# Energy Strategy Report

19-5503

24 Redington Gardens, London, NW3 7RX

May 2019

**Quality Standards Control**

The signatories below verify that this document has been prepared in accordance with our quality control requirements. These procedures do not affect the content and views expressed by the originator.

| *Revision* | *Initial* | *Rev A* | *Rev B* | *Rev C* |
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# 1. Executive Summary

This Energy Statement demonstrates the predicted energy performance and carbon dioxide emissions of the proposed development at **24 Redington Gardens, London, NW3 7RX** based on the information provided by the design team. The proposed development is **new construction of a detached house in the London Borough of Camden.**

## 1.1. Policy Requirements

The Council requires new developments to incorporate sustainable design and construction measures. The table below summarises the local policy requirements for this minor development.

| Policies | Requirements | Compliance Notes |
|---|---|---|
| **Camden Local Policy CC1 8.8** | All new residential development will be required to demonstrate a 19% CO2 reduction below Part L 2013 Building Regulations | The proposed development achieved an overall 25.12% carbon reduction via energy efficient measures and Air Source Heat Pumps (VRF systems). Detailed strategies can be found in the table below and section 6-8 of this report. |
| **London Plan 5.15 and Camden Local Policy CC3 8.55** | Water use of 110 litres/person/day or less (including an allowance of 5litres or less) is required for the new dwellings. | Water consumption of 110 litres/person/day or less achieved using energy efficient fittings. Design stage calculations are in section 6.1 of this report. |

Table 1 Policy Requirements

## 1.2. Methodology and Strategies

The methodology used to determine the $CO_2$ emissions is in accordance with the London Plan's three-step Energy Hierarchy (Policy 5.2). The below table shows the Energy Hierarchy and suggested strategies for the proposed development.

| Stages | Strategies |
|---|---|
| **BE LEAN**<br>Energy efficient design | • U-values and air permeability better than Building Regulations Part L1A 2013<br>• Use of accredited construction details at all thermal bridging junctions<br>• Mechanical Ventilation with Heat Recovery (MVHR) system<br>• Low water consumption<br>• 100% Low energy lights |
| **BE CLEAN**<br>District heat networks or CHP | • Not feasible on the site. Details are in Section 7. |
| **BE GREEN**<br>On-site renewable technologies | • Air Source Heat Pumps (VRF) for space heating and cooling. Details are in Section 8.2. |

Table 2 Energy Hierarchy and suggested strategies

## 1.3. Assessment Results

After the application of all strategies based on the Energy Hierarchy, the regulated carbon dioxide emissions have been reduced as follows;

| Energy Hierarchy | | Regulated Carbon Emissions (Tonnes $CO_2$/yr) |
|---|---|---|
| **BASELINE** | TER set by Building Regulations 2013 Part L | 12.52 |
| **BE LEAN** | After energy demand reduction | 9.79 |
| **BE CLEAN** | After CHP/ Communal Heating | 9.79 |
| **BE GREEN** | After renewable energy | 9.38 |

Table 3 Carbon Emissions after each stage of the proposed strategy

The carbon savings from each stage can be calculated based on the results above. The table below clearly shows that the development meets the 19% targeted carbon reduction.

| Energy Hierarchy | | Regulated Carbon Savings | |
|---|---|---|---|
| | | Tonnes $CO_2$/yr | % |
| **BE LEAN** | After energy demand reduction | 2.73 | 21.79 % |
| **BE CLEAN** | After heat network/ CHP | 0 | 0 % |
| **BE GREEN** | After renewable energy | 0.42 | 4.25 % |
| **Total Cumulative Savings** | | **3.15** | **25.12 %** |
| **Total Target Savings** | | 2.38 | 19 % |

Table 4 Carbon dioxide Emissions after each stage of the Energy Hierarchy

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Figure 1 below illustrates the hierarchical approach adopted and the resultant reduction in overall $CO_2$ emissions.

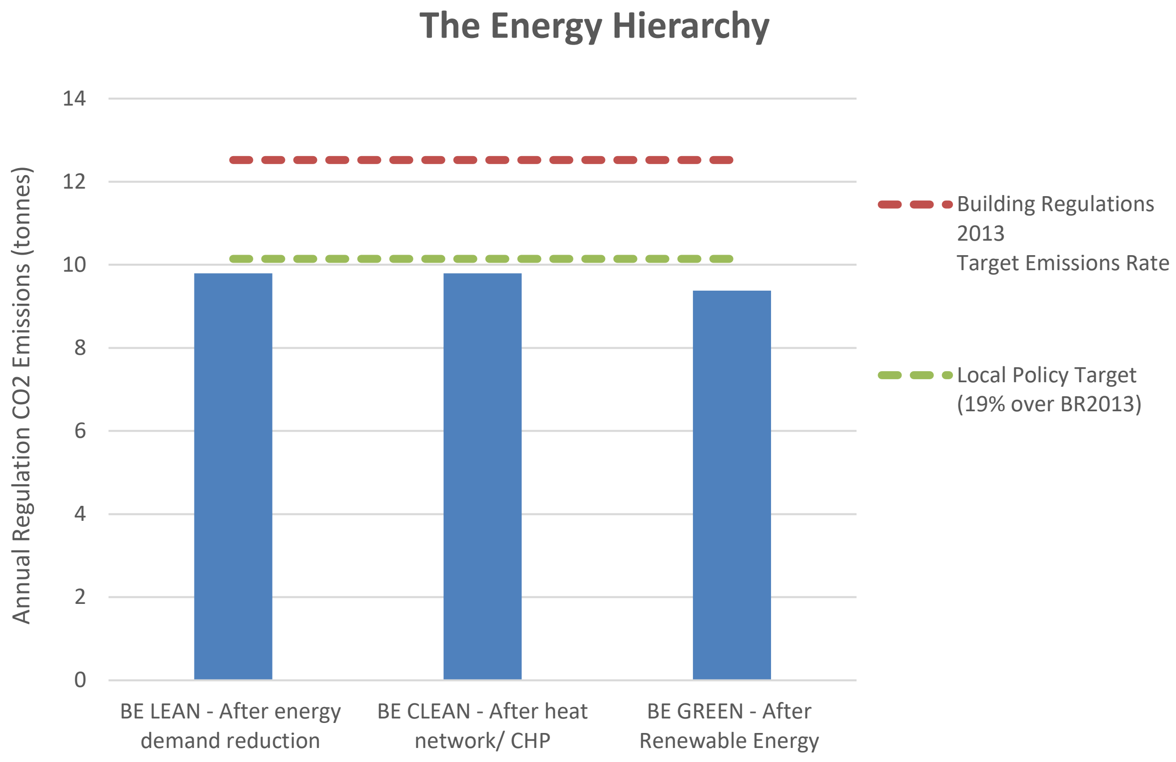
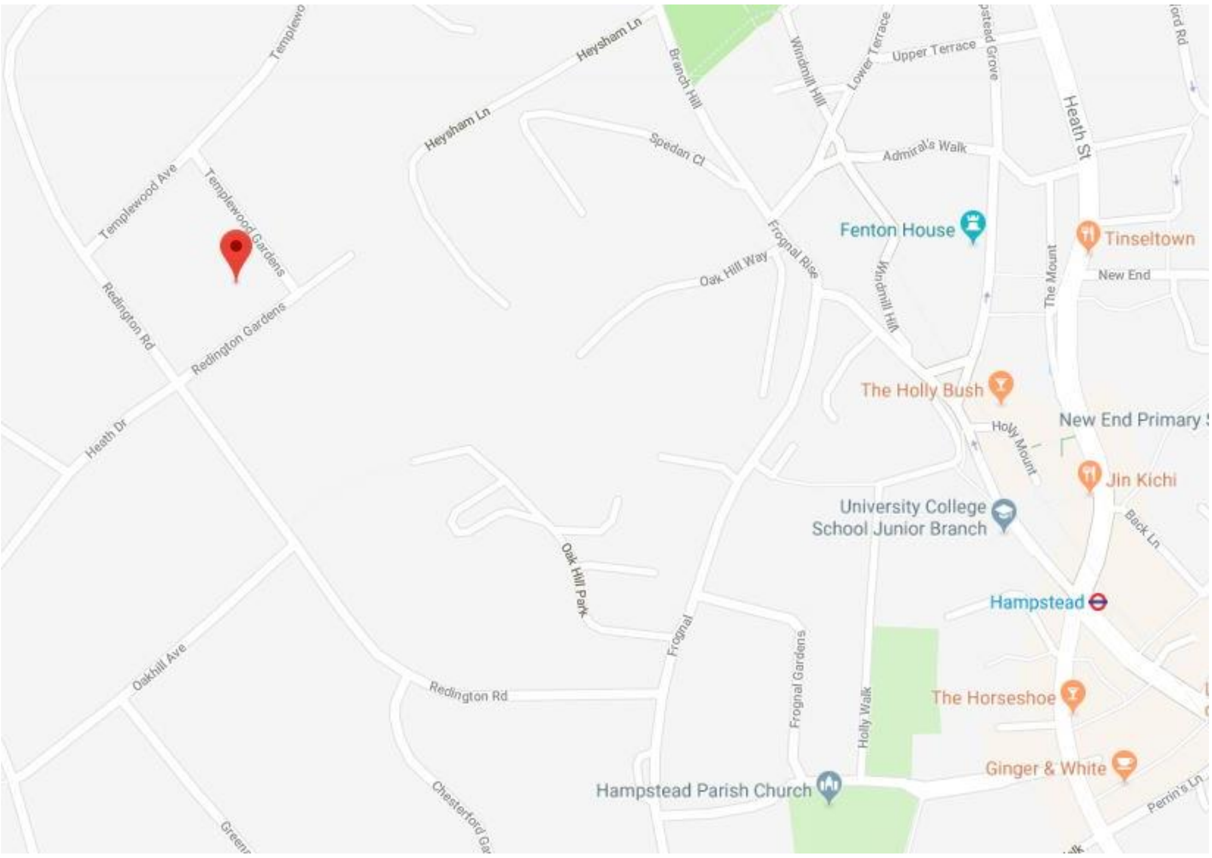



Figure 1 Carbon emissions in Energy Hierarchy

## 2. Introduction

This Energy Statement will be included as part of the planning application that addresses the environmental impact of the development. This report focuses on the energy strategy for the proposed scheme and how energy consumption and carbon emissions will be minimised and to meet the targeted carbon emissions in accordance with the London Plan and Local planning policy.

This development is to be located in the London Borough of Camden and it is in close proximity to Hampstead station (approx 0.6miles to the South-East). The proposal is **new construction of a detached house at 24 Redington Gardens, London, NW3 7RX.**



The Government approved software, i.e. FSAP 2012 has been utilised to carry out Standard Assessment Procedure (SAP) calculations. Syntegra received the architectural drawings and relevant documents, and they were used to undertake the energy assessments. The document references are listed in table below.

| No. | Document Name | Format | Received Date |
|---|---|---|---|
| 1 | 1011-1012 - Site Plans-Sheet - 1011 - Proposed Site Plan (roof) | dwg | 25/03/2019 |
| 2 | 1011-1012 - Site Plans-Sheet - 1012 - Proposed Site Plan (basement) | dwg | 25/03/2019 |
| 4 | 1101 | dwg | 25/03/2019 |
| 5 | 1102 | dwg | 25/03/2019 |
| 6 | 1103 | dwg | 25/03/2019 |
| 7 | 1104 | dwg | 25/03/2019 |
| 8 | 1105 | dwg | 25/03/2019 |
| 9 | 1106 | dwg | 25/03/2019 |
| 10 | 1111 | dwg | 25/03/2019 |
| 11 | 1112 | dwg | 25/03/2019 |
| 12 | 1113 | dwg | 25/03/2019 |
| 13 | 1114 | dwg | 25/03/2019 |
| 14 | 1115 | dwg | 25/03/2019 |
| 15 | 1116 | dwg | 25/03/2019 |
| 16 | 1201 | dwg | 25/03/2019 |
| 17 | 1202 | dwg | 25/03/2019 |
| 18 | 1203 | dwg | 25/03/2019 |
| 19 | 1204 | dwg | 25/03/2019 |
| 20 | 1205 | dwg | 25/03/2019 |
| 21 | 1206 | dwg | 25/03/2019 |
| 22 | 1207 | dwg | 25/03/2019 |
| 23 | 1208 | dwg | 25/03/2019 |
| 24 | 1209 | dwg | 25/03/2019 |
| 25 | 1301 | dwg | 25/03/2019 |
| 26 | 1302 | dwg | 25/03/2019 |
| 27 | 1303 | dwg | 25/03/2019 |
| 28 | 1304 | dwg | 25/03/2019 |
| 29 | 1311 | dwg | 25/03/2019 |
| 30 | 1312 | dwg | 25/03/2019 |
| 31 | 1313 | dwg | 25/03/2019 |
| 32 | 1314 | dwg | 25/03/2019 |

Table 5 The document list

# 3. Planning Policy

## 3.1. National Planning Policy Framework (February 2019)

The National Planning Policy Framework is a key part of our reforms to make the planning system less complex and more accessible, to protect the environment and to promote sustainable growth.

## 3.2. The London Plan (March 2016)

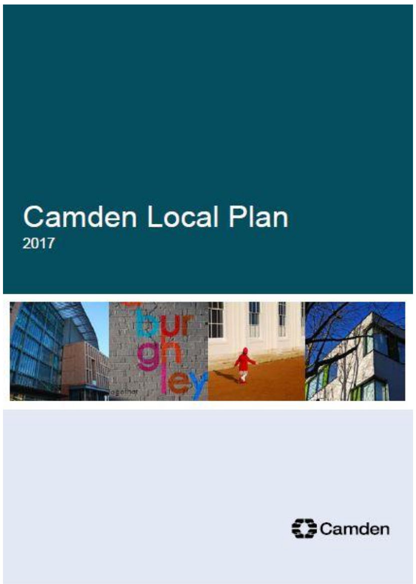

**Policy 5.2, 5.4, 5.5, 5.6, & 5.7**

According to Policy 5.2 all major new developments should show carbon emissions reduction through the Mayor's energy hierarchy (Be Lean, Be Clean and Be Green), unless it can be demonstrated that such provision is not feasible. From October 2016 Zero Carbon Standard apply to all new major residential development (10 or more units). This means that at least 35% of carbon reductions against a Building Regulations Part L 2013 must be achieved on-site, with the remaining emissions, up to 100%, to be offset through a contribution to the Council's Carbon Offset Fund. For the non-residential development, must achieve a 35% reduction in $CO_2$ emissions against a Building Regulations Part L 2013 baseline.

For retrofitting developments, it will be a challenge to meet these targets. However, available reductions in carbon emissions should be demonstrated along with water saving measures as per Policy 5.4.

Furthermore, intent must be shown for connecting to a Decentralised Energy Network and utilizing a Combined Heat & Power according to Policy 5.5 and 5.6. The Mayor and boroughs should in their DPDs adopt a presumption that developments will achieve a reduction in carbon dioxide emissions of 20% from onsite renewable energy generation according to paragraph 5.42 of Policy 5.7

## 3.3. London Borough of Camden




<u>**Camden Local Plan** (Adopted in 2017)</u>

**Policy CC1 Climate Change Mitigation**

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

We will:

a. promote zero carbon development and require all development to reduce carbon dioxide emissions through following the steps in the energy hierarchy;
b. require all major development to demonstrate how London Plan targets for carbon dioxide emissions have been meet;

a. ensure that the location of development and mix of land uses minimize the need to travel by car and help to support decentralized energy networks;
b. support and encourage sensitive energy efficiency improvements to existing buildings;
c. require all proposals that involve substantial demolition to demonstrate that it is not possible to retain and improve the existing building; and
d. expect all developments to optimize resource efficiency.

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

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

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

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8.8 All developments involving five or more dwellings and/or more than 500 sqm of (gross internal) any floorspace will be required to submit an energy statement demonstrating how the energy hierarchy has been applied to make the fullest contribution to CO2 reduction. **All new residential development will also be required to demonstrate a 19% CO2 reduction below Part L 2013 Building Regulations** (in addition to any requirements for renewable energy). This can be demonstrated through an energy statement or sustainability statement.

………..

8.11 The Council will expect developments of five or more dwellings and/or more than 500 sqm of any gross internal floorspace to achieve a 20% reduction in carbon dioxide emissions from on-site renewable energy generation (which can include sources of site related decentralised renewable energy), unless it can be demonstrated that such provision is not feasible. This is in line with stage three of the energy hierarchy 'BE green'. The 20% reduction should be calculated from the regulated CO2 emissions of the development after all proposed energy efficiency measures and any CO2 reduction from non-renewable decentralised energy (e.g. CHP) have been incorporated.

**Policy CC3 Water and Flooding**

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

We will require development to:

a. incorporate water efficiency measures;
b. avoid harm to the water environment and improve water quality;
c. consider the impact of development in areas at risk of flooding (including drainage);
d. incorporate flood resilient measures in areas prone to flooding;
e. utilise Sustainable Drainage Systems (SuDS) in line with the drainage hierarchy to achieve a greenfield run-off rate where feasible; and
f. not locate vulnerable development in flood-prone areas.

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

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

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8.55 Developments must be designed to be water efficient. This can be achieved through the installation of water efficient fittings and appliances (which can help reduce energy consumption as well as water consumption) and by capturing and re-using rain water and grey water on-site. **Residential developments will be expected to meet the requirement of 110 litres per person per day (including 5 litres for external water use).** Refurbishments and other non-domestic development will be expected to meet BREEAM water efficiency credits. Major developments and high or intense water use developments, such as hotels, hostels and student housing, should include a grey water and rainwater harvesting system. Where such a system is not feasible or practical, developers must demonstrate to the Council's satisfaction that this is the case.

# 4. Assessment Methodology

## 4.1. Mayor's Energy Hierarchy

The energy hierarchy is a classification of different methods to improve energy performance in a parallel sequence. This includes primarily a focus on reducing energy use by avoiding unnecessary use, to then improving the efficiency of energy systems to minimise loss, this is followed by exploiting renewable energy sources and then low carbon energy solutions for energy needs and finally, any remaining demand can be catered for by conventional fuel sources.

The Mayor's Energy Strategy adopts a set of principles to guide design development and decisions regarding energy, balanced with the need to optimise environmental and economic benefits. These guiding principles have been reordered since the publication of the Mayor's Energy Strategy in Feb 2004 and the adopted replacement London Plan 2011 with further alterations in 2015 stating that the following hierarchy should be used to assess applications:

- **BE LEAN** – By using less energy and taking into account the further energy efficiency measure in comparison to the baseline building.

- **BE CLEAN** – By supplying energy efficiently. The clean building looks at further carbon dioxide emission savings over the lean building by taking into consideration the use of decentralise energy via CHP.

- **BE GREEN** – By integrating renewable energy into the scheme which can further reduce the carbon dioxide emission rate.

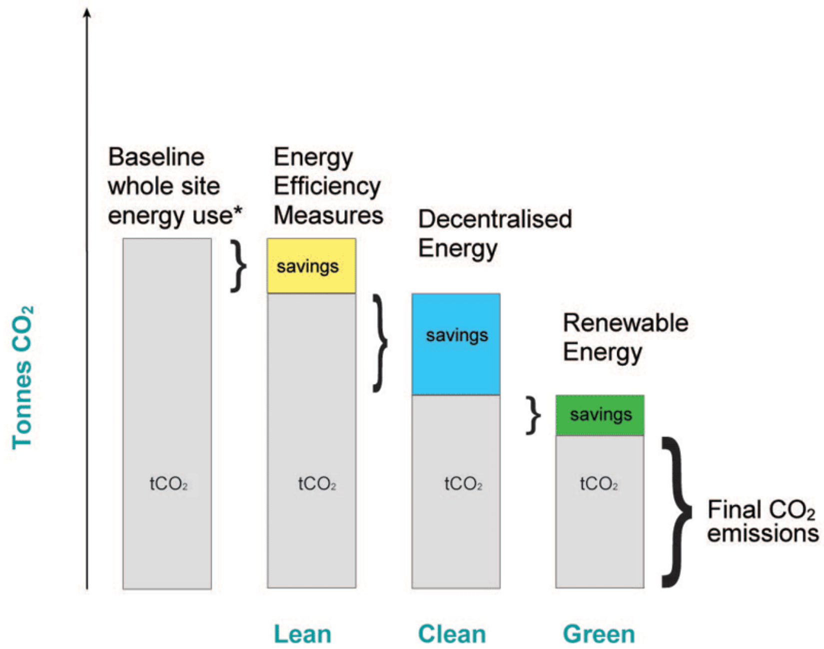



Figure 2 The Energy Hierarchy

## 5. Baseline – Target Emission Rate

The baseline (known as Target Emission Rate), as calculated in line with the Building Regulation 2013, is the maximum amount of carbon dioxide a dwelling or non-residential unit is allowed to emit. The Target Emission Rate (TER) includes carbon dioxide emissions which are covered by Part L of the Building Regulations, known as regulated emissions (space and water heating, ventilation, lighting, pumps, fans & controls). The baseline energy uses and resulting $CO_2$ emissions rates of the development have been assessed using the Government approved software.

The 'baseline' regulated $CO_2$ emissions for the development as a whole are presented in the tables below:

**BASELINE**

| **BASELINE** | **Regulated $CO_2$ Emissions** (Tonnes $CO_2$/yr) |
|---|---|
| 24 Redington Gardens | 12.52 |

Table 6 Regulated Carbon Emissions at Baseline

# 6. BE LEAN – Energy Efficient Design

This section outlines the energy efficient measures taken in order to minimise the building's energy demand and therefore reduce energy use and $CO_2$ emissions further than the Baseline requirements (Building Regulations 2013 Part L compliance).

## 6.1. Passive Design Measures

- **Enhanced Building Elements**

At the 'BE LEAN' stage of the energy hierarchy, energy efficient building elements have been incorporated into the build. The heat loss of different building element is dependent upon their U-value and air tightness. Therefore, better U-values and air permeability than the minimum values set in the Part L 2013 have been suggested in this development. And, Accredited Construction Detail for Part L was also applied at all thermal bridging junctions to reduce the heat loss from the thermal bridging. Please see below more specifically.

| | | Part L1A 2013 min. required values | Proposed building values |
|---|---|---|---|
| **U-value** ($W/m^2 K$) | Wall | 0.30 | 0.13 |
| | Window | 2.0 | 1.4 |
| | Roof lights | 2.0 | 1.4 |
| | Floor | 0.25 | 0.11 |
| | Roof | 0.20 | 0.11 |
| | Door | 1.0 (notional) | 1.4 |
| **Air Permeability** ($m^3/h.m^2$ at 50 Pa) | | 10 | 4 |
| **Accredited Construction Details for Part L** | | - | Applied to all thermal bridge junctions |

Table 7 Proposed building elements

- **Orientation & Natural Daylighting**

Passive solar gain reduces the amount of energy required for space heating during the winter months. The houses are positioned having front roads and rear gardens, which can maximise the passive solar gains into the building throughout the day. Moreover, the internal layout, windows, and roof lights have been designed to improve daylighting in all habitable spaces, as a way of improving the health and wellbeing of occupants.

- **Efficient Use of Water**

In accordance with London Plan Policy 5.15 and Local Plan, the development will be based upon the specification of water efficient fittings including low volume dual flush WCs, and low flow taps/ showers/bath. These measures will result in the total water consumption rate of 110 litres/person/day or less including the external water use. Design stage calculations are below.

| Installation Type | Unit of Measure | Capacity/ flow rate (1) | Use factor (2) | Fixed use (litres/head/ day) (3) | Total Consumption Litres/head/day [(1)x(2)]+(3) =(4) |
|---|---|---|---|---|---|
| **WC** (dual flush) | Full Flush Volume (litres) | **6** | 1.46 | 0 | **8.76** |
| | Part flush Volume (litres) | **4** | 2.96 | 0 | **11.85** |
| **Taps** (excluding kitchen/ utility room taps) | Flow rate (litres/minute) | **6.5** | 1.58 | 1.58 | **11.85** |
| **Bath** (where shower also present) | Capacity to overflow (litres) | **120** | 0.11 | 0 | **13.20** |
| **Shower** (where bath also present) | Flow rate (litres/minute) | **7.5** | 4.37 | 0 | **32.78** |
| **Kitchen / utility room sink taps** | Flow rate (litres/minute) | **6.5** | 0.44 | 10.36 | **13.22** |
| **Washing machine** | Litres/kg dry load | **9** | 2.1 | 0 | **18.90** |
| **Dishwasher** | Litres/place setting | **1.2** | 3.6 | 0 | **4.32** |
| **Waste disposal unit** | Litres/use | **If present = 1 If absent = 0** | 3.08 | 0.00 | **0** |
| **Water Softener** | Litres/person/day | - | 1.00 | 0.00 | - |
| **(5)** | **Total calculated use (litres/person/day) = Sum column 4** | | | | **114.9** |
| **(6)** | **Contribution from greywater (litres/person/day)** | | | | **0** |
| **(7)** | **Contribution from rainwater (litres/person/day)** | | | | **0** |
| **(8)** | **Normalisation Factor** | | | | **0.91** |
| **(9)** | **Total internal water consumption = (5) X (8)** | | | | **104.5** |
| **(10)** | **External water use** | | | | **5** |
| **Total water consumption (litres/person/day) = (9) + (10)** | | | | | **109.5** |

Table 8 Water Use Calculations

- **Solar Shading**

The dwelling will incorporate internal blinds or curtains to reduce the solar heat coming into the dwelling, and thus can reduce the cooling demand during summer.

- **Mechanical Ventilation with Heat Recovery (MVHR)**

MVHR systems have been proposed to ensure appropriate indoor air quality and noise level from the road. The mechanical ventilation will also include heat recovery to improve its efficiency and reduce any heat loss from the building. During the hot summer months, the MVHR unit will operate in summer bypass mode so that no heat recovery and no overheating occurs. For the Design Stage SAP calculation, the specifications below have been used. However, this should be reviewed with the mechanical engineers during the design development and can be substituted with other products having similar or better performance.

| | |
|---|---|
| **Ventilation Type** | Balanced with heat recovery |
| **Number of Wet rooms excluding kitchen** | 10 |
| **Duct insulation Type** | Insulation |
| **Ducting Type** | Rigid |
| **Specific Fan Power** | 1.3 W/(litre/sec) |
| **Heat Exchanger Efficiency** | 80 % |

Table 9 Design Stage MVHR Specifications

## 6.2. Active Design Measures

- **Heating, Cooling and Hot Water System**

At the 'BE LEAN' stage, individual condensing gas boilers (89.5% efficiency) have been examined for space heating and hot water, and the active cooling is provided by electrically powered equipment**.** Detailed specifications used at BE LEAN stage are in the table below.

**Please note that the heating system below has been used only for carbon emissions calculation at BE LEAN stage as per GLA Guidance on energy assessment. The suggested system will be mentioned at BE GREEN stage as renewable technology (ASHPs) has been suggested – Section 8.2.**

| Systems | General Specification | Controls/ Other inputs |
|---|---|---|
| **Heating** | Condensing boilers with fan coil units (efficiency of 89.5%) | • Controls – Programmer and at least two room thermostats<br>• Gas-fired warm air with fan-assisted flue |

| | | |
|---|---|---|
| **Cooling** | Split/multiple system | • EER – 3.1<br>• Compressor control – Systems with on/off control<br>• Cooled area – bedrooms, gym, cinema, games room & bar, snug, living room, formal dining |
| **Hot-water** | Electric immersion cylinder | • Cylinder – 250 litres per dwelling<br>• Loss factor - 1.7 kWh/day<br>• Cylinder in heated space<br>• Cylinderstate |

Table 10 Heating and Hot water systems

- **High Efficiency Lighting**

The proposed light fittings will be low energy efficient fittings. These can be T5 fluorescent fittings with high frequency ballasts, or LED fittings. The suggested specifications should be reviewed at detailed design stage with electric engineers.

The following table demonstrates the reduction in $CO_2$ emissions from the energy efficiency measures mentioned above. As shown in the table below, the carbon reduction of ***21.79%*** can be achieved on the site at BE LEAN stage against the Baseline set by Building Regulations Part L 2013.

## BE LEAN STAGE

| | **Regulated $CO_2$ Emissions** (Tonnes $CO_2$/yr) | | **Carbon Reduction** (%) |
|---|---|---|---|
| | **BASELINE** | **BE LEAN** | |
| 24 Redington Gardens | 12.52 | 9.79 | 21.79 % |

Table 11 Regulated Carbon Emissions at Be Lean Stage

# 7. BE CLEAN – CHP & Decentralised Energy Networks

The Energy Hierarchy encourages the use of a CHP system and the connection to District Heating system to reduce $CO_2$ emissions further.

## 7.1. Decentralised Energy Network

The Mayor's Energy Strategy favours community heating systems because they offer:

- Potential economies of scale in respect of efficiency and therefore reduced carbon emissions; and
- Greater potential for future replacement with Low or Zero Carbon (LZC) technologies.

The feasibility of connecting into an existing heating network or providing the building with its own combined heat and power plant has been assessed alongside the **London Heat Map Study for the London Borough of Camden** as part of this assessment. The study identifies that the site is not located near the existing/ potential district heating networks. This is demonstrated clearly from the London Heat Map (http://www.londonheatmap.org.uk) snapshot below.

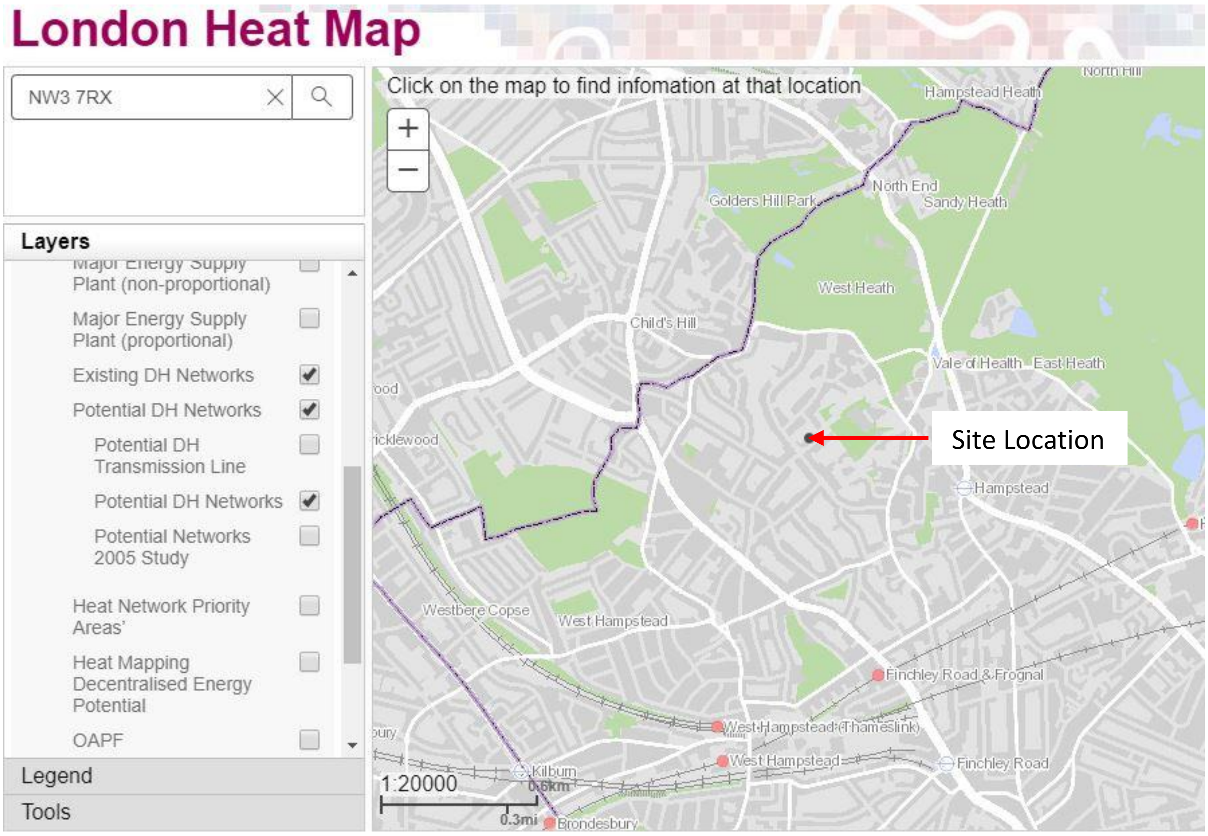



Figure 3 London Heat Map near the site

Moreover, the London heat map below identifies existing DH networks in more broaden area, and it could not find any existing DH networks (in yellow) within 1Km radius from the property. The costs involved in extending the existing DH network would outweigh the advantages in this small development. **Therefore, utilisation of the DH network has not been a feasible option for this development.**

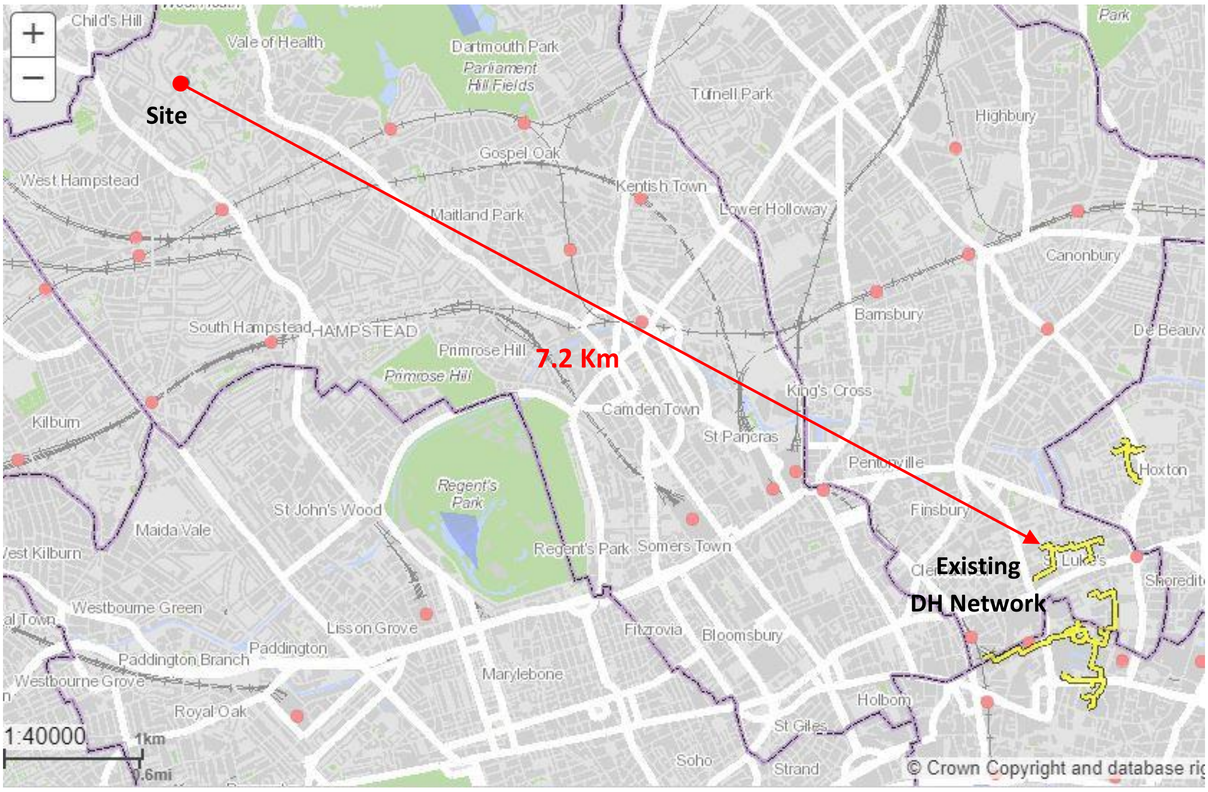



Figure 4 Existing DH Network near the site

## 7.2. CHP

The Energy Hierarchy identifies the combined heat and power (CHP) as a method of producing heat and electricity with much lower emissions than separate heat and power. Also, it encourages the creation of district heating systems supplied by CHP. The implementation of a CHP strategy should be decided according to good practice design. Key factors for the efficient implementation of the CHP system are:

- Development with high heating load for the majority of the year.
- CHP operation based on maximum heat load for minimum 10 hours per day.
- CHP operation at maximum capacity of 90% of its operating period.

To ensure that CHP is financially viable it is essential that the unit is selected to meet the base heat load and that this load is maintained over a large proportion of the day (a figure of 14 – 17 hours per day is often quoted subject to the load profiles and gas and electricity prices) to ensure that the additional costs (maintenance) associated with running a CHP unit can be recovered. This need to run the CHP plant, as far as possible continuously makes the building load profile of prime importance when reviewing the viability of such solutions and in particular the summer time heat load profile. To enable the CHP plant to run continuously when it is operating, a thermal store is often used so that excess CHP capacity can be used to generate hot water for use at a later time.

**Since this development consists of only one dwelling that does not require high heating loads, installing the CHP system would not be beneficial given the cost.** According to the Local Plan Policy LP22, developments of 50 units or more will need to provide an assessment of the provision of CHP. **Hence the CHP system has not been considered for this development at BE CLEAN stage.**

## 8. BE GREEN – Renewable Energy

In this section the viable renewable energy technologies that could reduce the development's $CO_2$ emissions are examined. In determining the appropriate renewable technology for the site, the following factors were considered;

- Renewable energy resource or fuel availability of the LZC technology on the site.
- Space limitations due to building design and urban location of the site.
- Capital, operating and maintenance cost.
- Planning Permission
- Implementation with regards the overall M&E design strategy for building type
- Available Grants

The table below summarises the various low zero carbon technologies considered for the projects, and we have identified that **Air Source Heat Pumps (ASHP)** would be the most appropriate option in this development.

| Technology | Local Planning Requirements | Carbon Payback | Grants/ Funding | Feasibility |
|---|---|---|---|---|
| **Air Source Heat Pumps (ASHP)** | Noise Issues from External units | High | Renewable Heat Incentive (RHI) | **HIGH** |
| **Photovoltaic (PV)** | Spatial and Shadowing | High | - | **LOW** |
| **Solar Thermal** | Spatial and Shadowing | Low | Renewable Heat Incentive (RHI) | **MEDIUM** |
| **Ground Source Heat Pumps (GSHP)** | Spatial issues for boring holes and noise | Medium | Renewable Heat Incentive (RHI) | **MEDIUM** |
| **Biomass** | Spatial requirement for fuel storage and biomass odour | High | Renewable Heat Incentive (RHI) | **LOW** |
| **Wind Power** | Extensive planning requirements for noise and local biodiversity | Low | - | **LOW** |
| **Hydro Power** | Extensive planning requirements for noise and water quality | None | - | **ZERO** |

Table 12 Feasibility Study of LZC Technologies

## 8.1. Non-feasible Technology

- **Photovoltaic (PV)**

The required size and angle of any proposed PV cells on the roof would mean a visible increase of approximately 1m above the current parapet height making the panels noticeable from the streetscape. The panels would also need to sit an oblique angle (due south) to the façade to be most effective and efficient creating an unattractive saw tooth like addition to the roof/ façade of the proposal.

Also, the available roof space is limited to install enough PV panels to have an impact on carbon emissions of the development. Since the proposed renewable technology (Air Source Heat Pumps) reduced the carbon emissions significantly, further carbon reduction via PV panels has not been considered.

- **Ground Source Heat Pumps (GSHP)**

Ground source heat pump would be a feasible option to meet the space heating requirements, however, it requires to bore ground holes to extract the ground heat to be utilised for space heating requirements. The costs involved in installing GSHP would outweigh the advantages in this minor development. Therefore, utilization of the GSHP has not been a feasible option for this development.

- **Solar Thermal**

The use of solar thermal for this development would be limited to domestic hot water only. The use of solar thermal for space heating would not be practical as it is not required when solar thermal is at its most effective during the summer months. Therefore, this system would require additional plumbing and space for hot water storage, incurring additional financial cost. Moreover, the amount of carbon offset from the system is generally lower than other technologies. Therefore, this technology is deemed to be unsuitable for this development.

- **Hydro power**

Although River Thames is close to the site, there is no river or lake within the development site boundaries. Therefore, small scale hydro-electric will not be studied any further because of the location and the spatial limitations of the development.

- **Wind Power**

Wind turbines need extensive planning requirements and they are only feasible at consistent wind speed. Moreover, since the development is located in an urban area, the site does not have sufficient wind speed to operate wind turbine at the height of 10 meters as shown below (http://www.renew-reuse-recycle.com/noabl.pl?n=503). Hence this option has been discounted.

Estimated average windspeeds around NW3 7..

| Wind speed at 10m above ground level (m/s) | | |
|---|---|---|
| 5 | 5.5 | 5.8 |
| 5 | **5.7** | 5.9 |
| 4.9 | 5.3 | 5.6 |

| Wind speed at 25m above ground level (m/s) | | |
|---|---|---|
| 5.8 | 6.3 | 6.5 |
| 5.8 | **6.4** | 6.6 |
| 5.7 | 6 | 6.3 |

| Wind speed at 45m above ground level (m/s) | | |
|---|---|---|
| 6.3 | 6.7 | 6.9 |
| 6.3 | **6.8** | 7 |
| 6.2 | 6.5 | 6.7 |

Squares surrounding the central square correspond to wind speeds for surrounding grid squares. Power generated is related to windspeed by a cubic ratio. That means if you halve the windspeed, the power goes down by a factor of 8 (which is 2 x 2 x 2). A quarter of the windspeed gives you a 64$^{th}$ of the power (4 x 4 x 4). As a rough guide, if your turbine is rated at producing 1KW at 12m/s then it will produce 125W at 6m/s and 15W at 3m/s.

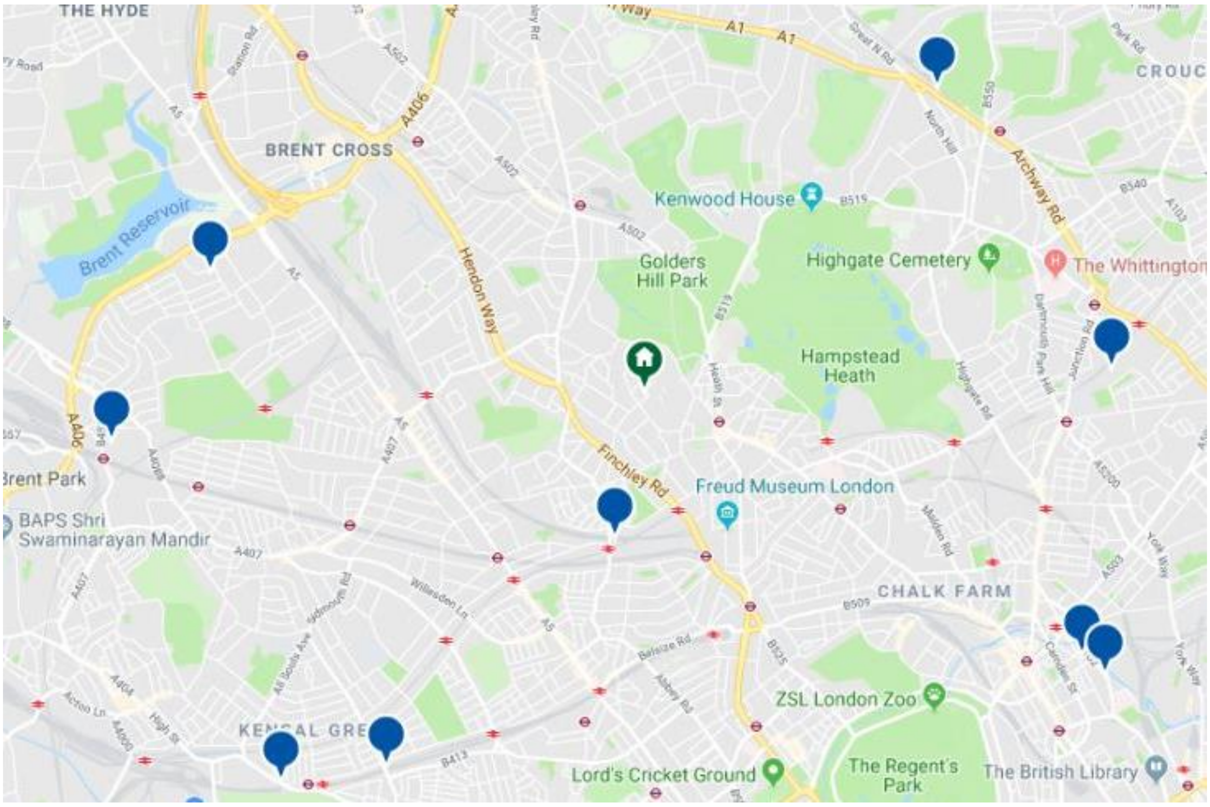
Please note that bear in mind that the NOABL windspeed dataset used here is a model of windspeeds across the country, assuming completely flat terrain. It isn't a database of measured windspeeds. Other factors such as hills, houses, trees and other obstructions in your vicinity need to be considered as well as they can have a significant effect. If you're thinking about installing a wind turbine, you should perform your own windspeed measurements using an anemometer to determine what the actual figures are.

- **Biomass**

A biomass system designed for this development would be fueled by wood pellets which have a high energy content. However, a biomass system would not be an appropriate technology for the site for the following reasons:

i. The burning of wood pellets releases substantially more NOx emissions when compared to similar gas boilers. As the development is situated within an urban area, the installation of a biomass boiler would further impact on the air quality in this area.
ii. the lack of spaces for pellet boiler and storage on the site.
iii. Pellets would need to be transported from local pellet suppliers, which causes carbon emissions to the air.

However, if the biomass system is considered at detailed design stage, local suppliers can be found near the site as shown in the map below (http://biomass-suppliers-list.service.gov.uk).




| Company name | Postcode | Contact | Fuel Supplied | Telephone |
|---|---|---|---|---|
| Travis Perkins Trading Co. Ltd | NW6 1SD | www.travisperkins.co.uk johnny.farmer@travisperkins.co.uk | Pellets | 020 7794 8151 |
| Wolseley UK Ltd | N6 4JD | www.draincenter.co.uk qdn.Highgate@wolseley.co.uk | Pellets | 0208 3400793 |
| Wolseley UK Ltd | NW2 7LZ | www.plumbcenter.co.uk YH.StaplesCorner@wolseley.co.uk | Pellets | 0208 8309106 |
| Travis Perkins Trading Co. Ltd | NW10 3NB | www.travisperkins.co.uk lee.gilmore@travisperkins.co.uk | Pellets | 020 8964 9000 |
| Travis Perkins Trading Co. Ltd | N19 5UN | www.travisperkins.co.uk toby.duncan@travisperkins.co.uk | Pellets | 0207 561 0516 |
| Wolseley UK Ltd | NW1 0BY | www.plumbcenter.co.uk FFP.Camden@wolseley.co.uk | Pellets | 0207 4240957 |
| Travis Perkins Trading Co. Ltd | NW10 5NY | www.travisperkins.co.uk daniel.mccafferty@travisperkins.co.uk | Pellets | 0208 969 2000 |
| Travis Perkins Trading Co. Ltd | NW10 1RZ | www.travisperkins.co.uk phil.pilditch@travisperkins.co.uk | Pellets | 0208 4386 715 |
| Travis Perkins Trading Co. Ltd | NW1 0PT | www.travisperkins.co.uk sean.mahon@travisperkins.co.uk | Pellets | 0207 380 6480 |
| Travis Perkins Trading Co. Ltd | W2 6NA | www.travisperkins.co.uk liam.clancy@travisperkins.co.uk | Pellets | 020 7262 6602 |

## 8.2. Proposed Technology

- **Air Source Heat Pumps (ASHP)**

ASHP can meet the space heating demands on site efficiently in comparison with gas boilers. Although this low carbon technology consumes electricity to operate, due to higher efficiency the heat output is much greater. Therefore, Variable Refrigerant Flow (VRF) system has been suggested for the space heating and cooling. However, the mechanical engineer should be reviewed the specification during the design development.

| Systems | General Specification | Controls/ Other inputs |
|---|---|---|
| **Heating** | VRF systems with fan coil units, 361% efficiency (electric air source heat pumps) | • Heating Fuel – heat from electric heat pump<br>• Emitter – fan coil units<br>• Control – Programmer and at least two room thermostats<br>• Heat distribution system - unknown |
| **Cooling** | Split/multiple system (as part of VRF) | • EER – 3.1<br>• Compressor control – Systems with on/off control<br>• Cooled area – bedrooms, gym, cinema, games room & bar, snug, living room, formal dining |

Table 13 Be Green Stage Heating and cooling systems

Given the proposed LZC technologies on the site (**ASHP**), the overall $CO_2$ reduction at BE GREEN stage can be calculated as shown below. And, it can be seen that the overall $CO_2$ reduction via on-site renewables is ***4.25%*** against the BE LEAN stage.

### BE GREEN stage

| | **Regulated $CO_2$ Emissions** (Tonnes $CO_2$/yr) | | **Carbon Reduction** (%) |
|---|---|---|---|
| | **BE LEAN** | **BE GREEN** | |
| 24 Redington Gardens | 9.79 | 9.38 | 4.25 % |

Table 14 Regulated Energy Use and Carbon Reduction at Be Green Stage

## 9. Conclusion

This report assesses the predicted energy performance and carbon dioxide emissions of the proposed development at **24 Redington Gardens, London, NW3 7RX,** based on the information provided by the design team.

In line with the local Council's three step energy hierarchy, the regulated $CO_2$ emissions for the development have been reduced by 25.12% over Building Regulation Part L 2013, once all measures in the table below are taken into account.

| Stages | Strategies |
|---|---|
| **BE LEAN**<br>Energy efficient design | • U-values and air permeability better than Building Regulations Part L1A 2013<br>• Use of accredited construction details at all thermal bridging junctions<br>• Mechanical Ventilation with Heat Recovery (MVHR) system<br>• Low water consumption<br>• 100% Low energy lights |
| **BE CLEAN**<br>District heat networks or CHP | • Not feasible on the site. Details are in Section 7. |
| **BE GREEN**<br>On-site renewable technologies | • Air Source Heat Pumps (VRF) for space heating and cooling. Details are in Section 8.2. |

Table 15 Energy Hierarchy and suggested strategies

The table below clearly shows that the development meets the 19% targeted carbon reduction.

| Energy Hierarchy | | Regulated Carbon Savings | |
|---|---|---|---|
| | | Tonnes $CO_2$/yr | % |
| **BE LEAN** | After energy demand reduction | 2.73 | 21.79 % |
| **BE CLEAN** | After heat network/ CHP | 0 | 0 % |
| **BE GREEN** | After renewable energy | 0.42 | 4.25 % |
| **Total Cumulative Savings** | | **3.15** | **25.12 %** |
| **Total Target Savings** | | 2.38 | 19 % |

Table 16 Carbon dioxide Emissions after each stage of the Energy Hierarchy

## 10. Appendix A – SAP Reports

# Regulations Compliance Report

Approved Document L1A, 2013 Edition, England assessed by Stroma FSAP 2012 program, Version: 1.0.4.17
*Printed on 09 May 2019 at 11:57:03*

## Project Information:

**Assessed By:** Su Lee (STRO031315) **Building Type:** Detached House

## Dwelling Details:

**NEW DWELLING DESIGN STAGE** Total Floor Area: 603.76m²

**Site Reference :** BE GREEN **Plot Reference:** 24 Redington Gardens

**Address :**

## Client Details:

**Name:**

**Address :**

**This report covers items included within the SAP calculations.**
**It is not a complete report of regulations compliance.**

## 1a TER and DER

Fuel for main heating system: Electricity (c)
Fuel factor: 1.55 (electricity (c))

| | | |
|---|---|---|
| Target Carbon Dioxide Emission Rate (TER) | 20.74 kg/m² | |
| Dwelling Carbon Dioxide Emission Rate (DER) | 15.53 kg/m² | OK |

## 1b TFEE and DFEE

| | | |
|---|---|---|
| Target Fabric Energy Efficiency (TFEE) | 62.6 kWh/m² | |
| Dwelling Fabric Energy Efficiency (DFEE) | 49.3 kWh/m² | |
| | | OK |

## 2 Fabric U-values

| Element | Average | Highest | |
|---|---|---|---|
| External wall | 0.13 (max. 0.30) | 0.13 (max. 0.70) | OK |
| Party wall | 0.00 (max. 0.20) | - | OK |
| Floor | 0.11 (max. 0.25) | 0.11 (max. 0.70) | OK |
| Roof | 0.11 (max. 0.20) | 0.11 (max. 0.35) | OK |
| Openings | 1.40 (max. 2.00) | 1.40 (max. 3.30) | OK |

## 2a Thermal bridging

Thermal bridging calculated from linear thermal transmittances for each junction

## 3 Air permeability

| | | |
|---|---|---|
| Air permeability at 50 pascals | 4.00 (design value) | |
| Maximum | 10.0 | OK |

## 4 Heating efficiency

Main Heating system: Community heating schemes - Heat pump
Community heat pump

Secondary heating system: None

## 5 Cylinder insulation

| | | |
|---|---|---|
| Hot water Storage: | Measured cylinder loss: 1.70 kWh/day | |
| | Permitted by DBSCG: 2.56 kWh/day | OK |
| Primary pipework insulated: | No primary pipework | |

# Regulations Compliance Report

## 6 Controls

| | | |
|---|---|---|
| Space heating controls | Flat rate charging, programmer and at least two room thermostats | **OK** |
| Hot water controls: | Cylinderstat | **OK** |

## 7 Low energy lights

| | | |
|---|---|---|
| Percentage of fixed lights with low-energy fittings | 100.0% | |
| Minimum | 75.0% | **OK** |

## 8 Mechanical ventilation

| | | |
|---|---|---|
| Continuous supply and extract system | | |
| Specific fan power: | 1.3 | |
| Maximum | 1.5 | **OK** |
| MVHR efficiency: | 80% | |
| Minimum | 70% | **OK** |

## 9 Summertime temperature

| | | |
|---|---|---|
| Overheating risk (Thames valley): | Not significant | **OK** |

Based on:

| | |
|---|---|
| Overshading: | Average or unknown |
| Windows facing: South East | 5.55m² |
| Windows facing: South East | 2.33m² |
| Windows facing: North West | 16.92m² |
| Windows facing: South East | 1.44m² |
| Windows facing: South East | 3.36m² |
| Windows facing: South East | 4.21m² |
| Windows facing: South East | 1.99m² |
| Windows facing: South East | 1.54m² |
| Windows facing: North West | 3.85m² |
| Windows facing: North West | 2.57m² |
| Windows facing: North West | 2.78m² |
| Windows facing: North West | 2.48m² |
| Windows facing: North West | 3.9m² |
| Windows facing: North West | 2.69m² |
| Windows facing: North West | 2.55m² |
| Windows facing: South East | 1.49m² |
| Roof windows facing: Horizontal | 6.86m² |
| Roof windows facing: Horizontal | 3.09m² |
| Roof windows facing: Horizontal | 3.61m² |
| Roof windows facing: Horizontal | 6.59m² |
| Roof windows facing: Horizontal | 1.78m² |
| Roof windows facing: Horizontal | 0.35m² |
| Ventilation rate: | 4.00 |
| Blinds/curtains: | None |

## 10 Key features

| | |
|---|---|
| Roofs U-value | 0.11 W/m²K |
| External Walls U-value | 0.13 W/m²K |
| Party Walls U-value | 0 W/m²K |
| Floors U-value | 0.11 W/m²K |
| Community heating, heat from electric heat pump | |
| Fixed cooling system | |

# Regulations Compliance Report

# DER WorkSheet: New dwelling design stage

User Details:

| | | | |
|---|---|---|---|
| **Assessor Name:** | Su Lee | **Stroma Number:** | STRO031315 |
| **Software Name:** | Stroma FSAP 2012 | **Software Version:** | Version: 1.0.4.17 |

Property Address: 24 Redington Gardens

**Address :**

## 1. Overall dwelling dimensions:

| | Area(m²) | | | Av. Height(m) | | | Volume(m³) | |
|---|---|---|---|---|---|---|---|---|
| Basement | 190.95 | (1a) | x | 3.37 | (2a) | = | 642.54 | (3a) |
| Ground floor | 135.66 | (1b) | x | 3.15 | (2b) | = | 427.34 | (3b) |
| First floor | 106.81 | (1c) | x | 3.3 | (2c) | = | 352.47 | (3c) |
| Second floor | 106.81 | (1d) | x | 3 | (2d) | = | 320.43 | (3d) |
| Third floor | 63.53 | (1e) | x | 2.95 | (2e) | = | 187.16 | (3e) |
| Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n) | 603.76 | (4) | | | | | | |
| Dwelling volume | | | | (3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) | | = | 1929.93 | (5) |

## 2. Ventilation rate:

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

**Air changes per hour**

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

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

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

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

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

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

| | | | |
|---|---|---|---|
| Number of sides sheltered | | 2 | (19) |
| Shelter factor | (20) = 1 - [0.075 x (19)] = | 0.85 | (20) |
| Infiltration rate incorporating shelter factor | (21) = (18) x (20) = | 0.17 | (21) |

# DER WorkSheet: New dwelling design stage

Infiltration rate modified for monthly wind speed

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly average wind speed from Table 7 | | | | | | | | | | | | | |
| (22)m= | 5.1 | 5 | 4.9 | 4.4 | 4.3 | 3.8 | 3.8 | 3.7 | 4 | 4.3 | 4.5 | 4.7 | |
| Wind Factor (22a)m = (22)m ÷ 4 | | | | | | | | | | | | | |
| (22a)m= | 1.27 | 1.25 | 1.23 | 1.1 | 1.08 | 0.95 | 0.95 | 0.92 | 1 | 1.08 | 1.12 | 1.18 | |
| Adjusted infiltration rate (allowing for shelter and wind speed) = (21a) x (22a)m | | | | | | | | | | | | | |
| | 0.22 | 0.21 | 0.21 | 0.19 | 0.18 | 0.16 | 0.16 | 0.16 | 0.17 | 0.18 | 0.19 | 0.2 | |
| *Calculate effective air change rate for the applicable case* | | | | | | | | | | | | | |
| If mechanical ventilation: | | | | | | | | | | | | 0.5 | (23a) |
| If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) | | | | | | | | | | | | 0.5 | (23b) |
| If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = | | | | | | | | | | | | 68 | (23c) |
| a) If balanced mechanical ventilation with heat recovery (MVHR) (24a)m = (22b)m + (23b) × [1 – (23c) ÷ 100] | | | | | | | | | | | | | |
| (24a)m= | 0.38 | 0.37 | 0.37 | 0.35 | 0.34 | 0.32 | 0.32 | 0.32 | 0.33 | 0.34 | 0.35 | 0.36 | (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<br>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<br>if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5] | | | | | | | | | | | | | |
| (24d)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (24d) |
| Effective air change rate - enter (24a) or (24b) or (24c) or (24d) in box (25) | | | | | | | | | | | | | |
| (25)m= | 0.38 | 0.37 | 0.37 | 0.35 | 0.34 | 0.32 | 0.32 | 0.32 | 0.33 | 0.34 | 0.35 | 0.36 | (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 | | | 4.67 | x | 1.4 | = | 6.538 | | | (26) |
| Doors Type 2 | | | 2.03 | x | 1.4 | = | 2.8476 | | | (26) |
| Doors Type 3 | | | 2.12 | x | 1.4 | = | 2.9722 | | | (26) |
| Doors Type 4 | | | 2.16 | x | 1.4 | = | 3.024 | | | (26) |
| Doors Type 5 | | | 2.41 | x | 1.4 | = | 3.3726 | | | (26) |
| Doors Type 6 | | | 1.82 | x | 1.4 | = | 2.541 | | | (26) |
| Doors Type 7 | | | 1.75 | x | 1.4 | = | 2.457 | | | (26) |
| Doors Type 8 | | | 2.16 | x | 1.4 | = | 3.024 | | | (26) |
| Doors Type 9 | | | 1.74 | x | 1.4 | = | 2.429 | | | (26) |
| Windows Type 1 | | | 5.553 | x1/[1/( 1.4 )+ 0.04] | | = | 7.36 | | | (27) |
| Windows Type 2 | | | 2.33 | x1/[1/( 1.4 )+ 0.04] | | = | 3.09 | | | (27) |
| Windows Type 3 | | | 16.925 | x1/[1/( 1.4 )+ 0.04] | | = | 22.44 | | | (27) |
| Windows Type 4 | | | 1.442 | x1/[1/( 1.4 )+ 0.04] | | = | 1.91 | | | (27) |

# DER WorkSheet: New dwelling design stage

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Windows Type 5 | | | 3.357 | x1/[1/( 1.4 )+ 0.04] | | = | 4.45 | | | (27) |
| Windows Type 6 | | | 4.21 | x1/[1/( 1.4 )+ 0.04] | | = | 5.58 | | | (27) |
| Windows Type 7 | | | 1.988 | x1/[1/( 1.4 )+ 0.04] | | = | 2.64 | | | (27) |
| Windows Type 8 | | | 1.538 | x1/[1/( 1.4 )+ 0.04] | | = | 2.04 | | | (27) |
| Windows Type 9 | | | 3.848 | x1/[1/( 1.4 )+ 0.04] | | = | 5.1 | | | (27) |
| Windows Type 10 | | | 2.565 | x1/[1/( 1.4 )+ 0.04] | | = | 3.4 | | | (27) |
| Windows Type 11 | | | 2.784 | x1/[1/( 1.4 )+ 0.04] | | = | 3.69 | | | (27) |
| Windows Type 12 | | | 2.48 | x1/[1/( 1.4 )+ 0.04] | | = | 3.29 | | | (27) |
| Windows Type 13 | | | 3.905 | x1/[1/( 1.4 )+ 0.04] | | = | 5.18 | | | (27) |
| Windows Type 14 | | | 2.692 | x1/[1/( 1.4 )+ 0.04] | | = | 3.57 | | | (27) |
| Windows Type 15 | | | 2.547 | x1/[1/( 1.4 )+ 0.04] | | = | 3.38 | | | (27) |
| Windows Type 16 | | | 1.493 | x1/[1/( 1.4 )+ 0.04] | | = | 1.98 | | | (27) |
| Rooflights Type 1 | | | 3.428 | x1/[1/(1.4) + 0.04] | | = | 4.7992 | | | (27b) |
| Rooflights Type 2 | | | 3.09 | x1/[1/(1.4) + 0.04] | | = | 4.326 | | | (27b) |
| Rooflights Type 3 | | | 3.611 | x1/[1/(1.4) + 0.04] | | = | 5.0554 | | | (27b) |
| Rooflights Type 4 | | | 3.297 | x1/[1/(1.4) + 0.04] | | = | 4.6158 | | | (27b) |
| Rooflights Type 5 | | | 1.784 | x1/[1/(1.4) + 0.04] | | = | 2.4976 | | | (27b) |
| Rooflights Type 6 | | | 0.349 | x1/[1/(1.4) + 0.04] | | = | 0.4886 | | | (27b) |
| Floor | | | 190.949 | x | 0.11 | = | 21.00439 | | | (28) |
| Walls Type1 | 141.8 | 0 | 141.8 | x | 0.13 | = | 18.43 | | | (29) |
| Walls Type2 | 165.84 | 23.46 | 142.38 | x | 0.13 | = | 18.51 | | | (29) |
| Walls Type3 | 147.8 | 28.01 | 119.8 | x | 0.13 | = | 15.57 | | | (29) |
| Walls Type4 | 134.37 | 25.01 | 109.36 | x | 0.13 | = | 14.22 | | | (29) |
| Walls Type5 | 37.06 | 0 | 37.06 | x | 0.13 | = | 4.82 | | | (29) |
| Walls Type6 | 12.4 | 4.04 | 8.36 | x | 0.13 | = | 1.09 | | | (29) |
| Roof Type1 | 64.55 | 9.95 | 54.6 | x | 0.11 | = | 6.01 | | | (30) |
| Roof Type2 | 30.02 | 3.61 | 26.41 | x | 0.11 | = | 2.91 | | | (30) |
| Roof Type3 | 5.01 | 0 | 5.01 | x | 0.11 | = | 0.55 | | | (30) |
| Roof Type4 | 38.49 | 0 | 38.49 | x | 0.11 | = | 4.23 | | | (30) |
| Roof Type5 | 31.15 | 8.73 | 22.42 | x | 0.11 | = | 2.47 | | | (30) |
| Total area of elements, m² | | | 999.44 | | | | | | | (31) |
| Party wall | | | 81.02 | 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) = | 247.64 | (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 | 57.76 | (36) |

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

Total fabric heat loss (33) + (36) = 305.4 (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= | 239.94 | 237.24 | 234.53 | 221 | 218.29 | 204.76 | 204.76 | 202.05 | 210.17 | 218.29 | 223.7 | 229.12 | (38) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (39)m= | 545.34 | 542.64 | 539.93 | 526.4 | 523.69 | 510.16 | 510.16 | 507.45 | 515.57 | 523.69 | 529.1 | 534.52 | |

Average = Sum(39)$_{1…12}$ /12= 525.72 (39)

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

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (40)m= | 0.9 | 0.9 | 0.89 | 0.87 | 0.87 | 0.84 | 0.84 | 0.84 | 0.85 | 0.87 | 0.88 | 0.89 |

Average = Sum(40)$_{1…12}$ /12= 0.87 (40)

Number of days in month (Table 1a)

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

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

Assumed occupancy, N 3.53 (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) + 36 117.96 (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= | 129.76 | 125.04 | 120.32 | 115.6 | 110.88 | 106.17 | 106.17 | 110.88 | 115.6 | 120.32 | 125.04 | 129.76 |

Total = Sum(44)$_{1…12}$ = 1415.54 (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= | 192.43 | 168.3 | 173.67 | 151.41 | 145.28 | 125.37 | 116.17 | 133.31 | 134.9 | 157.21 | 171.61 | 186.36 |

Total = Sum(45)$_{1…12}$ = 1856 (45)

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (46)m= | 28.86 | 25.24 | 26.05 | 22.71 | 21.79 | 18.8 | 17.43 | 20 | 20.23 | 23.58 | 25.74 | 27.95 | (46) |

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel 250 (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): 1.7 (48)

Temperature factor from Table 2b 0.6 (49)

Energy lost from water storage, kWh/year (48) x (49) = 1.02 (50)

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

Hot water storage loss factor from Table 2 (kWh/litre/day) 0 (51)

If community heating see section 4.3

Volume factor from Table 2a 0 (52)

Temperature factor from Table 2b 0 (53)

Energy lost from water storage, kWh/year (47) x (51) x (52) x (53) = 0 (54)

Enter (50) or (54) in (55) 1.02 (55)

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (56)m= | 31.62 | 28.56 | 31.62 | 30.6 | 31.62 | 30.6 | 31.62 | 31.62 | 30.6 | 31.62 | 30.6 | 31.62 | (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= | 31.62 | 28.56 | 31.62 | 30.6 | 31.62 | 30.6 | 31.62 | 31.62 | 30.6 | 31.62 | 30.6 | 31.62 | (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= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (61) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (62)m= | 224.05 | 196.86 | 205.29 | 182.01 | 176.9 | 155.97 | 147.79 | 164.93 | 165.5 | 188.83 | 202.21 | 217.98 | (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= | 224.05 | 196.86 | 205.29 | 182.01 | 176.9 | 155.97 | 147.79 | 164.93 | 165.5 | 188.83 | 202.21 | 217.98 |

Output from water heater (annual)$_{1...12}$ | 2228.3 | (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= | 89.28 | 78.81 | 83.04 | 74.82 | 73.6 | 66.16 | 63.92 | 69.62 | 69.33 | 77.57 | 81.54 | 87.26 | (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= | 176.34 | 176.34 | 176.34 | 176.34 | 176.34 | 176.34 | 176.34 | 176.34 | 176.34 | 176.34 | 176.34 | 176.34 | (66) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (67)m= | 64.13 | 56.96 | 46.33 | 35.07 | 26.22 | 22.13 | 23.92 | 31.09 | 41.72 | 52.98 | 61.83 | 65.92 | (67) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (68)m= | 673.92 | 680.92 | 663.29 | 625.78 | 578.42 | 533.91 | 504.17 | 497.18 | 514.8 | 552.32 | 599.68 | 644.19 | (68) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (69)m= | 40.63 | 40.63 | 40.63 | 40.63 | 40.63 | 40.63 | 40.63 | 40.63 | 40.63 | 40.63 | 40.63 | 40.63 | (69) |

Pumps and fans gains (Table 5a)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (70)m= | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | (70) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (71)m= | -141.07 | -141.07 | -141.07 | -141.07 | -141.07 | -141.07 | -141.07 | -141.07 | -141.07 | -141.07 | -141.07 | -141.07 | (71) |

Water heating gains (Table 5)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (72)m= | 120 | 117.27 | 111.61 | 103.92 | 98.93 | 91.89 | 85.92 | 93.58 | 96.3 | 104.26 | 113.25 | 117.28 | (72) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (73)m= | 933.96 | 931.05 | 897.14 | 840.67 | 779.47 | 723.84 | 689.91 | 697.75 | 728.73 | 785.46 | 850.66 | 903.29 | (73) |

## 6. Solar gains:

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

# DER 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 | 5.55 | x | 36.79 | x | 0.76 | x | 0.7 | = | 75.33 | (77) |
| Southeast 0.9x | 0.77 | x | 2.33 | x | 36.79 | x | 0.76 | x | 0.7 | = | 31.61 | (77) |
| Southeast 0.9x | 0.77 | x | 1.44 | x | 36.79 | x | 0.76 | x | 0.7 | = | 19.56 | (77) |
| Southeast 0.9x | 0.77 | x | 3.36 | x | 36.79 | x | 0.76 | x | 0.7 | = | 45.54 | (77) |
| Southeast 0.9x | 0.77 | x | 4.21 | x | 36.79 | x | 0.76 | x | 0.7 | = | 57.11 | (77) |
| Southeast 0.9x | 0.77 | x | 1.99 | x | 36.79 | x | 0.76 | x | 0.7 | = | 26.97 | (77) |
| Southeast 0.9x | 0.77 | x | 1.54 | x | 36.79 | x | 0.76 | x | 0.7 | = | 20.86 | (77) |
| Southeast 0.9x | 0.77 | x | 1.49 | x | 36.79 | x | 0.76 | x | 0.7 | = | 20.25 | (77) |
| Southeast 0.9x | 0.77 | x | 5.55 | x | 62.67 | x | 0.76 | x | 0.7 | = | 128.31 | (77) |
| Southeast 0.9x | 0.77 | x | 2.33 | x | 62.67 | x | 0.76 | x | 0.7 | = | 53.84 | (77) |
| Southeast 0.9x | 0.77 | x | 1.44 | x | 62.67 | x | 0.76 | x | 0.7 | = | 33.32 | (77) |
| Southeast 0.9x | 0.77 | x | 3.36 | x | 62.67 | x | 0.76 | x | 0.7 | = | 77.57 | (77) |
| Southeast 0.9x | 0.77 | x | 4.21 | x | 62.67 | x | 0.76 | x | 0.7 | = | 97.28 | (77) |
| Southeast 0.9x | 0.77 | x | 1.99 | x | 62.67 | x | 0.76 | x | 0.7 | = | 45.94 | (77) |
| Southeast 0.9x | 0.77 | x | 1.54 | x | 62.67 | x | 0.76 | x | 0.7 | = | 35.54 | (77) |
| Southeast 0.9x | 0.77 | x | 1.49 | x | 62.67 | x | 0.76 | x | 0.7 | = | 34.5 | (77) |
| Southeast 0.9x | 0.77 | x | 5.55 | x | 85.75 | x | 0.76 | x | 0.7 | = | 175.56 | (77) |
| Southeast 0.9x | 0.77 | x | 2.33 | x | 85.75 | x | 0.76 | x | 0.7 | = | 73.66 | (77) |
| Southeast 0.9x | 0.77 | x | 1.44 | x | 85.75 | x | 0.76 | x | 0.7 | = | 45.59 | (77) |
| Southeast 0.9x | 0.77 | x | 3.36 | x | 85.75 | x | 0.76 | x | 0.7 | = | 106.13 | (77) |
| Southeast 0.9x | 0.77 | x | 4.21 | x | 85.75 | x | 0.76 | x | 0.7 | = | 133.1 | (77) |
| Southeast 0.9x | 0.77 | x | 1.99 | x | 85.75 | x | 0.76 | x | 0.7 | = | 62.85 | (77) |
| Southeast 0.9x | 0.77 | x | 1.54 | x | 85.75 | x | 0.76 | x | 0.7 | = | 48.62 | (77) |
| Southeast 0.9x | 0.77 | x | 1.49 | x | 85.75 | x | 0.76 | x | 0.7 | = | 47.2 | (77) |
| Southeast 0.9x | 0.77 | x | 5.55 | x | 106.25 | x | 0.76 | x | 0.7 | = | 217.52 | (77) |
| Southeast 0.9x | 0.77 | x | 2.33 | x | 106.25 | x | 0.76 | x | 0.7 | = | 91.27 | (77) |
| Southeast 0.9x | 0.77 | x | 1.44 | x | 106.25 | x | 0.76 | x | 0.7 | = | 56.49 | (77) |
| Southeast 0.9x | 0.77 | x | 3.36 | x | 106.25 | x | 0.76 | x | 0.7 | = | 131.5 | (77) |
| Southeast 0.9x | 0.77 | x | 4.21 | x | 106.25 | x | 0.76 | x | 0.7 | = | 164.92 | (77) |
| Southeast 0.9x | 0.77 | x | 1.99 | x | 106.25 | x | 0.76 | x | 0.7 | = | 77.87 | (77) |
| Southeast 0.9x | 0.77 | x | 1.54 | x | 106.25 | x | 0.76 | x | 0.7 | = | 60.25 | (77) |
| Southeast 0.9x | 0.77 | x | 1.49 | x | 106.25 | x | 0.76 | x | 0.7 | = | 58.48 | (77) |
| Southeast 0.9x | 0.77 | x | 5.55 | x | 119.01 | x | 0.76 | x | 0.7 | = | 243.65 | (77) |
| Southeast 0.9x | 0.77 | x | 2.33 | x | 119.01 | x | 0.76 | x | 0.7 | = | 102.23 | (77) |
| Southeast 0.9x | 0.77 | x | 1.44 | x | 119.01 | x | 0.76 | x | 0.7 | = | 63.27 | (77) |
| Southeast 0.9x | 0.77 | x | 3.36 | x | 119.01 | x | 0.76 | x | 0.7 | = | 147.29 | (77) |
| Southeast 0.9x | 0.77 | x | 4.21 | x | 119.01 | x | 0.76 | x | 0.7 | = | 184.72 | (77) |
| Southeast 0.9x | 0.77 | x | 1.99 | x | 119.01 | x | 0.76 | x | 0.7 | = | 87.23 | (77) |
| Southeast 0.9x | 0.77 | x | 1.54 | x | 119.01 | x | 0.76 | x | 0.7 | = | 67.48 | (77) |

## DER WorkSheet: New dwelling design stage

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Southeast | 0.9x | 0.77 | x | 1.49 | x | 119.01 | x | 0.76 | x | 0.7 | = | 65.51 | (77) |
| Southeast | 0.9x | 0.77 | x | 5.55 | x | 118.15 | x | 0.76 | x | 0.7 | = | 241.88 | (77) |
| Southeast | 0.9x | 0.77 | x | 2.33 | x | 118.15 | x | 0.76 | x | 0.7 | = | 101.49 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.44 | x | 118.15 | x | 0.76 | x | 0.7 | = | 62.81 | (77) |
| Southeast | 0.9x | 0.77 | x | 3.36 | x | 118.15 | x | 0.76 | x | 0.7 | = | 146.23 | (77) |
| Southeast | 0.9x | 0.77 | x | 4.21 | x | 118.15 | x | 0.76 | x | 0.7 | = | 183.38 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.99 | x | 118.15 | x | 0.76 | x | 0.7 | = | 86.6 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.54 | x | 118.15 | x | 0.76 | x | 0.7 | = | 66.99 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.49 | x | 118.15 | x | 0.76 | x | 0.7 | = | 65.03 | (77) |
| Southeast | 0.9x | 0.77 | x | 5.55 | x | 113.91 | x | 0.76 | x | 0.7 | = | 233.2 | (77) |
| Southeast | 0.9x | 0.77 | x | 2.33 | x | 113.91 | x | 0.76 | x | 0.7 | = | 97.85 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.44 | x | 113.91 | x | 0.76 | x | 0.7 | = | 60.56 | (77) |
| Southeast | 0.9x | 0.77 | x | 3.36 | x | 113.91 | x | 0.76 | x | 0.7 | = | 140.98 | (77) |
| Southeast | 0.9x | 0.77 | x | 4.21 | x | 113.91 | x | 0.76 | x | 0.7 | = | 176.8 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.99 | x | 113.91 | x | 0.76 | x | 0.7 | = | 83.49 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.54 | x | 113.91 | x | 0.76 | x | 0.7 | = | 64.59 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.49 | x | 113.91 | x | 0.76 | x | 0.7 | = | 62.7 | (77) |
| Southeast | 0.9x | 0.77 | x | 5.55 | x | 104.39 | x | 0.76 | x | 0.7 | = | 213.71 | (77) |
| Southeast | 0.9x | 0.77 | x | 2.33 | x | 104.39 | x | 0.76 | x | 0.7 | = | 89.67 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.44 | x | 104.39 | x | 0.76 | x | 0.7 | = | 55.5 | (77) |
| Southeast | 0.9x | 0.77 | x | 3.36 | x | 104.39 | x | 0.76 | x | 0.7 | = | 129.2 | (77) |
| Southeast | 0.9x | 0.77 | x | 4.21 | x | 104.39 | x | 0.76 | x | 0.7 | = | 162.03 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.99 | x | 104.39 | x | 0.76 | x | 0.7 | = | 76.51 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.54 | x | 104.39 | x | 0.76 | x | 0.7 | = | 59.19 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.49 | x | 104.39 | x | 0.76 | x | 0.7 | = | 57.46 | (77) |
| Southeast | 0.9x | 0.77 | x | 5.55 | x | 92.85 | x | 0.76 | x | 0.7 | = | 190.09 | (77) |
| Southeast | 0.9x | 0.77 | x | 2.33 | x | 92.85 | x | 0.76 | x | 0.7 | = | 79.76 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.44 | x | 92.85 | x | 0.76 | x | 0.7 | = | 49.36 | (77) |
| Southeast | 0.9x | 0.77 | x | 3.36 | x | 92.85 | x | 0.76 | x | 0.7 | = | 114.92 | (77) |
| Southeast | 0.9x | 0.77 | x | 4.21 | x | 92.85 | x | 0.76 | x | 0.7 | = | 144.12 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.99 | x | 92.85 | x | 0.76 | x | 0.7 | = | 68.05 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.54 | x | 92.85 | x | 0.76 | x | 0.7 | = | 52.65 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.49 | x | 92.85 | x | 0.76 | x | 0.7 | = | 51.11 | (77) |
| Southeast | 0.9x | 0.77 | x | 5.55 | x | 69.27 | x | 0.76 | x | 0.7 | = | 141.81 | (77) |
| Southeast | 0.9x | 0.77 | x | 2.33 | x | 69.27 | x | 0.76 | x | 0.7 | = | 59.5 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.44 | x | 69.27 | x | 0.76 | x | 0.7 | = | 36.82 | (77) |
| Southeast | 0.9x | 0.77 | x | 3.36 | x | 69.27 | x | 0.76 | x | 0.7 | = | 85.73 | (77) |
| Southeast | 0.9x | 0.77 | x | 4.21 | x | 69.27 | x | 0.76 | x | 0.7 | = | 107.51 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.99 | x | 69.27 | x | 0.76 | x | 0.7 | = | 50.77 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.54 | x | 69.27 | x | 0.76 | x | 0.7 | = | 39.28 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.49 | x | 69.27 | x | 0.76 | x | 0.7 | = | 38.13 | (77) |

# DER WorkSheet: New dwelling design stage

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Southeast | 0.9x | 0.77 | x | 5.55 | x | 44.07 | x | 0.76 | x | 0.7 | = | 90.22 | (77) |
| Southeast | 0.9x | 0.77 | x | 2.33 | x | 44.07 | x | 0.76 | x | 0.7 | = | 37.86 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.44 | x | 44.07 | x | 0.76 | x | 0.7 | = | 23.43 | (77) |
| Southeast | 0.9x | 0.77 | x | 3.36 | x | 44.07 | x | 0.76 | x | 0.7 | = | 54.54 | (77) |
| Southeast | 0.9x | 0.77 | x | 4.21 | x | 44.07 | x | 0.76 | x | 0.7 | = | 68.4 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.99 | x | 44.07 | x | 0.76 | x | 0.7 | = | 32.3 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.54 | x | 44.07 | x | 0.76 | x | 0.7 | = | 24.99 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.49 | x | 44.07 | x | 0.76 | x | 0.7 | = | 24.26 | (77) |
| Southeast | 0.9x | 0.77 | x | 5.55 | x | 31.49 | x | 0.76 | x | 0.7 | = | 64.46 | (77) |
| Southeast | 0.9x | 0.77 | x | 2.33 | x | 31.49 | x | 0.76 | x | 0.7 | = | 27.05 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.44 | x | 31.49 | x | 0.76 | x | 0.7 | = | 16.74 | (77) |
| Southeast | 0.9x | 0.77 | x | 3.36 | x | 31.49 | x | 0.76 | x | 0.7 | = | 38.97 | (77) |
| Southeast | 0.9x | 0.77 | x | 4.21 | x | 31.49 | x | 0.76 | x | 0.7 | = | 48.87 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.99 | x | 31.49 | x | 0.76 | x | 0.7 | = | 23.08 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.54 | x | 31.49 | x | 0.76 | x | 0.7 | = | 17.85 | (77) |
| Southeast | 0.9x | 0.77 | x | 1.49 | x | 31.49 | x | 0.76 | x | 0.7 | = | 17.33 | (77) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 11.28 | x | 0.76 | x | 0.7 | = | 70.4 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 11.28 | x | 0.76 | x | 0.7 | = | 16.01 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 11.28 | x | 0.76 | x | 0.7 | = | 10.67 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 11.28 | x | 0.76 | x | 0.7 | = | 11.58 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 11.28 | x | 0.76 | x | 0.7 | = | 10.32 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 11.28 | x | 0.76 | x | 0.7 | = | 16.24 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 11.28 | x | 0.76 | x | 0.7 | = | 11.2 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 11.28 | x | 0.76 | x | 0.7 | = | 10.59 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 22.97 | x | 0.76 | x | 0.7 | = | 143.31 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 22.97 | x | 0.76 | x | 0.7 | = | 32.58 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 22.97 | x | 0.76 | x | 0.7 | = | 21.72 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 22.97 | x | 0.76 | x | 0.7 | = | 23.57 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 22.97 | x | 0.76 | x | 0.7 | = | 21 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 22.97 | x | 0.76 | x | 0.7 | = | 33.06 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 22.97 | x | 0.76 | x | 0.7 | = | 22.79 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 22.97 | x | 0.76 | x | 0.7 | = | 21.57 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 41.38 | x | 0.76 | x | 0.7 | = | 258.2 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 41.38 | x | 0.76 | x | 0.7 | = | 58.7 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 41.38 | x | 0.76 | x | 0.7 | = | 39.13 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 41.38 | x | 0.76 | x | 0.7 | = | 42.47 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 41.38 | x | 0.76 | x | 0.7 | = | 37.83 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 41.38 | x | 0.76 | x | 0.7 | = | 59.57 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 41.38 | x | 0.76 | x | 0.7 | = | 41.07 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 41.38 | x | 0.76 | x | 0.7 | = | 38.86 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 67.96 | x | 0.76 | x | 0.7 | = | 424.03 | (81) |

# DER WorkSheet: New dwelling design stage

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 67.96 | x | 0.76 | x | 0.7 | = | 96.41 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 67.96 | x | 0.76 | x | 0.7 | = | 64.26 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 67.96 | x | 0.76 | x | 0.7 | = | 69.75 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 67.96 | x | 0.76 | x | 0.7 | = | 62.13 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 67.96 | x | 0.76 | x | 0.7 | = | 97.83 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 67.96 | x | 0.76 | x | 0.7 | = | 67.44 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 67.96 | x | 0.76 | x | 0.7 | = | 63.81 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 91.35 | x | 0.76 | x | 0.7 | = | 569.98 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 91.35 | x | 0.76 | x | 0.7 | = | 129.59 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 91.35 | x | 0.76 | x | 0.7 | = | 86.38 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 91.35 | x | 0.76 | x | 0.7 | = | 93.76 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 91.35 | x | 0.76 | x | 0.7 | = | 83.52 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 91.35 | x | 0.76 | x | 0.7 | = | 131.51 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 91.35 | x | 0.76 | x | 0.7 | = | 90.66 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 91.35 | x | 0.76 | x | 0.7 | = | 85.78 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 97.38 | x | 0.76 | x | 0.7 | = | 607.66 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 97.38 | x | 0.76 | x | 0.7 | = | 138.16 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 97.38 | x | 0.76 | x | 0.7 | = | 92.09 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 97.38 | x | 0.76 | x | 0.7 | = | 99.95 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 97.38 | x | 0.76 | x | 0.7 | = | 89.04 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 97.38 | x | 0.76 | x | 0.7 | = | 140.2 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 97.38 | x | 0.76 | x | 0.7 | = | 96.65 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 97.38 | x | 0.76 | x | 0.7 | = | 91.45 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 91.1 | x | 0.76 | x | 0.7 | = | 568.46 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 91.1 | x | 0.76 | x | 0.7 | = | 129.24 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 91.1 | x | 0.76 | x | 0.7 | = | 86.15 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 91.1 | x | 0.76 | x | 0.7 | = | 93.51 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 91.1 | x | 0.76 | x | 0.7 | = | 83.3 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 91.1 | x | 0.76 | x | 0.7 | = | 131.16 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 91.1 | x | 0.76 | x | 0.7 | = | 90.42 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 91.1 | x | 0.76 | x | 0.7 | = | 85.55 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 72.63 | x | 0.76 | x | 0.7 | = | 453.18 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 72.63 | x | 0.76 | x | 0.7 | = | 103.03 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 72.63 | x | 0.76 | x | 0.7 | = | 68.68 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 72.63 | x | 0.76 | x | 0.7 | = | 74.54 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 72.63 | x | 0.76 | x | 0.7 | = | 66.4 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 72.63 | x | 0.76 | x | 0.7 | = | 104.56 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 72.63 | x | 0.76 | x | 0.7 | = | 72.08 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 72.63 | x | 0.76 | x | 0.7 | = | 68.2 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 50.42 | x | 0.76 | x | 0.7 | = | 314.62 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 50.42 | x | 0.76 | x | 0.7 | = | 71.53 | (81) |

# DER WorkSheet: New dwelling design stage

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 50.42 | x | 0.76 | x | 0.7 | = | 47.68 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 50.42 | x | 0.76 | x | 0.7 | = | 51.75 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 50.42 | x | 0.76 | x | 0.7 | = | 46.1 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 50.42 | x | 0.76 | x | 0.7 | = | 72.59 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 50.42 | x | 0.76 | x | 0.7 | = | 50.04 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 50.42 | x | 0.76 | x | 0.7 | = | 47.35 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 28.07 | x | 0.76 | x | 0.7 | = | 175.13 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 28.07 | x | 0.76 | x | 0.7 | = | 39.82 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 28.07 | x | 0.76 | x | 0.7 | = | 26.54 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 28.07 | x | 0.76 | x | 0.7 | = | 28.81 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 28.07 | x | 0.76 | x | 0.7 | = | 25.66 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 28.07 | x | 0.76 | x | 0.7 | = | 40.41 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 28.07 | x | 0.76 | x | 0.7 | = | 27.86 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 28.07 | x | 0.76 | x | 0.7 | = | 26.36 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 14.2 | x | 0.76 | x | 0.7 | = | 88.59 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 14.2 | x | 0.76 | x | 0.7 | = | 20.14 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 14.2 | x | 0.76 | x | 0.7 | = | 13.43 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 14.2 | x | 0.76 | x | 0.7 | = | 14.57 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 14.2 | x | 0.76 | x | 0.7 | = | 12.98 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 14.2 | x | 0.76 | x | 0.7 | = | 20.44 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 14.2 | x | 0.76 | x | 0.7 | = | 14.09 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 14.2 | x | 0.76 | x | 0.7 | = | 13.33 | (81) |
| Northwest | 0.9x | 0.77 | x | 16.92 | x | 9.21 | x | 0.76 | x | 0.7 | = | 57.5 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.85 | x | 9.21 | x | 0.76 | x | 0.7 | = | 13.07 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.57 | x | 9.21 | x | 0.76 | x | 0.7 | = | 8.71 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.78 | x | 9.21 | x | 0.76 | x | 0.7 | = | 9.46 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.48 | x | 9.21 | x | 0.76 | x | 0.7 | = | 8.42 | (81) |
| Northwest | 0.9x | 0.77 | x | 3.9 | x | 9.21 | x | 0.76 | x | 0.7 | = | 13.27 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.69 | x | 9.21 | x | 0.76 | x | 0.7 | = | 9.14 | (81) |
| Northwest | 0.9x | 0.77 | x | 2.55 | x | 9.21 | x | 0.76 | x | 0.7 | = | 8.65 | (81) |
| Rooflights | 0.9x | 1 | x | 3.43 | x | 26 | x | 0.76 | x | 0.7 | = | 85.35 | (82) |
| Rooflights | 0.9x | 1 | x | 3.09 | x | 26 | x | 0.76 | x | 0.7 | = | 38.47 | (82) |
| Rooflights | 0.9x | 1 | x | 3.61 | x | 26 | x | 0.76 | x | 0.7 | = | 44.95 | (82) |
| Rooflights | 0.9x | 1 | x | 3.3 | x | 26 | x | 0.76 | x | 0.7 | = | 82.09 | (82) |
| Rooflights | 0.9x | 1 | x | 1.78 | x | 26 | x | 0.76 | x | 0.7 | = | 22.21 | (82) |
| Rooflights | 0.9x | 1 | x | 0.35 | x | 26 | x | 0.76 | x | 0.7 | = | 4.34 | (82) |
| Rooflights | 0.9x | 1 | x | 3.43 | x | 54 | x | 0.76 | x | 0.7 | = | 177.26 | (82) |
| Rooflights | 0.9x | 1 | x | 3.09 | x | 54 | x | 0.76 | x | 0.7 | = | 79.89 | (82) |
| Rooflights | 0.9x | 1 | x | 3.61 | x | 54 | x | 0.76 | x | 0.7 | = | 93.36 | (82) |
| Rooflights | 0.9x | 1 | x | 3.3 | x | 54 | x | 0.76 | x | 0.7 | = | 170.49 | (82) |
| Rooflights | 0.9x | 1 | x | 1.78 | x | 54 | x | 0.76 | x | 0.7 | = | 46.13 | (82) |

# DER WorkSheet: New dwelling design stage

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rooflights | 0.9x | 1 | x | 0.35 | x | 54 | x | 0.76 | x | 0.7 | = | 9.02 | (82) |
| Rooflights | 0.9x | 1 | x | 3.43 | x | 96 | x | 0.76 | x | 0.7 | = | 315.13 | (82) |
| Rooflights | 0.9x | 1 | x | 3.09 | x | 96 | x | 0.76 | x | 0.7 | = | 142.03 | (82) |
| Rooflights | 0.9x | 1 | x | 3.61 | x | 96 | x | 0.76 | x | 0.7 | = | 165.98 | (82) |
| Rooflights | 0.9x | 1 | x | 3.3 | x | 96 | x | 0.76 | x | 0.7 | = | 303.09 | (82) |
| Rooflights | 0.9x | 1 | x | 1.78 | x | 96 | x | 0.76 | x | 0.7 | = | 82 | (82) |
| Rooflights | 0.9x | 1 | x | 0.35 | x | 96 | x | 0.76 | x | 0.7 | = | 16.04 | (82) |
| Rooflights | 0.9x | 1 | x | 3.43 | x | 150 | x | 0.76 | x | 0.7 | = | 492.4 | (82) |
| Rooflights | 0.9x | 1 | x | 3.09 | x | 150 | x | 0.76 | x | 0.7 | = | 221.92 | (82) |
| Rooflights | 0.9x | 1 | x | 3.61 | x | 150 | x | 0.76 | x | 0.7 | = | 259.34 | (82) |
| Rooflights | 0.9x | 1 | x | 3.3 | x | 150 | x | 0.76 | x | 0.7 | = | 473.58 | (82) |
| Rooflights | 0.9x | 1 | x | 1.78 | x | 150 | x | 0.76 | x | 0.7 | = | 128.13 | (82) |
| Rooflights | 0.9x | 1 | x | 0.35 | x | 150 | x | 0.76 | x | 0.7 | = | 25.07 | (82) |
| Rooflights | 0.9x | 1 | x | 3.43 | x | 192 | x | 0.76 | x | 0.7 | = | 630.27 | (82) |
| Rooflights | 0.9x | 1 | x | 3.09 | x | 192 | x | 0.76 | x | 0.7 | = | 284.06 | (82) |
| Rooflights | 0.9x | 1 | x | 3.61 | x | 192 | x | 0.76 | x | 0.7 | = | 331.96 | (82) |
| Rooflights | 0.9x | 1 | x | 3.3 | x | 192 | x | 0.76 | x | 0.7 | = | 606.18 | (82) |
| Rooflights | 0.9x | 1 | x | 1.78 | x | 192 | x | 0.76 | x | 0.7 | = | 164 | (82) |
| Rooflights | 0.9x | 1 | x | 0.35 | x | 192 | x | 0.76 | x | 0.7 | = | 32.08 | (82) |
| Rooflights | 0.9x | 1 | x | 3.43 | x | 200 | x | 0.76 | x | 0.7 | = | 656.53 | (82) |
| Rooflights | 0.9x | 1 | x | 3.09 | x | 200 | x | 0.76 | x | 0.7 | = | 295.9 | (82) |
| Rooflights | 0.9x | 1 | x | 3.61 | x | 200 | x | 0.76 | x | 0.7 | = | 345.79 | (82) |
| Rooflights | 0.9x | 1 | x | 3.3 | x | 200 | x | 0.76 | x | 0.7 | = | 631.44 | (82) |
| Rooflights | 0.9x | 1 | x | 1.78 | x | 200 | x | 0.76 | x | 0.7 | = | 170.84 | (82) |
| Rooflights | 0.9x | 1 | x | 0.35 | x | 200 | x | 0.76 | x | 0.7 | = | 33.42 | (82) |
| Rooflights | 0.9x | 1 | x | 3.43 | x | 189 | x | 0.76 | x | 0.7 | = | 620.42 | (82) |
| Rooflights | 0.9x | 1 | x | 3.09 | x | 189 | x | 0.76 | x | 0.7 | = | 279.62 | (82) |
| Rooflights | 0.9x | 1 | x | 3.61 | x | 189 | x | 0.76 | x | 0.7 | = | 326.77 | (82) |
| Rooflights | 0.9x | 1 | x | 3.3 | x | 189 | x | 0.76 | x | 0.7 | = | 596.71 | (82) |
| Rooflights | 0.9x | 1 | x | 1.78 | x | 189 | x | 0.76 | x | 0.7 | = | 161.44 | (82) |
| Rooflights | 0.9x | 1 | x | 0.35 | x | 189 | x | 0.76 | x | 0.7 | = | 31.58 | (82) |
| Rooflights | 0.9x | 1 | x | 3.43 | x | 157 | x | 0.76 | x | 0.7 | = | 515.38 | (82) |
| Rooflights | 0.9x | 1 | x | 3.09 | x | 157 | x | 0.76 | x | 0.7 | = | 232.28 | (82) |
| Rooflights | 0.9x | 1 | x | 3.61 | x | 157 | x | 0.76 | x | 0.7 | = | 271.44 | (82) |
| Rooflights | 0.9x | 1 | x | 3.3 | x | 157 | x | 0.76 | x | 0.7 | = | 495.68 | (82) |
| Rooflights | 0.9x | 1 | x | 1.78 | x | 157 | x | 0.76 | x | 0.7 | = | 134.11 | (82) |
| Rooflights | 0.9x | 1 | x | 0.35 | x | 157 | x | 0.76 | x | 0.7 | = | 26.23 | (82) |
| Rooflights | 0.9x | 1 | x | 3.43 | x | 115 | x | 0.76 | x | 0.7 | = | 377.51 | (82) |
| Rooflights | 0.9x | 1 | x | 3.09 | x | 115 | x | 0.76 | x | 0.7 | = | 170.14 | (82) |
| Rooflights | 0.9x | 1 | x | 3.61 | x | 115 | x | 0.76 | x | 0.7 | = | 198.83 | (82) |
| Rooflights | 0.9x | 1 | x | 3.3 | x | 115 | x | 0.76 | x | 0.7 | = | 363.08 | (82) |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rooflights 0.9x | 1 | x | 1.78 | x | 115 | x | 0.76 | x | 0.7 | = | 98.23 | (82) |
| Rooflights 0.9x | 1 | x | 0.35 | x | 115 | x | 0.76 | x | 0.7 | = | 19.22 | (82) |
| Rooflights 0.9x | 1 | x | 3.43 | x | 66 | x | 0.76 | x | 0.7 | = | 216.66 | (82) |
| Rooflights 0.9x | 1 | x | 3.09 | x | 66 | x | 0.76 | x | 0.7 | = | 97.65 | (82) |
| Rooflights 0.9x | 1 | x | 3.61 | x | 66 | x | 0.76 | x | 0.7 | = | 114.11 | (82) |
| Rooflights 0.9x | 1 | x | 3.3 | x | 66 | x | 0.76 | x | 0.7 | = | 208.38 | (82) |
| Rooflights 0.9x | 1 | x | 1.78 | x | 66 | x | 0.76 | x | 0.7 | = | 56.38 | (82) |
| Rooflights 0.9x | 1 | x | 0.35 | x | 66 | x | 0.76 | x | 0.7 | = | 11.03 | (82) |
| Rooflights 0.9x | 1 | x | 3.43 | x | 33 | x | 0.76 | x | 0.7 | = | 108.33 | (82) |
| Rooflights 0.9x | 1 | x | 3.09 | x | 33 | x | 0.76 | x | 0.7 | = | 48.82 | (82) |
| Rooflights 0.9x | 1 | x | 3.61 | x | 33 | x | 0.76 | x | 0.7 | = | 57.06 | (82) |
| Rooflights 0.9x | 1 | x | 3.3 | x | 33 | x | 0.76 | x | 0.7 | = | 104.19 | (82) |
| Rooflights 0.9x | 1 | x | 1.78 | x | 33 | x | 0.76 | x | 0.7 | = | 28.19 | (82) |
| Rooflights 0.9x | 1 | x | 0.35 | x | 33 | x | 0.76 | x | 0.7 | = | 5.51 | (82) |
| Rooflights 0.9x | 1 | x | 3.43 | x | 21 | x | 0.76 | x | 0.7 | = | 68.94 | (82) |
| Rooflights 0.9x | 1 | x | 3.09 | x | 21 | x | 0.76 | x | 0.7 | = | 31.07 | (82) |
| Rooflights 0.9x | 1 | x | 3.61 | x | 21 | x | 0.76 | x | 0.7 | = | 36.31 | (82) |
| Rooflights 0.9x | 1 | x | 3.3 | x | 21 | x | 0.76 | x | 0.7 | = | 66.3 | (82) |
| Rooflights 0.9x | 1 | x | 1.78 | x | 21 | x | 0.76 | x | 0.7 | = | 17.94 | (82) |
| Rooflights 0.9x | 1 | x | 0.35 | x | 21 | x | 0.76 | x | 0.7 | = | 3.51 | (82) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (83)m= | 731.65 | 1402.04 | 2292.82 | 3404.42 | 4281.11 | 4443.55 | 4204.48 | 3529.08 | 2678.72 | 1654.32 | 905.66 | 606.65 | (83) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (84)m= | 1665.6 | 2333.1 | 3189.96 | 4245.09 | 5060.57 | 5167.38 | 4894.39 | 4226.82 | 3407.45 | 2439.78 | 1756.33 | 1509.94 | (84) |

## 7. Mean internal temperature (heating season)

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

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

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (86)m= | 1 | 1 | 1 | 0.97 | 0.85 | 0.62 | 0.46 | 0.55 | 0.88 | 1 | 1 | 1 | (86) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (87)m= | 19.79 | 19.96 | 20.24 | 20.63 | 20.9 | 20.99 | 21 | 21 | 20.91 | 20.51 | 20.08 | 19.78 | (87) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (88)m= | 20.16 | 20.17 | 20.17 | 20.19 | 20.2 | 20.21 | 20.21 | 20.22 | 20.21 | 20.2 | 20.19 | 20.18 | (88) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (89)m= | 1 | 1 | 1 | 0.96 | 0.8 | 0.55 | 0.38 | 0.46 | 0.83 | 0.99 | 1 | 1 | (89) |

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (90)m= | 19.03 | 19.2 | 19.49 | 19.89 | 20.13 | 20.21 | 20.21 | 20.22 | 20.15 | 19.77 | 19.34 | 19.03 | (90) |

fLA = Living area ÷ (4) = | 0.06 | (91)

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

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (92)m= | 19.07 | 19.24 | 19.53 | 19.93 | 20.18 | 20.26 | 20.26 | 20.27 | 20.2 | 19.81 | 19.39 | 19.08 | (92) |

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

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| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (93)m= | 19.07 | 19.24 | 19.53 | 19.93 | 20.18 | 20.26 | 20.26 | 20.27 | 20.2 | 19.81 | 19.39 | 19.08 | (93) |

## 8. Space heating requirement

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

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Utilisation factor for gains, hm: | | | | | | | | | | | | | |
| (94)m= | 1 | 1 | 1 | 0.96 | 0.8 | 0.55 | 0.38 | 0.46 | 0.83 | 0.99 | 1 | 1 | (94) |
| Useful gains, hmGm , W = (94)m x (84)m | | | | | | | | | | | | | |
| (95)m= | 1665.52 | 2332.11 | 3176.76 | 4069.24 | 4055.11 | 2856.66 | 1866.1 | 1954.21 | 2822.03 | 2423.67 | 1755.98 | 1509.9 | (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= | 8056.68 | 7783.95 | 7036.96 | 5807.69 | 4440.34 | 2886.31 | 1868.35 | 1961.34 | 3144.91 | 4825.5 | 6501.1 | 7951.86 | (97) |
| Space heating requirement for each month, kWh/month = 0.024 x [(97)m – (95)m] x (41)m | | | | | | | | | | | | | |
| (98)m= | 4755.03 | 3663.64 | 2871.99 | 1251.69 | 286.61 | 0 | 0 | 0 | 0 | 1786.96 | 3416.48 | 4792.82 | |

Total per year (kWh/year) = Sum(98)1...5,9...12 = 22825.21 (98)

Space heating requirement in kWh/m²/year 37.81 (99)

## 8c. Space cooling requirement

Calculated for June, July and August. See Table 10b

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heat loss rate Lm (calculated using 25°C internal temperature and external temperature from Table 10) | | | | | | | | | | | | | |
| (100)m= | 0 | 0 | 0 | 0 | 0 | 4795.48 | 3775.16 | 3856.62 | 0 | 0 | 0 | 0 | (100) |
| Utilisation factor for loss hm | | | | | | | | | | | | | |
| (101)m= | 0 | 0 | 0 | 0 | 0 | 0.94 | 0.97 | 0.95 | 0 | 0 | 0 | 0 | (101) |
| Useful loss, hmLm (Watts) = (100)m x (101)m | | | | | | | | | | | | | |
| (102)m= | 0 | 0 | 0 | 0 | 0 | 4499.61 | 3674.49 | 3646.83 | 0 | 0 | 0 | 0 | (102) |
| Gains (solar gains calculated for applicable weather region, see Table 10) | | | | | | | | | | | | | |
| (103)m= | 0 | 0 | 0 | 0 | 0 | 5907.81 | 5602.3 | 4885.66 | 0 | 0 | 0 | 0 | (103) |
| *Space cooling requirement for month, whole dwelling, continuous ( kWh) = 0.024 x [(103)m – (102)m ] x (41)m* set (104)m to zero if (104)m < 3 × (98)m | | | | | | | | | | | | | |
| (104)m= | 0 | 0 | 0 | 0 | 0 | 1013.91 | 1434.3 | 921.69 | 0 | 0 | 0 | 0 | |

Total = Sum(104)6...8 = 3369.89 (104)

Cooled fraction f C = cooled area ÷ (4) = 0.5 (105)

Intermittency factor (Table 10b)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (106)m= | 0 | 0 | 0 | 0 | 0 | 0.25 | 0.25 | 0.25 | 0 | 0 | 0 | 0 |

*Total = Sum(104)6...8* = 0 (106)

Space cooling requirement for month = (104)m × (105) × (106)m

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (107)m= | 0 | 0 | 0 | 0 | 0 | 125.59 | 177.66 | 114.16 | 0 | 0 | 0 | 0 |

Total = Sum(107)6...8 = 417.41 (107)

Space cooling requirement in kWh/m²/year (107) ÷ (4) = 0.69 (108)

## 9b. Energy requirements – Community heating scheme

This part is used for space heating, space cooling or water heating provided by a community scheme.

Fraction of space heat from secondary/supplementary heating (Table 11) '0' if none 0 (301)

Fraction of space heat from community system 1 – (301) = 1 (302)

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*The community scheme may obtain heat from several sources. The procedure allows for CHP and up to four other heat sources; the latter includes boilers, heat pumps, geothermal and waste heat from power stations. See Appendix C.*

| | | | |
|---|---|---|---|
| Fraction of heat from Community heat pump | | 1 | (303a) |
| Fraction of total space heat from Community heat pump | (302) x (303a) = | 1 | (304a) |
| Factor for control and charging method (Table 4c(3)) for community heating system | | 1.05 | (305) |
| Distribution loss factor (Table 12c) for community heating system | | 1.5 | (306) |
| **Space heating** | | **kWh/year** | |
| Annual space heating requirement | | 22825.21 | |
| Space heat from Community heat pump | (98) x (304a) x (305) x (306) = | 35949.71 | (307a) |
| Efficiency of secondary/supplementary heating system in % (from Table 4a or Appendix E) | | 0 | (308 |
| Space heating requirement from secondary/supplementary system | (98) x (301) x 100 ÷ (308) = | 0 | (309) |
| **Water heating** | | | |
| Annual water heating requirement | | 2228.3 | |
| If DHW from community scheme: | | | |
| If DHW by immersion or instantaneous heater within dwelling: | | | |
| Efficiency of water heater | | 100 | (311) |
| Water heated by immersion or instantaneous heater | (64) x 100 ÷ (311) = | 2228.3 | (312) |
| Electricity used for heat distribution | 0.01 × [(307a)…(307e) + (310a)…(310e)] = | 359.5 | (313) |
| Cooling System Energy Efficiency Ratio | | 3.87 | (314) |
| Space cooling (if there is a fixed cooling system, if not enter 0) | = (107) ÷ (314) = | 107.72 | (315) |
| Electricity for pumps and fans within dwelling (Table 4f): | | | |
| mechanical ventilation - balanced, extract or positive input from outside | | 4285.23 | (330a) |
| warm air heating system fans | | 0 | (330b) |
| pump for solar water heating | | 0 | (330g) |
| Total electricity for the above, kWh/year | =(330a) + (330b) + (330g) = | 4285.23 | (331) |
| Energy for lighting (calculated in Appendix L) | | 1132.62 | (332) |

## 12b. CO2 Emissions – Community heating scheme

| | | Energy kWh/year | Emission factor kg CO2/kWh | | Emissions kg CO2/year | |
|---|---|---|---|---|---|---|
| CO2 from other sources of space and water heating (not CHP) | | | | | | |
| Efficiency of heat source 1 (%) | If there is CHP using two fuels repeat (363) to (366) for the second fuel | | | | 361 | (367a) |
| CO2 associated with heat source 1 | [(307b)+(310b)] x 100 ÷ (367b) x | | 0.52 | = | 5168.39 | (367) |
| Electrical energy for heat distribution | [(313) x | | 0.52 | = | 186.58 | (372) |
| Total CO2 associated with community systems | (363)…(366) + (368)...(372) | | | = | 5354.97 | (373) |
| CO2 associated with space heating (secondary) | (309) x | | 0 | = | 0 | (374) |
| CO2 associated with water from immersion heater or instantaneous heater | (312) x | | 0.52 | = | 1156.49 | (375) |
| Total CO2 associated with space and water heating | (373) + (374) + (375) = | | | | 6511.46 | (376) |
| CO2 associated with space cooling | (315) x | | 0.52 | = | 55.91 | (377) |
| CO2 associated with electricity for pumps and fans within dwelling | (331)) x | | 0.52 | = | 2224.03 | (378) |

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| | | | | | |
|---|---|---|---|---|---|
| CO2 associated with electricity for lighting | (332))) x | 0.52 | = | 587.83 | (379) |
| **Total CO2, kg/year** | sum of (376)…(382) = | | | 9379.23 | (383) |
| **Dwelling CO2 Emission Rate** | (383) ÷ (4) = | | | 15.53 | (384) |
| **EI rating (section 14)** | | | | 80.63 | (385) |