# 9_367_FREDERICK STREET_ENERGY STATEMENT_190710

3–7 Frederick Street

Produced by XCO2 for Project 5 Architecture LLP

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# EXECUTIVE SUMMARY

The energy strategy for the 3–7 Frederick Street development has been developed in line with the energy policies of the London Plan and of the Camden Local Plan. The three-step Energy Hierarchy has been implemented and the estimated regulated $CO_2$ savings on site are 25.7% against a Part L1B compliant scheme with SAP2012 carbon factors.

This report assesses the predicted energy performance and carbon dioxide emissions of the proposed development at 3–7 Frederick Street, located in the London Borough of Camden.

The proposed development comprises the restoration of 3 Grade II listed townhouses from the previous use of a hostel to 7 dwellings. The proposed change of use development will be compared to the existing building according to Part L1B.

The energy strategy outlined in this report has been developed using the SAP 2012 emissions factors as per the current version of Building Regulations.

The methodology used to determine the expected operational $CO_2$ emissions for the development is in accordance with the London Plan's three-step Energy Hierarchy (Policy 5.2A) and the $CO_2$ savings achieved for each step are outlined below:

### BE LEAN – USE LESS ENERGY

The first step addresses reduction in energy demand, through the adoption of passive and active design measures.

The proposed energy efficiency measures include improvements to building fabric beyond the existing notional building, efficient lighting, energy efficient individual boilers as well as energy saving controls for space heating.

By means of energy efficiency measures alone, regulated $CO_2$ emissions are shown to reduce by:

Table 1: Regulated $CO_2$ Savings

| Cumulative Regulated $CO_2$ Savings | | |
|---|---|---|
| | SAP2012 | |
| | % | t/yr |
| Domestic | 25.7 | 10.2 |

### BE CLEAN – SUPPLY ENERGY EFFICIENTLY

The application site is located in an area where a district heat network is considered feasible; however, no firm plans for its development are in place to date.

The scale of the development is not deemed large enough to feasibly and economically incorporate a district heat network; high efficiency individual gas boilers are therefore proposed to provide heating and domestic hot water to all dwellings.

### BE GREEN – USE RENEWABLE ENERGY

The renewable technologies feasibility study carried out for the development identified that no suitable technologies were deemed acceptable for various reasons. The protected façade and historic nature of the building as well as its location within the Bloomsbury Conservation Area deems the building unsuitable for photovoltaics, solar thermal panels, wind and biomass technologies. The inclusion of these technologies would create unacceptable visual harm and would be contrary to Policies D1 and D2 in Camden's Local Plan, and are unlikely to be supported by the Local Authority's Heritage Officers.

### CUMULATIVE ON SITE SAVINGS

The overall regulated $CO_2$ savings *on site* against a Part L1B compliant scheme are therefore 25.7% over the existing building baseline.

# INTRODUCTION

## SITE & PROPOSAL

The proposed development includes the restoration of 3 Grade II listed townhouses. The proposal includes a change of use from a hostel into 7 dwellings. The new scheme includes three 2-storey, one 3-storey apartments and three 1-storey dwellings. The site's main access is from Frederick Street and it is located approximately 1.5 miles from Kings Cross Station.

The location of the development site is shown in the figure below.

Site Location

Figure 1: Proposed site location

## POLICY FRAMEWORK

The proposal will seek to respond to the energy policies of the London Plan and of the policies within Camden's Local Plan

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

### *THE LONDON PLAN*

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 policies of the London Plan are included in Chapter Five *London's Response to Climate Change* and include Policies 5.2 to 5.9:

- 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, and,
- Policy 5.9: Overheating and cooling.

Extracts of Policies 5.2, 5.6, 5.7 and 5.9 are presented below as these are considered most relevant to the proposed scheme.

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

### 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 2: $CO_2$ 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 5.6 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).*

### *GLA GUIDANCE ON PREPARING ENERGY ASSESSMENTS*

This document (last updated in March 2016) 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.*

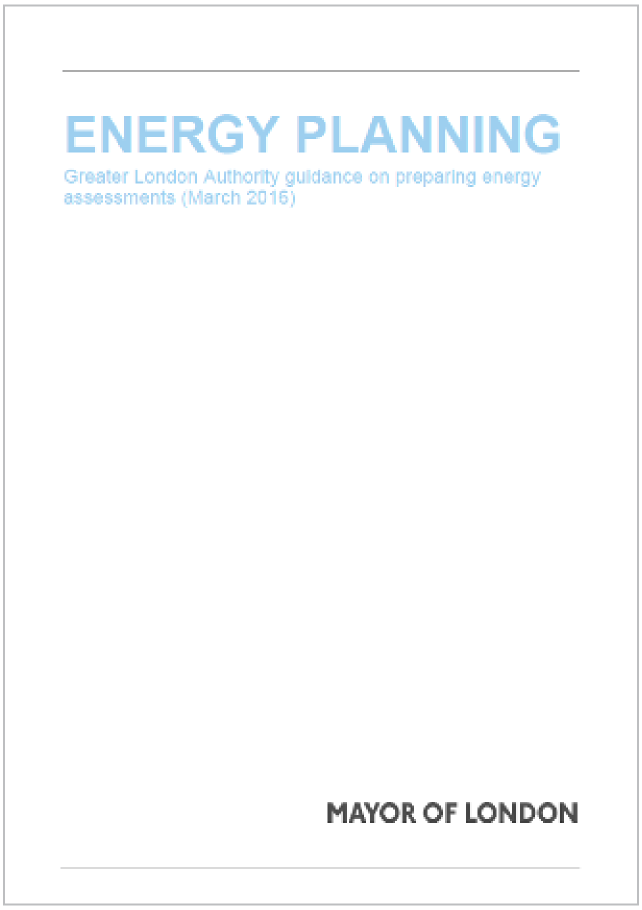
The definition of zero carbon homes is provided in section 5.3 of the guidance:

> *'Zero carbon' homes are homes forming part of major development applications where the residential element of the application achieves at least a 35 per cent reduction in regulated carbon dioxide emissions (beyond Part L 2013) on-site. The remaining regulated carbon dioxide emissions, to 100 per cent, are to be 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.

The proposed development is considered a minor scheme and therefore is not required to comply with the zero carbon homes policies set out by the GLA.


ENERGY PLANNING

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

MAYOR OF LONDON

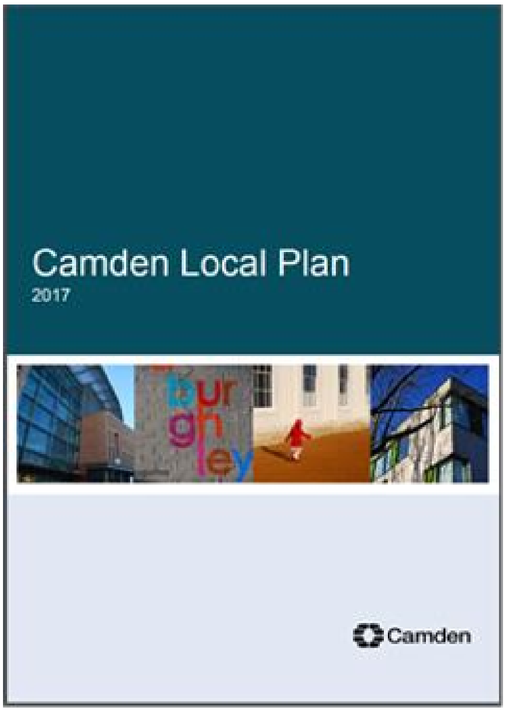
## *CAMDEN LOCAL PLAN*

*The Council's Sustainability Plan 'Green Action for Change' commits the Council to seek low and where possible zero carbon buildings.*

*New developments in Camden will be expected to be designed to minimise energy use and $CO_2$ emissions in operation through the application of the energy hierarchy.*

*It is understood that some sustainable design measures may be challenging for listed buildings and some conservation areas and we would advise developers to engage early with the Council to develop innovative solutions.*

*Proposals that reduce the energy consumption of listed buildings will be welcomed provided that they do not cause harm to the special architectural and historic interest of the building or group. Energy use can be reduced by means that do not harm the fabric or appearance of the building, for instance roof insulation, draught proofing, secondary glazing, more efficient boilers and Camden Local Plan | Design and Heritage 241 heating and lighting systems and use of green energy sources. Depending on the form of the building, renewable energy technologies may also be installed, for instance solar water heating and photovoltaics.*



## METHODOLOGY

The sections below present the methodology followed in determining the on-site and off-site carbon savings for the proposed scheme.

### *ON-SITE CARBON SAVINGS – THE ENERGY HIERARCHY*

The methodology employed to develop the energy strategy for the scheme and achieve on-site carbon savings is in line with the GLA's *Guidance on preparing energy assessments* and is as follows:

The **baseline** $CO_2$ emissions are first established, i.e. the emissions of a scheme that is compliant with Part L1B of the Building Regulations. For refurbishments and change of use projects, the baseline is obtained based on the existing fabric and building services system.

The software used to model and calculate the energy performance and carbon emissions of the domestic element is SAP2012. The emissions of the domestic element are established by modelling representative dwelling types and multiplying the Target Emission Rate (TER) of each type with the cumulative floor area for that type to establish the total emissions for the domestic element of the proposal. Similarly, the TER for each non-domestic element is multiplied by its floor area to establish the total emissions.

The same approach is followed to determine the energy performance and $CO_2$ emissions of the proposed scheme for each of the steps of the **Energy Hierarchy**. The $CO_2$ emissions are estimated based on the SAP Dwelling Emission Rate (DER). The Energy Hierarchy aims at delivering significant carbon savings on-site.

The three consecutive steps of the Energy Hierarchy are:

- **Be Lean** whereby the demand for energy is reduced through a range of passive and active energy efficiency measures;
- **Be Clean** whereby as much of the remaining energy demand is supplied as efficiently as possible (e.g. by connecting to a district energy network or developing a site-wide CHP network), and,
- **Be Green** whereby renewable technologies are incorporated to offset part of the carbon emissions of the development. The uptake of renewable technologies is based on feasibility and viability considerations, including their compatibility with the energy system determined in the previous step.

The implementation of the Energy Hierarchy determines the total regulated carbon savings that can be feasibly and viably achieved on site.

The % improvement against the baseline emissions is compared to the relevant targets for each element. As this scheme is a refurbishment, Camden has no targets as to the percentage savings required.

# 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. The regulated carbon saving achieved in this step of the Energy Hierarchy is 25.7% over the site wide baseline level.

## PASSIVE DESIGN MEASURES

### *ENHANCED U-VALUES*

The heat loss of different building fabric elements is dependent upon their U-value. A building with low U-values provides better levels of insulation and reduced heating demand during the cooler months.

The proposed refurbishment will incorporate additional insulation to the basement ground floor and roof to improve the building's performance and reduce the demand for space heating. Additionally, as both existing and new sash windows are required to be single glazed to keep in character with the Conservation Area, these will be improved with secondary glazing. All new casement windows and rooflights will be double glazed to produce an improved u-value.

The tables to the right demonstrate the improved performance of the proposed building fabric beyond the existing building as a Grade II listed building.

Table 3: Thermal Envelope U-values

| Domestic (U-values in W/m².K) | | | |
|---|---|---|---|
| **Element** | **Existing building** | **Proposed** | **Improvement** |
| Floor | 2.1 | 0.18 | 91% |
| Roof | 2.1 | 0.25 | 10% |
| New casement windows | 4.8 | 1.8 | 38% |
| Roof Lights | 4.8 | 1.4 | 71% |
| Retained windows | 4.8 | 2.6 | 46% |

### *REDUCING THE NEED FOR ARTIFICIAL LIGHTING*

The development has been designed to ensure all habitable spaces within the new dwellings will achieved good levels of daylighting as a way of improving the health and wellbeing of its occupants.

All of the habitable areas will benefit from large areas of glazing and additional glazing such as the rooflights to increase the amount of daylight within the internal spaces where possible. This is expected to reduce the need for artificial lighting whilst delivering pleasant, healthy spaces for occupants.

## ACTIVE DESIGN MEASURES

### *HIGH EFFICACY LIGHTING*

The fit out of the refurbishment intends to incorporate low energy lighting fittings throughout the habitable spaces. All light fittings will be specified as low energy lighting, and will accommodate LED, compact fluorescent (CFLs) or fluorescent luminaires only.

### *HEAT GENERATION*

Space heating and domestic hot water will be provided by new individual highly efficient gas boilers. It is proposed that the gross efficiency of the boilers falls in the region of 89%.

### *CONTROLS*

Advanced lighting and space conditioning controls will be incorporated, specifically:

- For corridors and communal areas, occupant sensors will be fitted for lighting, whereas day lit areas will incorporate daylight sensors where appropriate;
- Heating controls in dwellings will comprise programmers and room thermostats.

### *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 each dwelling; the display board will demonstrate real-time and historical energy use data and will be installed at an accessible location within the dwellings

## ENERGY USE

The table below shows a breakdown of carbon dioxide emissions associated with the proposed development's fossil fuel. The figures provide a comparison between the baseline condition and the proposed development once energy efficiency measures (Lean) have been applied.

This table demonstrates the energy savings achieved through energy efficiency measures (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

| | Baseline | | | Lean | | |
|---|---|---|---|---|---|---|
| | **Energy (kWh/yr.)** | **$kgCO_2$ /yr.** | **$kgCO_2/m^2$** | **Energy (kWh/yr.)** | **$kgCO_2$ /yr.** | **$kgCO_2/m^2$** |
| Hot Water | 17,230 | 3,720 | 6.7 | 17,230 | 3,720 | 6.7 |
| Space Heating | 112,970 | 24,400 | 44.2 | 112,970 | 24,400 | 44.2 |
| Cooling | 0 | 0 | 0.0 | 0 | 0 | 0.0 |
| Auxiliary | 0 | 0 | 0.0 | 530 | 270 | 0.5 |
| Lighting | 530 | 270 | 0.5 | 2,430 | 1,260 | 2.3 |
| Equipment | 2,950 | 1,530 | 2.8 | 2,950 | 1,530 | 2.8 |
| **Total Part L** | 132,620 | 28,390 | 51.4 | 133,160 | 29,650 | 53.7 |
| **Total (incl. equipment)** | 135,570 | 29,920 | 54.2 | 136,110 | 31,190 | 56.5 |

## BE LEAN $CO_2$ EMISSIONS & SAVINGS

By means of energy efficiency measures alone, regulated $CO_2$ emissions are shown to reduce by 25.7%, equivalent to 10 tonnes per annum.

# BE CLEAN – SUPPLY ENERGY EFFICIENTLY

No existing or proposed district energy network is located within feasible proximity to the proposed development. A communal heating scheme will not be feasible for a minor scheme of this size and nature. Consequently, no $CO_2$ savings will be achieved at this stage 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:

1. Connection to existing heating and cooling networks;
2. Site wide CHP network; and,
3. 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.

The map highlights in a red line any existing and proposed district heating networks within the vicinity of the development.

A review of the map shows that there is an existing heat network approximately 1km away from the proposed site. The scale of the development does not make it economically viable for connection with networks located at a distance from the site. For this reason, connection to district heat networks are currently not considered feasible.

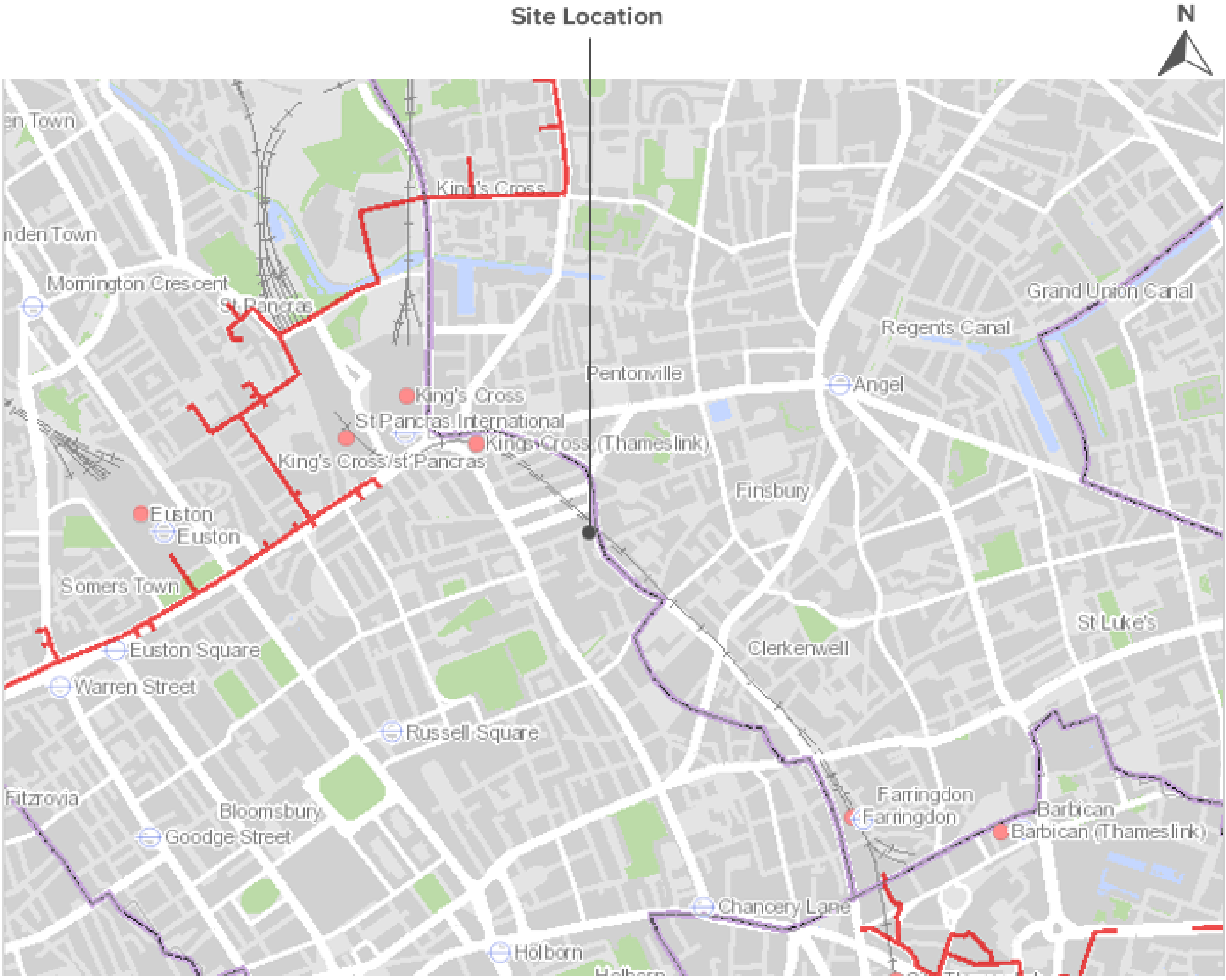



Figure 2: Excerpt from the London Heat Map. Existing district networks outlined in yellow, proposed networks in red.

### *BE CLEAN $CO_2$ EMISSIONS & SAVINGS*

Given that it has not been found feasible or viable for the refurbishment to incorporate the supply of low carbon heating or cooling, 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 that there are no suitable technologies for the development at 3 – 7 Frederick Street.

## 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 3–7 Frederick Street 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*

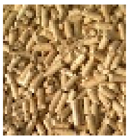
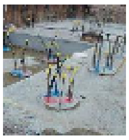
The table below summarises the factors taken into account in determining appropriate renewable technologies for this project. This includes estimated capital cost, lifetime, level of maintenance and level of impact on external appearance. The final column indicates the feasibility of the technology in 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 there are no feasible renewable technologies for the refurbishment of the 3-7 Frederick Street. Making changes to the external or roof of the building would likely result in unacceptable harm to the Grade II listed building and would be contrary to Heritage polices in Camden's Local Plan.

## *BE GREEN $CO_2$ EMISSIONS & SAVINGS*

Given that green technologies have not been found feasible or viable for the refurbishment, no carbon savings are achieved for this step of the Energy Hierarchy.

Table 5: 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 mounted on the pitched roof would significantly alter the appearance and character of the Listed Building. | 25 yrs. | Low | Med | 3 |
| Solar thermal |  | Not adopted - Solar thermal array mounted on the pitched roof would significantly alter the appearance and character of the Listed Building. | 25 yrs. | Low | Med | 3 |
| 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 | 2 |
| ASHP |  | Not adopted -ASHP evaporator units are located externally and produce noise which can be an issue in a residential location, especially at night. | 20 yrs. | Med | Med | 3 |
| Wind |  | Not adopted - Wind turbines located at the site will have a significant visual impact on the existing building within the Conservation Area. | 25 yrs. | Med | High | 1 |

# CONCLUSIONS

Following the implementation of the three-step Energy Hierarchy, the cumulative $CO_2$ savings on site are estimated at 25.7% against an existing building baseline, in line with Part L1B.

## ON SITE $CO_2$ SAVINGS

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 L1B compliant scheme through on site measures alone by:

Table 6: Cumulative $CO_2$ Savings

| Cumulative Regulated $CO_2$ Savings | | |
|---|---|---|
| | SAP2012 | |
| | % | t/yr |
| Domestic | 25.7 | 10.2 |

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.

Overall, the proposed development has been designed to best 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.

## CUMULATIVE SAVINGS

Table 7: $CO_2$ emissions after each step of the Energy Hierarchy

| | Carbon dioxide emissions for domestic buildings (tonnes CO2 per annum) | |
|---|---|---|
| | Regulated | Unregulated |
| Baseline | 39.9 | 1.5 |
| After energy demand reduction | 29.7 | 1.5 |
| After heat network/CHP | 29.7 | 1.5 |
| After renewable energy | 29.7 | 1.5 |

Table 8: Regulated $CO_2$ savings from each stage of the Energy Hierarchy

| | Regulated domestic carbon dioxide savings | |
|---|---|---|
| | Tonnes $CO_2$ per annum | % over baseline |
| Savings from energy demand reduction | 10.2 | 25.7 |
| Savings from heat network/CHP | 0.0 | 0.0 |
| Savings from renewable energy | 0.0 | 0.0 |
| Cumulative on site savings | 10.2 | 25.7 |

# APPENDIX A – SAP RESULTS

The table below lists the 7 dwellings that were modelled using SAP methodology, the TER and DER outputs and the % $CO_2$ reduction achieved after the Be Lean, Be Clean and Be Green measures have been applied.

The following pages show the DER/TER FSAP2012 worksheets for 2 sample dwellings. The SAP outputs for all sample flats are available on request.

| SAP Ref No. | Unit Ref. | TER ($kgCO_2/m^2/yr$) | DER ($kgCO_2/m^2/yr$) | % $CO_2$ reduction |
|---|---|---|---|---|
| 1 | Unit 3a | 78.17 | 57.60 | 30% |
| 2 | Unit 3b | 75.76 | 58.43 | 25% |
| 3 | Unit 5 | 62.79 | 46.05 | 30% |
| 4 | Unit 7a | 74.13 | 58.33 | 24% |
| 5 | Unit 7b | 70.68 | 56.99 | 22% |
| 6 | Unit 7c | 59.69 | 48.71 | 22% |
| 7 | Unit 7d | 89.22 | 75.05 | 19% |

# SAP WorkSheet: New dwelling design stage

**User Details:**

| | | | |
|---|---|---|---|
| **Assessor Name:** | | **Stroma Number:** | |
| **Software Name:** | Stroma FSAP 2012 | **Software Version:** | Version: 1.0.4.18 |

**Property Address: 5 Frederick Street**

**Address :**

## 1. Overall dwelling dimensions:

| | Area(m²) | | | Av. Height(m) | | | Volume(m³) | |
|---|---|---|---|---|---|---|---|---|
| Basement | 41.7 | (1a) | x | 2.6 | (2a) | = | 108.42 | (3a) |
| Ground floor | 42.8 | (1b) | x | 3 | (2b) | = | 128.4 | (3b) |
| Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n) | 84.5 | (4) | | | | | | |
| Dwelling volume | | | | (3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) | | = | 236.82 | (5) |

## 2. Ventilation rate:

| | main heating | | secondary heating | | other | | total | | m³ per hour | |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of chimneys | 0 | + | 0 | + | 1 | = | 1 | x 40 = | 40 | (6a) |
| Number of open flues | 0 | + | 0 | + | 0 | = | 0 | x 20 = | 0 | (6b) |
| Number of intermittent fans | | | | | | | 2 | x 10 = | 20 | (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) = | 60 | ÷ (5) = | 0.25 | (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) | 1 | (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) = | 0.85 | (21) |

Infiltration rate modified for monthly wind speed

Monthly average wind speed from Table 7

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

Wind Factor (22a)m = (22)m ÷ 4

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

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

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.09 | 1.07 | 1.04 | 0.94 | 0.92 | 0.81 | 0.81 | 0.79 | 0.85 | 0.92 | 0.96 | 1 |

*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= | 1.09 | 1.07 | 1.04 | 0.94 | 0.92 | 0.83 | 0.83 | 0.81 | 0.86 | 0.92 | 0.96 | 1 | (24d) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (25)m= | 1.09 | 1.07 | 1.04 | 0.94 | 0.92 | 0.83 | 0.83 | 0.81 | 0.86 | 0.92 | 0.96 | 1 | (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 Type 1 | | | 1.69 | x | 1.8 | = | 3.042 | | | (26) |
| Doors Type 2 | | | 1.87 | x | 1.8 | = | 3.366 | | | (26) |
| Windows Type 1 | | | 3.6 | x1/[1/( 2.6 )+ 0.04] | | = | 8.48 | | | (27) |
| Windows Type 2 | | | 1.68 | x1/[1/( 2.6 )+ 0.04] | | = | 3.96 | | | (27) |
| Windows Type 3 | | | 0.55 | x1/[1/( 2.6 )+ 0.04] | | = | 1.3 | | | (27) |
| Windows Type 4 | | | 2.52 | x1/[1/( 2.6 )+ 0.04] | | = | 5.93 | | | (27) |
| Windows Type 5 | | | 0.28 | x1/[1/( 2.6 )+ 0.04] | | = | 0.66 | | | (27) |
| Windows Type 6 | | | 1.87 | x1/[1/( 2.6 )+ 0.04] | | = | 4.4 | | | (27) |
| Windows Type 7 | | | 0.57 | x1/[1/( 1.8 )+ 0.04] | | = | 0.96 | | | (27) |
| Floor | | | 41.7 | x | 0.25 | = | 10.425 | | | (28) |
| Walls Type1 | 35.1 | 12.95 | 22.15 | x | 2.1 | = | 46.51 | | | (29) |
| Walls Type2 | 40.8 | 1.68 | 39.12 | x | 2.1 | = | 82.15 | | | (29) |
| Roof | 3.9 | 0 | 3.9 | x | 2.3 | = | 8.97 | | | (30) |
| Total area of elements, m² | | | 121.5 | | | | | | | (31) |
| Party wall | | | 41.6 | x | 0 | = | 0 | | | (32) |
| Party wall | | | 48 | x | 0 | = | 0 | | | (32) |

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

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

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 180.16 (33)

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| | | | |
|---|---|---|---|
| Heat capacity Cm = S(A x k ) | ((28)…(30) + (32) + (32a)…(32e) = | 0 | (34) |
| Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K | Indicative Value: Medium | 250 | (35) |

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

| | | | |
|---|---|---|---|
| Thermal bridges : S (L x Y) calculated using Appendix K | | 18.23 | (36) |

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

| | | | |
|---|---|---|---|
| Total fabric heat loss | (33) + (36) = | 198.38 | (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= | 84.98 | 83.31 | 81.65 | 73.47 | 71.92 | 64.73 | 64.73 | 63.39 | 67.5 | 71.92 | 75.05 | 78.31 | (38) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (39)m= | 283.36 | 281.69 | 280.03 | 271.85 | 270.3 | 263.11 | 263.11 | 261.77 | 265.88 | 270.3 | 273.43 | 276.7 | |

Average = Sum(39)1…12 /12= 271.79 (39)

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (40)m= | 3.35 | 3.33 | 3.31 | 3.22 | 3.2 | 3.11 | 3.11 | 3.1 | 3.15 | 3.2 | 3.24 | 3.27 | |

Average = Sum(40)1…12 /12= 3.22 (40)

Number of days in month (Table 1a)

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



## 4. Water heating energy requirement: kWh/year:

Assumed occupancy, N — 2.54 (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 — 94.59 (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= | 104.05 | 100.27 | 96.48 | 92.7 | 88.91 | 85.13 | 85.13 | 88.91 | 92.7 | 96.48 | 100.27 | 104.05 | |

Total = Sum(44)1…12 = 1135.08 (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= | 154.3 | 134.95 | 139.26 | 121.41 | 116.5 | 100.53 | 93.15 | 106.89 | 108.17 | 126.06 | 137.61 | 149.43 | |

Total = Sum(45)1…12 = 1488.26 (45)

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (46)m= | 23.15 | 20.24 | 20.89 | 18.21 | 17.47 | 15.08 | 13.97 | 16.03 | 16.23 | 18.91 | 20.64 | 22.41 | (46) |

Water storage loss:

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

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

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

Water storage loss:

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

Temperature factor from Table 2b — 0 (49)

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

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

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

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (56)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (56) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (57)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (57) |

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

Primary circuit loss calculated for each month (59)m = (58) ÷ 365 × (41)m
(modified by factor from Table H5 if there is solar water heating and a cylinder thermostat)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (59)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (59) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (61)m= | 50.96 | 46.03 | 49.17 | 45.71 | 45.31 | 41.98 | 43.38 | 45.31 | 45.71 | 49.17 | 49.32 | 50.96 | (61) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (62)m= | 205.26 | 180.98 | 188.43 | 167.12 | 161.81 | 142.51 | 136.53 | 152.2 | 153.88 | 175.23 | 186.92 | 200.39 | (62) |

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

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (63)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (63) |

Output from water heater

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (64)m= | 205.26 | 180.98 | 188.43 | 167.12 | 161.81 | 142.51 | 136.53 | 152.2 | 153.88 | 175.23 | 186.92 | 200.39 | |

Output from water heater (annual)$_{1...12}$ | 2051.27 | (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= | 64.04 | 56.38 | 58.6 | 51.8 | 50.06 | 43.92 | 41.82 | 46.87 | 47.4 | 54.21 | 58.08 | 62.43 | (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= | 152.56 | 152.56 | 152.56 | 152.56 | 152.56 | 152.56 | 152.56 | 152.56 | 152.56 | 152.56 | 152.56 | 152.56 | (66) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (67)m= | 51.64 | 45.87 | 37.3 | 28.24 | 21.11 | 17.82 | 19.26 | 25.03 | 33.6 | 42.66 | 49.79 | 53.08 | (67) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (68)m= | 341.18 | 344.72 | 335.8 | 316.8 | 292.83 | 270.29 | 255.24 | 251.7 | 260.62 | 279.61 | 303.59 | 326.12 | (68) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (69)m= | 52.8 | 52.8 | 52.8 | 52.8 | 52.8 | 52.8 | 52.8 | 52.8 | 52.8 | 52.8 | 52.8 | 52.8 | (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= | -101.71 | -101.71 | -101.71 | -101.71 | -101.71 | -101.71 | -101.71 | -101.71 | -101.71 | -101.71 | -101.71 | -101.71 | (71) |

Water heating gains (Table 5)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (72)m= | 86.08 | 83.9 | 78.76 | 71.94 | 67.29 | 61 | 56.21 | 63 | 65.83 | 72.86 | 80.67 | 83.91 | (72) |

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

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (73)m= | 585.55 | 581.13 | 558.51 | 523.64 | 487.88 | 455.77 | 437.36 | 446.38 | 466.7 | 501.78 | 540.7 | 569.76 | (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) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Southeast 0.9x | 0.77 | x | 1.68 | x | 36.79 | x | 0.76 | x | 0.7 | = | 22.79 | (77) |
| Southeast 0.9x | 0.77 | x | 0.55 | x | 36.79 | x | 0.76 | x | 0.7 | = | 7.46 | (77) |
| Southeast 0.9x | 0.77 | x | 1.87 | x | 36.79 | x | 0.76 | x | 0.7 | = | 25.37 | (77) |
| Southeast 0.9x | 0.77 | x | 0.57 | x | 36.79 | x | 0.85 | x | 0.7 | = | 8.65 | (77) |
| Southeast 0.9x | 0.77 | x | 1.68 | x | 62.67 | x | 0.76 | x | 0.7 | = | 38.82 | (77) |
| Southeast 0.9x | 0.77 | x | 0.55 | x | 62.67 | x | 0.76 | x | 0.7 | = | 12.71 | (77) |
| Southeast 0.9x | 0.77 | x | 1.87 | x | 62.67 | x | 0.76 | x | 0.7 | = | 43.21 | (77) |
| Southeast 0.9x | 0.77 | x | 0.57 | x | 62.67 | x | 0.85 | x | 0.7 | = | 14.73 | (77) |
| Southeast 0.9x | 0.77 | x | 1.68 | x | 85.75 | x | 0.76 | x | 0.7 | = | 53.11 | (77) |
| Southeast 0.9x | 0.77 | x | 0.55 | x | 85.75 | x | 0.76 | x | 0.7 | = | 17.39 | (77) |
| Southeast 0.9x | 0.77 | x | 1.87 | x | 85.75 | x | 0.76 | x | 0.7 | = | 59.12 | (77) |
| Southeast 0.9x | 0.77 | x | 0.57 | x | 85.75 | x | 0.85 | x | 0.7 | = | 20.15 | (77) |
| Southeast 0.9x | 0.77 | x | 1.68 | x | 106.25 | x | 0.76 | x | 0.7 | = | 65.81 | (77) |
| Southeast 0.9x | 0.77 | x | 0.55 | x | 106.25 | x | 0.76 | x | 0.7 | = | 21.54 | (77) |
| Southeast 0.9x | 0.77 | x | 1.87 | x | 106.25 | x | 0.76 | x | 0.7 | = | 73.25 | (77) |
| Southeast 0.9x | 0.77 | x | 0.57 | x | 106.25 | x | 0.85 | x | 0.7 | = | 24.97 | (77) |
| Southeast 0.9x | 0.77 | x | 1.68 | x | 119.01 | x | 0.76 | x | 0.7 | = | 73.71 | (77) |
| Southeast 0.9x | 0.77 | x | 0.55 | x | 119.01 | x | 0.76 | x | 0.7 | = | 24.13 | (77) |
| Southeast 0.9x | 0.77 | x | 1.87 | x | 119.01 | x | 0.76 | x | 0.7 | = | 82.05 | (77) |
| Southeast 0.9x | 0.77 | x | 0.57 | x | 119.01 | x | 0.85 | x | 0.7 | = | 27.97 | (77) |
| Southeast 0.9x | 0.77 | x | 1.68 | x | 118.15 | x | 0.76 | x | 0.7 | = | 73.18 | (77) |
| Southeast 0.9x | 0.77 | x | 0.55 | x | 118.15 | x | 0.76 | x | 0.7 | = | 23.96 | (77) |
| Southeast 0.9x | 0.77 | x | 1.87 | x | 118.15 | x | 0.76 | x | 0.7 | = | 81.46 | (77) |
| Southeast 0.9x | 0.77 | x | 0.57 | x | 118.15 | x | 0.85 | x | 0.7 | = | 27.77 | (77) |
| Southeast 0.9x | 0.77 | x | 1.68 | x | 113.91 | x | 0.76 | x | 0.7 | = | 70.55 | (77) |
| Southeast 0.9x | 0.77 | x | 0.55 | x | 113.91 | x | 0.76 | x | 0.7 | = | 23.1 | (77) |
| Southeast 0.9x | 0.77 | x | 1.87 | x | 113.91 | x | 0.76 | x | 0.7 | = | 78.53 | (77) |
| Southeast 0.9x | 0.77 | x | 0.57 | x | 113.91 | x | 0.85 | x | 0.7 | = | 26.77 | (77) |
| Southeast 0.9x | 0.77 | x | 1.68 | x | 104.39 | x | 0.76 | x | 0.7 | = | 64.66 | (77) |
| Southeast 0.9x | 0.77 | x | 0.55 | x | 104.39 | x | 0.76 | x | 0.7 | = | 21.17 | (77) |
| Southeast 0.9x | 0.77 | x | 1.87 | x | 104.39 | x | 0.76 | x | 0.7 | = | 71.97 | (77) |
| Southeast 0.9x | 0.77 | x | 0.57 | x | 104.39 | x | 0.85 | x | 0.7 | = | 24.53 | (77) |
| Southeast 0.9x | 0.77 | x | 1.68 | x | 92.85 | x | 0.76 | x | 0.7 | = | 57.51 | (77) |
| Southeast 0.9x | 0.77 | x | 0.55 | x | 92.85 | x | 0.76 | x | 0.7 | = | 18.83 | (77) |

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| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Southeast | 0.9x | 0.77 | x | 1.87 | x | 92.85 | x | 0.76 | x | 0.7 | = | 64.01 | (77) |
| Southeast | 0.9x | 0.77 | x | 0.57 | x | 92.85 | x | 0.85 | x | 0.7 | = | 21.82 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.68 | x | 69.27 | x | 0.76 | x | 0.7 | = | 42.9 | (77) |
| Southeast | 0.9x | 0.77 | x | 0.55 | x | 69.27 | x | 0.76 | x | 0.7 | = | 14.05 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.87 | x | 69.27 | x | 0.76 | x | 0.7 | = | 47.75 | (77) |
| Southeast | 0.9x | 0.77 | x | 0.57 | x | 69.27 | x | 0.85 | x | 0.7 | = | 16.28 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.68 | x | 44.07 | x | 0.76 | x | 0.7 | = | 27.3 | (77) |
| Southeast | 0.9x | 0.77 | x | 0.55 | x | 44.07 | x | 0.76 | x | 0.7 | = | 8.94 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.87 | x | 44.07 | x | 0.76 | x | 0.7 | = | 30.38 | (77) |
| Southeast | 0.9x | 0.77 | x | 0.57 | x | 44.07 | x | 0.85 | x | 0.7 | = | 10.36 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.68 | x | 31.49 | x | 0.76 | x | 0.7 | = | 19.5 | (77) |
| Southeast | 0.9x | 0.77 | x | 0.55 | x | 31.49 | x | 0.76 | x | 0.7 | = | 6.38 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.87 | x | 31.49 | x | 0.76 | x | 0.7 | = | 21.71 | (77) |
| Southeast | 0.9x | 0.77 | x | 0.57 | x | 31.49 | x | 0.85 | x | 0.7 | = | 7.4 | (77) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 11.28 | x | 0.76 | x | 0.7 | = | 14.98 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 11.28 | x | 0.76 | x | 0.7 | = | 10.48 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 11.28 | x | 0.76 | x | 0.7 | = | 1.16 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 22.97 | x | 0.76 | x | 0.7 | = | 30.48 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 22.97 | x | 0.76 | x | 0.7 | = | 21.34 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 22.97 | x | 0.76 | x | 0.7 | = | 2.37 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 41.38 | x | 0.76 | x | 0.7 | = | 54.92 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 41.38 | x | 0.76 | x | 0.7 | = | 38.44 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 41.38 | x | 0.76 | x | 0.7 | = | 4.27 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 67.96 | x | 0.76 | x | 0.7 | = | 90.19 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 67.96 | x | 0.76 | x | 0.7 | = | 63.14 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 67.96 | x | 0.76 | x | 0.7 | = | 7.02 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 91.35 | x | 0.76 | x | 0.7 | = | 121.24 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 91.35 | x | 0.76 | x | 0.7 | = | 84.87 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 91.35 | x | 0.76 | x | 0.7 | = | 9.43 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 97.38 | x | 0.76 | x | 0.7 | = | 129.25 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 97.38 | x | 0.76 | x | 0.7 | = | 90.48 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 97.38 | x | 0.76 | x | 0.7 | = | 10.05 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 91.1 | x | 0.76 | x | 0.7 | = | 120.91 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 91.1 | x | 0.76 | x | 0.7 | = | 84.64 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 91.1 | x | 0.76 | x | 0.7 | = | 9.4 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 72.63 | x | 0.76 | x | 0.7 | = | 96.39 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 72.63 | x | 0.76 | x | 0.7 | = | 67.48 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 72.63 | x | 0.76 | x | 0.7 | = | 7.5 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 50.42 | x | 0.76 | x | 0.7 | = | 66.92 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 50.42 | x | 0.76 | x | 0.7 | = | 46.84 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 50.42 | x | 0.76 | x | 0.7 | = | 5.2 | (81) |

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| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 28.07 | x | 0.76 | x | 0.7 | = | 37.25 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 28.07 | x | 0.76 | x | 0.7 | = | 26.08 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 28.07 | x | 0.76 | x | 0.7 | = | 2.9 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 14.2 | x | 0.76 | x | 0.7 | = | 18.84 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 14.2 | x | 0.76 | x | 0.7 | = | 13.19 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 14.2 | x | 0.76 | x | 0.7 | = | 1.47 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.6 | x | 9.21 | x | 0.76 | x | 0.7 | = | 12.23 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.52 | x | 9.21 | x | 0.76 | x | 0.7 | = | 8.56 | (81) |
| Northwest | 0.9x | 0.77 | x | 0.28 | x | 9.21 | x | 0.76 | x | 0.7 | = | 0.95 | (81) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (83)m= | 90.89 | 163.66 | 247.41 | 345.92 | 423.4 | 436.14 | 413.91 | 353.69 | 281.14 | 187.21 | 110.47 | 76.74 | (83) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (84)m= | 676.44 | 744.79 | 805.92 | 869.56 | 911.27 | 891.91 | 851.27 | 800.07 | 747.84 | 688.99 | 651.17 | 646.5 | (84) |

## 7. Mean internal temperature (heating season)

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

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

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (86)m= | 0.99 | 0.99 | 0.98 | 0.97 | 0.95 | 0.89 | 0.81 | 0.84 | 0.93 | 0.98 | 0.99 | 0.99 | (86) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (87)m= | 17.78 | 17.98 | 18.39 | 19.03 | 19.66 | 20.27 | 20.62 | 20.56 | 20.07 | 19.27 | 18.46 | 17.79 | (87) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (88)m= | 18.58 | 18.59 | 18.6 | 18.65 | 18.65 | 18.69 | 18.69 | 18.7 | 18.68 | 18.65 | 18.64 | 18.62 | (88) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (89)m= | 0.99 | 0.98 | 0.98 | 0.95 | 0.9 | 0.78 | 0.55 | 0.61 | 0.86 | 0.96 | 0.98 | 0.99 | (89) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (90)m= | 14.66 | 14.95 | 15.56 | 16.49 | 17.4 | 18.23 | 18.59 | 18.56 | 17.99 | 16.86 | 15.67 | 14.69 | (90) |

fLA = Living area ÷ (4) = | 0.16 | (91)

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (92)m= | 15.15 | 15.43 | 16.01 | 16.89 | 17.76 | 18.55 | 18.91 | 18.88 | 18.32 | 17.24 | 16.11 | 15.18 | (92) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (93)m= | 15.15 | 15.43 | 16.01 | 16.89 | 17.76 | 18.55 | 18.91 | 18.88 | 18.32 | 17.24 | 16.11 | 15.18 | (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 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Utilisation factor for gains, hm:

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (94)m= | 0.98 | 0.97 | 0.96 | 0.93 | 0.88 | 0.77 | 0.59 | 0.64 | 0.84 | 0.94 | 0.97 | 0.98 | (94) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (95)m= | 662 | 724.05 | 773.32 | 811.17 | 800.27 | 683.01 | 499.22 | 508.53 | 626.67 | 646.61 | 632.1 | 634.28 | (95) |

Monthly average external temperature from Table 8

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (96)m= | 4.3 | 4.9 | 6.5 | 8.9 | 11.7 | 14.6 | 16.6 | 16.4 | 14.1 | 10.6 | 7.1 | 4.2 | (96) |

Heat loss rate for mean internal temperature, Lm , W =[(39)m x [(93)m– (96)m ]

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (97)m= | 3074.35 | 2966.27 | 2662.56 | 2172.75 | 1637.6 | 1040.42 | 608.26 | 648.37 | 1121.77 | 1793.62 | 2463.32 | 3036.88 | (97) |

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

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (98)m= | 1794.79 | 1506.77 | 1405.59 | 980.33 | 622.98 | 0 | 0 | 0 | 0 | 853.37 | 1318.48 | 1787.53 | |

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 10269.86 (98)

Space heating requirement in kWh/m²/year 121.54 (99)

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

**Space heating:**

| | | | |
|---|---|---|---|
| Fraction of space heat from secondary/supplementary system | | 0 | (201) |
| Fraction of space heat from main system(s) | (202) = 1 – (201) = | 1 | (202) |
| Fraction of total heating from main system 1 | (204) = (202) × [1 – (203)] = | 1 | (204) |
| Efficiency of main space heating system 1 | | 90.3 | (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) | 1794.79 | 1506.77 | 1405.59 | 980.33 | 622.98 | 0 | 0 | 0 | 0 | 853.37 | 1318.48 | 1787.53 | |
| (211)m = {[(98)m x (204)] } x 100 ÷ (206) | 1987.59 | 1668.63 | 1556.58 | 1085.64 | 689.9 | 0 | 0 | 0 | 0 | 945.04 | 1460.11 | 1979.55 | (211) |

Total (kWh/year) =Sum(211)$_{1...5,10...12}$= 11373.05 (211)

Space heating fuel (secondary), kWh/month
= {[(98)m x (201)] } x 100 ÷ (208)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (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)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 205.26 | 180.98 | 188.43 | 167.12 | 161.81 | 142.51 | 136.53 | 152.2 | 153.88 | 175.23 | 186.92 | 200.39 | |
| Efficiency of water heater | | | | | | | | | | | | 81 | (216) |
| (217)m= | 89.25 | 89.2 | 89.09 | 88.81 | 88.21 | 81 | 81 | 81 | 81 | 88.57 | 89.03 | 89.27 | (217) |

Fuel for water heating, kWh/month
(219)m = (64)m x 100 ÷ (217)m

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (219)m= | 229.99 | 202.89 | 211.5 | 188.17 | 183.43 | 175.94 | 168.56 | 187.91 | 189.98 | 197.85 | 209.95 | 224.49 |

Total = Sum(219a)$_{1...12}$ = 2370.64 (219)

| **Annual totals** | | **kWh/year** | **kWh/year** | |
|---|---|---|---|---|
| Space heating fuel used, main system 1 | | | 11373.05 | |
| Water heating fuel used | | | 2370.64 | |
| Electricity for pumps, fans and electric keep-hot | | | | |
| 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 | | | 364.79 | (232) |

## 10a. Fuel costs - individual heating systems:

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

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| | | | | |
|---|---|---|---|---|
| Space heating - main system 1 | (211) x | 3.48 | x 0.01 = | 395.78 (240) |
| Space heating - main system 2 | (213) x | 0 | x 0.01 = | 0 (241) |
| Space heating - secondary | (215) x | 13.19 | x 0.01 = | 0 (242) |
| Water heating cost (other fuel) | (219) | 3.48 | x 0.01 = | 82.5 (247) |
| Pumps, fans and electric keep-hot | (231) | 13.19 | x 0.01 = | 9.89 (249) |

(if off-peak tariff, list each of (230a) to (230g) separately as applicable and apply fuel price according to Table 12a

| | | | | |
|---|---|---|---|---|
| Energy for lighting | (232) | 13.19 | x 0.01 = | 48.12 (250) |
| Additional standing charges (Table 12) | | | | 120 (251) |

Appendix Q items: repeat lines (253) and (254) as needed

**Total energy cost** (245)...(247) + (250)...(254) = 656.29 (255)

## 11a. SAP rating - individual heating systems

| | | |
|---|---|---|
| Energy cost deflator (Table 12) | | 0.42 (256) |
| Energy cost factor (ECF) | [(255) x (256)] ÷ [(4) + 45.0] = | 2.13 (257) |
| **SAP rating (Section 12)** | | 70.31 (258) |

## 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 | = | 2456.58 (261) |
| Space heating (secondary) | (215) x | 0.519 | = | 0 (263) |
| Water heating | (219) x | 0.216 | = | 512.06 (264) |
| Space and water heating | (261) + (262) + (263) + (264) = | | | 2968.64 (265) |
| Electricity for pumps, fans and electric keep-hot | (231) x | 0.519 | = | 38.93 (267) |
| Electricity for lighting | (232) x | 0.519 | = | 189.33 (268) |
| Total CO2, kg/year | | sum of (265)…(271) = | | 3196.89 (272) |
| **CO2 emissions per m²** | | (272) ÷ (4) = | | 37.83 (273) |
| EI rating (section 14) | | | | 67 (274) |

## 13a. Primary Energy

| | **Energy** kWh/year | **Primary** factor | | **P. Energy** kWh/year |
|---|---|---|---|---|
| Space heating (main system 1) | (211) x | 1.22 | = | 13875.12 (261) |
| Space heating (secondary) | (215) x | 3.07 | = | 0 (263) |
| Energy for water heating | (219) x | 1.22 | = | 2892.18 (264) |
| Space and water heating | (261) + (262) + (263) + (264) = | | | 16767.3 (265) |
| Electricity for pumps, fans and electric keep-hot | (231) x | 3.07 | = | 230.25 (267) |
| Electricity for lighting | (232) x | 0 | = | 1119.91 (268) |
| 'Total Primary Energy | | sum of (265)…(271) = | | 18117.46 (272) |

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| | | | |
|---|---|---|---|
| **Primary energy kWh/m²/year** | (272) ÷ (4) = | 214.41 | (273) |

# SAP WorkSheet: New dwelling design stage

## User Details:

| | | | |
|---|---|---|---|
| **Assessor Name:** | | **Stroma Number:** | |
| **Software Name:** | Stroma FSAP 2012 | **Software Version:** | Version: 1.0.4.18 |

## Property Address: 7b Frederick Street

**Address :**

## 1. Overall dwelling dimensions:

| | Area(m²) | | Av. Height(m) | | Volume(m³) | |
|---|---|---|---|---|---|---|
| Ground floor | 75.1 | (1a) x | 3.7 | (2a) = | 277.87 | (3a) |
| Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n) | 75.1 | (4) | | | | |
| Dwelling volume | | | | (3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) = | 277.87 | (5) |

## 2. Ventilation rate:

| | main heating | | secondary heating | | other | | total | | m³ per hour | |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of chimneys | 0 | + | 0 | + | 1 | = | 1 | x 40 = | 40 | (6a) |
| Number of open flues | 0 | + | 0 | + | 0 | = | 0 | x 20 = | 0 | (6b) |
| Number of intermittent fans | | | | | | | 2 | x 10 = | 20 | (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) = | 60 | ÷ (5) = | 0.22 | (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) | 0.97 | (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) = | 0.82 | (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 |

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

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.05 | 1.03 | 1.01 | 0.9 | 0.88 | 0.78 | 0.78 | 0.76 | 0.82 | 0.88 | 0.92 | 0.96 |

*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= | 1.05 | 1.03 | 1.01 | 0.91 | 0.89 | 0.8 | 0.8 | 0.79 | 0.84 | 0.89 | 0.93 | 0.97 | (24d) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (25)m= | 1.05 | 1.03 | 1.01 | 0.91 | 0.89 | 0.8 | 0.8 | 0.79 | 0.84 | 0.89 | 0.93 | 0.97 | (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 | | | 1.68 | x | 3 | = | 5.04 | | | (26) |
| Windows Type 1 | | | 2.5 | x1/[1/( 2.6 )+ 0.04] | | = | 5.89 | | | (27) |
| Windows Type 2 | | | 2.5 | x1/[1/( 2.6 )+ 0.04] | | = | 5.89 | | | (27) |
| Windows Type 3 | | | 2.5 | x1/[1/( 2.6 )+ 0.04] | | = | 5.89 | | | (27) |
| Windows Type 4 | | | 2.5 | x1/[1/( 2.6 )+ 0.04] | | = | 5.89 | | | (27) |
| Windows Type 5 | | | 1.85 | x1/[1/( 2.6 )+ 0.04] | | = | 4.36 | | | (27) |
| Windows Type 6 | | | 1.69 | x1/[1/( 2.6 )+ 0.04] | | = | 3.98 | | | (27) |
| Windows Type 7 | | | 1.9 | x1/[1/( 2.6 )+ 0.04] | | = | 4.47 | | | (27) |
| Walls Type1 | 104.71 | 17.12 | 87.59 | x | 2.1 | = | 183.94 | | | (29) |
| Walls Type2 | 21.46 | 0 | 21.46 | x | 2.1 | = | 45.07 | | | (29) |
| Total area of elements, m² | | | 126.17 | | | | | | | (31) |
| Party wall | | | 29.6 | x | 0 | = | 0 | | | (32) |

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

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

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 270.41 (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 18.93 (36)

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

# SAP WorkSheet: New dwelling design stage

| | | | |
|---|---|---|---|
| Total fabric heat loss | (33) + (36) = | 289.33 | (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= | 95.99 | 94.11 | 92.23 | 83.25 | 81.57 | 73.74 | 73.74 | 72.29 | 76.76 | 81.57 | 84.96 | 88.52 | (38) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (39)m= | 385.32 | 383.44 | 381.56 | 372.58 | 370.9 | 363.07 | 363.07 | 361.63 | 366.09 | 370.9 | 374.3 | 377.85 | |

Average = Sum(39)1...12 /12= 372.56 (39)

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (40)m= | 5.13 | 5.11 | 5.08 | 4.96 | 4.94 | 4.83 | 4.83 | 4.82 | 4.87 | 4.94 | 4.98 | 5.03 | |

Average = Sum(40)1...12 /12= 4.96 (40)

Number of days in month (Table 1a)

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

## 4. Water heating energy requirement: kWh/year:

Assumed occupancy, N 2.36 (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 90.33 (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= | 99.36 | 95.75 | 92.14 | 88.52 | 84.91 | 81.3 | 81.3 | 84.91 | 88.52 | 92.14 | 95.75 | 99.36 | |

Total = Sum(44)1...12 = 1083.95 (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= | 147.35 | 128.87 | 132.99 | 115.94 | 111.25 | 96 | 88.96 | 102.08 | 103.3 | 120.38 | 131.41 | 142.7 | |

Total = Sum(45)1...12 = 1421.23 (45)

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (46)m= | 22.1 | 19.33 | 19.95 | 17.39 | 16.69 | 14.4 | 13.34 | 15.31 | 15.49 | 18.06 | 19.71 | 21.41 | (46) |

Water storage loss:

| | | | |
|---|---|---|---|
| Storage volume (litres) including any solar or WWHRS storage within same vessel | | 0 | (47) |
| If community heating and no tank in dwelling, enter 110 litres in (47) | | | |
| Otherwise if no stored hot water (this includes instantaneous combi boilers) enter '0' in (47) | | | |
| Water storage loss: | | | |
| a) If manufacturer's declared loss factor is known (kWh/day): | | 0 | (48) |
| Temperature factor from Table 2b | | 0 | (49) |
| Energy lost from water storage, kWh/year | (48) x (49) = | 0 | (50) |
| b) If manufacturer's declared cylinder loss factor is not known: | | | |
| Hot water storage loss factor from Table 2 (kWh/litre/day) | | 0 | (51) |
| If community heating see section 4.3 | | | |
| Volume factor from Table 2a | | 0 | (52) |
| Temperature factor from Table 2b | | 0 | (53) |
| Energy lost from water storage, kWh/year | (47) x (51) x (52) x (53) = | 0 | (54) |
| Enter (50) or (54) in (55) | | 0 | (55) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (56)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (56) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (57)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (57) |

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

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

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (59)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (59) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (61)m= | 50.63 | 44.07 | 46.95 | 43.65 | 43.27 | 40.09 | 41.43 | 43.27 | 43.65 | 46.95 | 47.22 | 50.63 | (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= | 197.98 | 172.94 | 179.94 | 159.6 | 154.52 | 136.09 | 130.38 | 145.35 | 146.95 | 167.34 | 178.63 | 193.34 | (62) |

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

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (63)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (63) |

Output from water heater

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (64)m= | 197.98 | 172.94 | 179.94 | 159.6 | 154.52 | 136.09 | 130.38 | 145.35 | 146.95 | 167.34 | 178.63 | 193.34 | |

Output from water heater (annual)1…12 | 1963.05 | (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= | 61.65 | 53.87 | 55.96 | 49.46 | 47.81 | 41.94 | 39.94 | 44.76 | 45.26 | 51.77 | 55.5 | 60.11 | (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= | 141.8 | 141.8 | 141.8 | 141.8 | 141.8 | 141.8 | 141.8 | 141.8 | 141.8 | 141.8 | 141.8 | 141.8 | (66) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (67)m= | 46.56 | 41.35 | 33.63 | 25.46 | 19.03 | 16.07 | 17.36 | 22.57 | 30.29 | 38.46 | 44.89 | 47.85 | (67) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (68)m= | 311.79 | 315.02 | 306.87 | 289.51 | 267.6 | 247.01 | 233.25 | 230.02 | 238.17 | 255.53 | 277.44 | 298.03 | (68) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (69)m= | 51.54 | 51.54 | 51.54 | 51.54 | 51.54 | 51.54 | 51.54 | 51.54 | 51.54 | 51.54 | 51.54 | 51.54 | (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= | -94.53 | -94.53 | -94.53 | -94.53 | -94.53 | -94.53 | -94.53 | -94.53 | -94.53 | -94.53 | -94.53 | -94.53 | (71) |

Water heating gains (Table 5)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (72)m= | 82.87 | 80.16 | 75.21 | 68.7 | 64.26 | 58.25 | 53.68 | 60.16 | 62.86 | 69.58 | 77.08 | 80.79 | (72) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (73)m= | 543.02 | 538.34 | 517.52 | 485.48 | 452.7 | 423.14 | 406.1 | 414.55 | 433.13 | 465.37 | 501.22 | 528.48 | (73) |

## 6. Solar gains:

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

## SAP WorkSheet: New dwelling design stage

| Orientation: | | Access Factor Table 6d | | Area m² | | Flux Table 6a | | g_ Table 6b | | FF Table 6c | | Gains (W) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 36.79 | x | 0.76 | x | 0.7 | = | 25.1 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 36.79 | x | 0.76 | x | 0.7 | = | 22.92 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 36.79 | x | 0.76 | x | 0.7 | = | 25.77 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 62.67 | x | 0.76 | x | 0.7 | = | 42.75 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 62.67 | x | 0.76 | x | 0.7 | = | 39.05 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 62.67 | x | 0.76 | x | 0.7 | = | 43.9 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 85.75 | x | 0.76 | x | 0.7 | = | 58.49 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 85.75 | x | 0.76 | x | 0.7 | = | 53.43 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 85.75 | x | 0.76 | x | 0.7 | = | 60.07 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 106.25 | x | 0.76 | x | 0.7 | = | 72.47 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 106.25 | x | 0.76 | x | 0.7 | = | 66.2 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 106.25 | x | 0.76 | x | 0.7 | = | 74.43 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 119.01 | x | 0.76 | x | 0.7 | = | 81.17 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 119.01 | x | 0.76 | x | 0.7 | = | 74.15 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 119.01 | x | 0.76 | x | 0.7 | = | 83.37 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 118.15 | x | 0.76 | x | 0.7 | = | 80.58 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 118.15 | x | 0.76 | x | 0.7 | = | 73.61 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 118.15 | x | 0.76 | x | 0.7 | = | 82.76 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 113.91 | x | 0.76 | x | 0.7 | = | 77.69 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 113.91 | x | 0.76 | x | 0.7 | = | 70.97 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 113.91 | x | 0.76 | x | 0.7 | = | 79.79 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 104.39 | x | 0.76 | x | 0.7 | = | 71.2 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 104.39 | x | 0.76 | x | 0.7 | = | 65.04 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 104.39 | x | 0.76 | x | 0.7 | = | 73.12 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 92.85 | x | 0.76 | x | 0.7 | = | 63.33 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 92.85 | x | 0.76 | x | 0.7 | = | 57.85 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 92.85 | x | 0.76 | x | 0.7 | = | 65.04 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 69.27 | x | 0.76 | x | 0.7 | = | 47.24 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 69.27 | x | 0.76 | x | 0.7 | = | 43.16 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 69.27 | x | 0.76 | x | 0.7 | = | 48.52 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 44.07 | x | 0.76 | x | 0.7 | = | 30.06 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 44.07 | x | 0.76 | x | 0.7 | = | 27.46 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 44.07 | x | 0.76 | x | 0.7 | = | 30.87 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.85 | x | 31.49 | x | 0.76 | x | 0.7 | = | 21.48 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.69 | x | 31.49 | x | 0.76 | x | 0.7 | = | 19.62 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.9 | x | 31.49 | x | 0.76 | x | 0.7 | = | 22.06 | (77) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 11.28 | x | 0.76 | x | 0.7 | = | 10.4 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 11.28 | x | 0.76 | x | 0.7 | = | 10.4 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 11.28 | x | 0.76 | x | 0.7 | = | 10.4 | (81) |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 11.28 | x | 0.76 | x | 0.7 | = | 10.4 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 22.97 | x | 0.76 | x | 0.7 | = | 21.17 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 22.97 | x | 0.76 | x | 0.7 | = | 21.17 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 22.97 | x | 0.76 | x | 0.7 | = | 21.17 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 22.97 | x | 0.76 | x | 0.7 | = | 21.17 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 41.38 | x | 0.76 | x | 0.7 | = | 38.14 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 41.38 | x | 0.76 | x | 0.7 | = | 38.14 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 41.38 | x | 0.76 | x | 0.7 | = | 38.14 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 41.38 | x | 0.76 | x | 0.7 | = | 38.14 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 67.96 | x | 0.76 | x | 0.7 | = | 62.63 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 67.96 | x | 0.76 | x | 0.7 | = | 62.63 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 67.96 | x | 0.76 | x | 0.7 | = | 62.63 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 67.96 | x | 0.76 | x | 0.7 | = | 62.63 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 91.35 | x | 0.76 | x | 0.7 | = | 84.19 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 91.35 | x | 0.76 | x | 0.7 | = | 84.19 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 91.35 | x | 0.76 | x | 0.7 | = | 84.19 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 91.35 | x | 0.76 | x | 0.7 | = | 84.19 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 97.38 | x | 0.76 | x | 0.7 | = | 89.76 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 97.38 | x | 0.76 | x | 0.7 | = | 89.76 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 97.38 | x | 0.76 | x | 0.7 | = | 89.76 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 97.38 | x | 0.76 | x | 0.7 | = | 89.76 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 91.1 | x | 0.76 | x | 0.7 | = | 83.97 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 91.1 | x | 0.76 | x | 0.7 | = | 83.97 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 91.1 | x | 0.76 | x | 0.7 | = | 83.97 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 91.1 | x | 0.76 | x | 0.7 | = | 83.97 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 72.63 | x | 0.76 | x | 0.7 | = | 66.94 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 72.63 | x | 0.76 | x | 0.7 | = | 66.94 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 72.63 | x | 0.76 | x | 0.7 | = | 66.94 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 72.63 | x | 0.76 | x | 0.7 | = | 66.94 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 50.42 | x | 0.76 | x | 0.7 | = | 46.47 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 50.42 | x | 0.76 | x | 0.7 | = | 46.47 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 50.42 | x | 0.76 | x | 0.7 | = | 46.47 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 50.42 | x | 0.76 | x | 0.7 | = | 46.47 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 28.07 | x | 0.76 | x | 0.7 | = | 25.87 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 28.07 | x | 0.76 | x | 0.7 | = | 25.87 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 28.07 | x | 0.76 | x | 0.7 | = | 25.87 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 28.07 | x | 0.76 | x | 0.7 | = | 25.87 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 14.2 | x | 0.76 | x | 0.7 | = | 13.09 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 14.2 | x | 0.76 | x | 0.7 | = | 13.09 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 14.2 | x | 0.76 | x | 0.7 | = | 13.09 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.5 | x | 14.2 | x | 0.76 | x | 0.7 | = | 13.09 | (81) |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northwest 0.9x | 0.77 | x | 2.5 | x | 9.21 | x | 0.76 | x | 0.7 | = | 8.49 | (81) |
| Northwest 0.9x | 0.77 | x | 2.5 | x | 9.21 | x | 0.76 | x | 0.7 | = | 8.49 | (81) |
| Northwest 0.9x | 0.77 | x | 2.5 | x | 9.21 | x | 0.76 | x | 0.7 | = | 8.49 | (81) |
| Northwest 0.9x | 0.77 | x | 2.5 | x | 9.21 | x | 0.76 | x | 0.7 | = | 8.49 | (81) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (83)m= | 115.39 | 210.37 | 324.54 | 463.63 | 575.46 | 595.99 | 564.32 | 477.12 | 372.11 | 242.4 | 140.73 | 97.12 | (83) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (84)m= | 658.41 | 748.72 | 842.06 | 949.12 | 1028.16 | 1019.13 | 970.42 | 891.68 | 805.24 | 707.77 | 641.94 | 625.6 | (84) |

## 7. Mean internal temperature (heating season)

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

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

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (86)m= | 0.99 | 0.98 | 0.98 | 0.96 | 0.93 | 0.88 | 0.81 | 0.84 | 0.92 | 0.97 | 0.98 | 0.99 | (86) |
| Mean internal temperature in living area T1 (follow steps 3 to 7 in Table 9c) | | | | | | | | | | | | | |
| (87)m= | 16.82 | 17.06 | 17.58 | 18.35 | 19.16 | 19.93 | 20.39 | 20.31 | 19.67 | 18.66 | 17.64 | 16.82 | (87) |
| Temperature during heating periods in rest of dwelling from Table 9, Th2 (°C) | | | | | | | | | | | | | |
| (88)m= | 18.06 | 18.07 | 18.07 | 18.09 | 18.09 | 18.11 | 18.11 | 18.12 | 18.11 | 18.09 | 18.09 | 18.08 | (88) |
| Utilisation factor for gains for rest of dwelling, h2,m (see Table 9a) | | | | | | | | | | | | | |
| (89)m= | 0.98 | 0.98 | 0.97 | 0.94 | 0.88 | 0.73 | 0.47 | 0.54 | 0.83 | 0.95 | 0.98 | 0.99 | (89) |
| Mean internal temperature in the rest of dwelling T2 (follow steps 3 to 7 in Table 9c) | | | | | | | | | | | | | |
| (90)m= | 13.22 | 13.56 | 14.3 | 15.4 | 16.53 | 17.54 | 18.01 | 17.96 | 17.25 | 15.85 | 14.39 | 13.21 | (90) |

fLA = Living area ÷ (4) = | 0.26 | (91)

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (92)m= | 14.18 | 14.49 | 15.17 | 16.18 | 17.23 | 18.18 | 18.64 | 18.59 | 17.89 | 16.59 | 15.25 | 14.16 | (92) |
| Apply adjustment to the mean internal temperature from Table 4e, where appropriate | | | | | | | | | | | | | |
| (93)m= | 14.18 | 14.49 | 15.17 | 16.18 | 17.23 | 18.18 | 18.64 | 18.59 | 17.89 | 16.59 | 15.25 | 14.16 | (93) |

## 8. Space heating requirement

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

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Utilisation factor for gains, hm: | | | | | | | | | | | | | |
| (94)m= | 0.97 | 0.96 | 0.94 | 0.91 | 0.85 | 0.74 | 0.57 | 0.62 | 0.82 | 0.92 | 0.96 | 0.97 | (94) |
| Useful gains, hmGm , W = (94)m x (84)m | | | | | | | | | | | | | |
| (95)m= | 638.95 | 719.76 | 795.26 | 864.19 | 873.07 | 752.31 | 553.03 | 554.55 | 658.96 | 653.32 | 616.63 | 608.88 | (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= | 3805.44 | 3677.53 | 3308.08 | 2712.66 | 2049.41 | 1298.23 | 740.98 | 790.86 | 1388.18 | 2222.2 | 3052.36 | 3764.11 | (97) |
| Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m | | | | | | | | | | | | | |
| (98)m= | 2355.88 | 1987.62 | 1869.54 | 1330.9 | 875.2 | 0 | 0 | 0 | 0 | 1167.25 | 1753.73 | 2347.49 | |

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = | 13687.59 | (98)

Space heating requirement in kWh/m²/year | 182.26 | (99)

# SAP WorkSheet: New dwelling design stage

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

**Space heating:**

| | | | |
|---|---|---|---|
| Fraction of space heat from secondary/supplementary system | | 0 | (201) |
| Fraction of space heat from main system(s) | (202) = 1 – (201) = | 1 | (202) |
| Fraction of total heating from main system 1 | (204) = (202) × [1 – (203)] = | 1 | (204) |
| Efficiency of main space heating system 1 | | 90.3 | (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) | 2355.88 | 1987.62 | 1869.54 | 1330.9 | 875.2 | 0 | 0 | 0 | 0 | 1167.25 | 1753.73 | 2347.49 | | |
| (211)m = {[(98)m x (204)] } x 100 ÷ (206) | 2608.94 | 2201.13 | 2070.36 | 1473.86 | 969.21 | 0 | 0 | 0 | 0 | 1292.63 | 1942.11 | 2599.66 | | (211) |
| Total (kWh/year) =Sum(211)$_{1...5,10...12}$= | | | | | | | | | | | | | 15157.91 | (211) |
| Space heating fuel (secondary), kWh/month = {[(98)m x (201)] } x 100 ÷ (208) (215)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | |
| Total (kWh/year) =Sum(215)$_{1...5,10...12}$= | | | | | | | | | | | | | 0 | (215) |

**Water heating**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Output from water heater (calculated above) | 197.98 | 172.94 | 179.94 | 159.6 | 154.52 | 136.09 | 130.38 | 145.35 | 146.95 | 167.34 | 178.63 | 193.34 | | |
| Efficiency of water heater | | | | | | | | | | | | | 81 | (216) |
| (217)m= | 89.5 | 89.48 | 89.4 | 89.2 | 88.77 | 81 | 81 | 81 | 81 | 89.02 | 89.35 | 89.52 | | (217) |
| Fuel for water heating, kWh/month (219)m = (64)m x 100 ÷ (217)m (219)m= | 221.2 | 193.28 | 201.28 | 178.91 | 174.06 | 168.01 | 160.97 | 179.44 | 181.42 | 187.98 | 199.91 | 215.97 | | |
| Total = Sum(219a)$_{1...12}$ = | | | | | | | | | | | | | 2262.45 | (219) |

| **Annual totals** | | **kWh/year** | **kWh/year** | |
|---|---|---|---|---|
| Space heating fuel used, main system 1 | | | 15157.91 | |
| Water heating fuel used | | | 2262.45 | |
| Electricity for pumps, fans and electric keep-hot | | | | |
| 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 | | | 328.89 | (232) |

## 10a. Fuel costs - individual heating systems:

| | **Fuel** kWh/year | **Fuel Price** (Table 12) | | **Fuel Cost** £/year | |
|---|---|---|---|---|---|
| Space heating - main system 1 | (211) x | 3.48 | x 0.01 = | 527.5 | (240) |
| Space heating - main system 2 | (213) x | 0 | x 0.01 = | 0 | (241) |
| Space heating - secondary | (215) x | 13.19 | x 0.01 = | 0 | (242) |
| Water heating cost (other fuel) | (219) | 3.48 | x 0.01 = | 78.73 | (247) |

| | | | | | |
|---|---|---|---|---|---|
| Pumps, fans and electric keep-hot | (231) | 13.19 | x 0.01 = | 9.89 | (249) |

(if off-peak tariff, list each of (230a) to (230g) separately as applicable and apply fuel price according to Table 12a

| | | | | | |
|---|---|---|---|---|---|
| Energy for lighting | (232) | 13.19 | x 0.01 = | 43.38 | (250) |
| Additional standing charges (Table 12) | | | | 120 | (251) |

Appendix Q items: repeat lines (253) and (254) as needed

| | | | |
|---|---|---|---|
| **Total energy cost** | (245)...(247) + (250)...(254) = | 779.5 | (255) |

## 11a. SAP rating - individual heating systems

| | | | |
|---|---|---|---|
| Energy cost deflator (Table 12) | | 0.42 | (256) |
| Energy cost factor (ECF) | [(255) x (256)] ÷ [(4) + 45.0] = | 2.73 | (257) |
| **SAP rating (Section 12)** | | 61.97 | (258) |

## 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 | = | 3274.11 | (261) |
| Space heating (secondary) | (215) x | 0.519 | = | 0 | (263) |
| Water heating | (219) x | 0.216 | = | 488.69 | (264) |
| Space and water heating | (261) + (262) + (263) + (264) = | | | 3762.8 | (265) |
| Electricity for pumps, fans and electric keep-hot | (231) x | 0.519 | = | 38.93 | (267) |
| Electricity for lighting | (232) x | 0.519 | = | 170.7 | (268) |
| Total CO2, kg/year | | sum of (265)…(271) = | | 3972.42 | (272) |
| **CO2 emissions per m²** | | (272) ÷ (4) = | | 52.9 | (273) |
| EI rating (section 14) | | | | 56 | (274) |



## 13a. Primary Energy

| | **Energy** kWh/year | **Primary** factor | | **P. Energy** kWh/year | |
|---|---|---|---|---|---|
| Space heating (main system 1) | (211) x | 1.22 | = | 18492.65 | (261) |
| Space heating (secondary) | (215) x | 3.07 | = | 0 | (263) |
| Energy for water heating | (219) x | 1.22 | = | 2760.19 | (264) |
| Space and water heating | (261) + (262) + (263) + (264) = | | | 21252.83 | (265) |
| Electricity for pumps, fans and electric keep-hot | (231) x | 3.07 | = | 230.25 | (267) |
| Electricity for lighting | (232) x | 0 | = | 1009.7 | (268) |
| 'Total Primary Energy | | sum of (265)…(271) = | | 22492.79 | (272) |
| **Primary energy kWh/m²/year** | | (272) ÷ (4) = | | 299.5 | (273) |

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