9x	0.77	x	2.14	x	9.21	x	0.63	x	0.7	=	6.03	(81)
Northwest	0.9x	0.77	x	3.71	x	9.21	x	0.63	x	0.7	=	10.45	(81)
Northwest	0.9x	0.77	x	1.61	x	9.21	x	0.63	x	0.7	=	4.53	(81)

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

(83)m=	1881.51	3261.94	4618.88	5991.04	6960.14	7020.98	6722.61	5981.73	5090.79	3646.72	2263.9	1603.58	(83)

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

(84)m=	3529.51	4905.78	6202.4	7473.45	8331.15	8292.42	7934.53	7204.08	6369.73	5027.11	3760.76	3196.21	(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	1	1	0.98	0.93	0.81	0.87	0.98	1	1	1	(86)

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

(87)m=	19.57	19.71	19.95	20.26	20.58	20.84	20.95	20.92	20.7	20.29	19.87	19.55	(87)

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

(88)m=	20.07	20.07	20.07	20.07	20.08	20.08	20.08	20.08	20.08	20.08	20.07	20.07	(88)

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

(89)m=	1	1	1	1	0.98	0.88	0.68	0.76	0.97	1	1	1	(89)

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

(90)m=	18.1	18.31	18.66	19.12	19.59	19.94	20.06	20.04	19.76	19.16	18.55	18.08	(90)

fLA = Living area ÷ (4) = | 0.07 | (91)

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

(92)m=	18.21	18.41	18.75	19.21	19.66	20	20.12	20.1	19.83	19.24	18.64	18.18	(92)

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

(93)m=	18.21	18.41	18.75	19.21	19.66	20	20.12	20.1	19.83	19.24	18.64	18.18	(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

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Utilisation factor for gains, hm:

(94)m=	1	1	1	0.99	0.97	0.87	0.69	0.77	0.96	1	1	1	(94)

Useful gains, hmGm , W = (94)m x (84)m

(95)m=	3529.42	4904.95	6196.52	7430.83	8077.9	7255.76	5469.66	5523.99	6119.96	5017.46	3760.41	3196.16	(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=	23188.25	22494.01	20361.39	17010.6	13115.36	8847.72	5768.55	6056.22	9409.86	14243.32	19074.92	23172.98	(97)

Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m

(98)m=	14626.17	11819.84	10538.66	6897.44	3747.87	0	0	0	0	6864.04	11026.44	14862.75

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 80383.23 (98)

Space heating requirement in kWh/m²/year 49.19 (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		93.5	(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)														
	14626.17	11819.84	10538.66	6897.44	3747.87	0	0	0	0	6864.04	11026.44	14862.75		
(211)m = {[(98)m x (204)] } x 100 ÷ (206)														(211)
	15642.97	12641.54	11271.3	7376.94	4008.42	0	0	0	0	7341.22	11792.99	15895.99		
Total (kWh/year) =Sum(211)$_{1...5,10....12}$=													85971.37	(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

Output from water heater (calculated above)

	302.94	266.64	279.13	248.97	243.08	215.91	206.12	227.88	228.01	258.23	274.62	295.24

Efficiency of water heater 79.8 (216)

(217)m=	90.25	90.23	90.19	90.08	89.77	79.8	79.8	79.8	79.8	90.06	90.21	90.26	(217)

Fuel for water heating, kWh/month

(219)m = (64)m x 100 ÷ (217)m

(219)m=	335.66	295.5	309.5	276.39	270.79	270.56	258.3	285.57	285.73	286.73	304.44	327.08

Total = Sum(219a)$_{1...12}$ = 3506.24 (219)

Annual totals	**kWh/year**	**kWh/year**
Space heating fuel used, main system 1		85971.37
Water heating fuel used		3506.24
Electricity for pumps, fans and electric keep-hot		

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central heating pump:		30		(230c)
boiler with a fan-assisted flue		45		(230e)
Total electricity for the above, kWh/year	sum of (230a)…(230g) =		75	(231)
Electricity for lighting			2166.06	(232)

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	=	18569.82	(261)
Space heating (secondary)	(215) x	0.519	=	0	(263)
Water heating	(219) x	0.216	=	757.35	(264)
Space and water heating	(261) + (262) + (263) + (264) =			19327.16	(265)
Electricity for pumps, fans and electric keep-hot	(231) x	0.519	=	38.93	(267)
Electricity for lighting	(232) x	0.519	=	1124.18	(268)
Total CO2, kg/year		sum of (265)…(271) =		20490.27	(272)

TER = 19.05 (273)

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