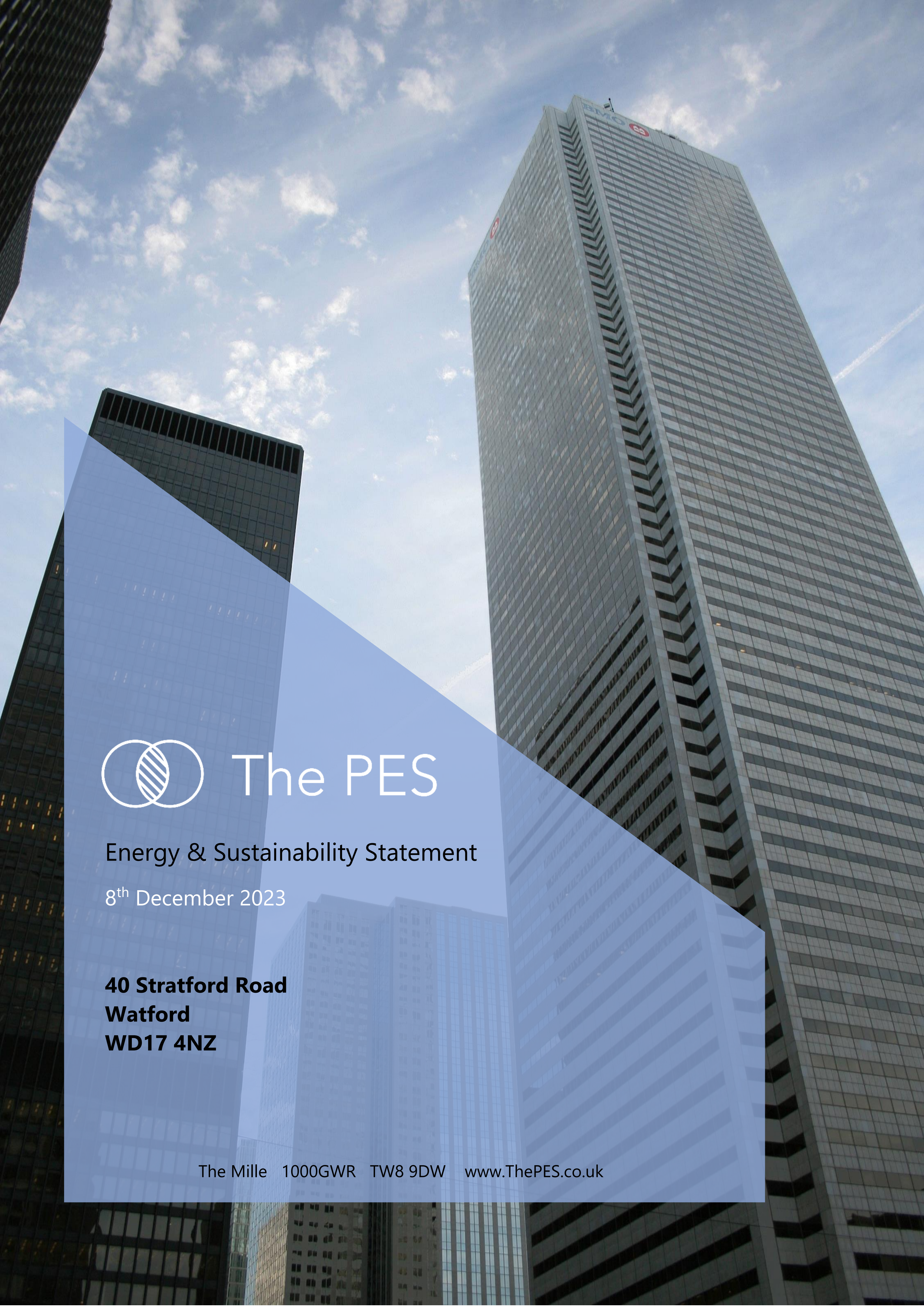

The PES

Energy & Sustainability Statement

8th December 2023

40 Stratford Road
Watford
WD17 4NZ

The Mille 1000GWR TW8 9DW www.ThePES.co.uk

The PES

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1.0 Executive Summary

The proposed development project at 40 Stratford Road involves the development of a 3 x new build detached dwellings

The residential development project has been designed to achieve the highest of environmental performance standards following the Energy Hierarchy in order to comply with national policies and the Local Plan Policies of Watford Borough Council.

'Lean, Clean, Green' approach has been adopted and the development achieves an overall improvement (DER/TER) in regulated emissions at over **84%** above Part L 2021 standard, through the adoption of very high standards of insulation, with heat pump driven heating and hot water systems.

2.0 The Site & Proposal

The development site is located on the corner of Stratford Road and Langley Road.

The proposed development project for the demolition of the existing dwelling on site and the erection of 3 x new build dwellings.

2.1 Local Planning Context

The site sits within the administrative boundaries of Watford Borough

Watford Borough Council adopted the Watford Local Plan 2021-2038 on 17 October 2022.

Policy CC8.1: Mitigating Climate Change and Reducing Carbon Emissions

The Council will support proposals that help combat climate change and ensure the borough becomes more resilient, sustainable and adaptable to climate change. New development will need to demonstrate how it is contributing positively towards:

A carbon neutral Watford

Developments are expected to contribute towards the borough becoming carbon neutral and reducing the overall environmental impact.

Sustainable construction

Proposals need to consider how they will affect the environment from start to finish including the construction process and how occupants will use the building and surrounding area.

New buildings

New buildings will need to be high quality, use resources efficiently, reduce pollution, be safe to live in and encourage healthy lifestyles.

Cumulative development

New development should consider opportunities associated with cumulative development. This includes materials used in construction, the layout of the scheme and measures that will create a comfortable micro-climate such as light, shading and landscaping.

Low carbon and renewable energy

On site low carbon and renewable energy technologies will be encouraged, particularly where the scale of growth can support community energy networks.

Policy CC8.3: Sustainable Construction and Resource Management

Energy efficiency

To minimise the impact of new homes on the environment, residential developments should:
a) Be designed so they can be adapted to be carbon neutral;
b) Avoid overheating and use passive ventilation when possible; and
c) Achieve a 19% improvement for carbon emissions over the target emission rate (TER) as set out in National Building Regulations Part L (2013) , or any updated government standards, whichever results in a higher target.

Proposals that do not meet the energy efficiency target will only be supported if it is unfeasible and a financial contribution is made towards the Carbon Offset Fund to provide equivalent carbon savings off site.

Water efficiency

All residential developments should meet the technical standard for water efficiency of 110 litres per person, per day.

In new, non-residential developments, that are unable to achieve BREEAM 'excellent' standard, water conservation measures should be incorporated to reduce water consumption to a standard equivalent to BREEAM 'very good' for the appropriate building typology.

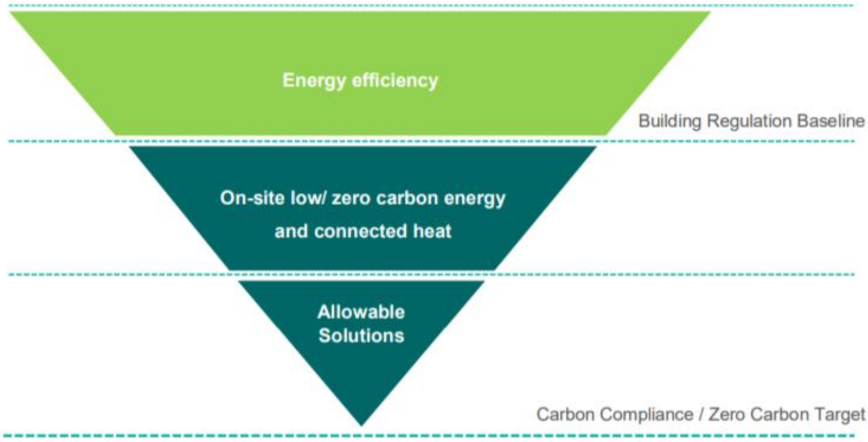
Materials and waste management

Development proposals should reduce construction waste through the re-use and recycling of materials. Practices undertaken should reflect the Hertfordshire Waste Hierarchy. As part of an application, applicants should set out how waste management of the site is in accordance with the Hertfordshire Waste Local Plan.

2.2 The Energy Hierarchy

In order to assess the overall efficiency of the proposed retirement village, this report will utilise the principles of the energy hierarchy as set out below; the 3 stages being:-

- Be lean: use less energy and manage demand during construction and operation.
- Be clean: exploit local energy resources (such as secondary heat) and supply energy efficiently and cleanly.
- Be green: generate, store and use renewable energy on-site.


Energy efficiency
Building Regulation Baseline
On-site low/ zero carbon energy and connected heat
Allowable Solutions
Carbon Compliance / Zero Carbon Target

3.0 Baseline energy results

The first stage of the Mayor's Energy Hierarchy is to consider the baseline energy model.

The following section details the baseline energy requirements for the development – the starting point when considering the energy hierarchy.

3.1 New Build Dwellings

For the new build dwelling, baseline emission levels – the Target Emission Rate (TER) - is obtained by applying the design to a reference 'notional' building the characteristics of which are set by regulations – SAP10.2; The new Part L Building Regulations 2021 came into force in June 2022 and introduced a completely new notional dwelling as detailed below:-

Table 1.1 Summary of notional dwelling specification for new dwelling[1]

Element or system	Reference value for target setting
Opening areas (windows, roof windows, rooflights and doors)	Same as for actual dwelling not exceeding a total area of openings of 25% of total floor area[2]
External walls including semi-exposed walls	U = 0.18 W/(m²K)
Party walls	U = 0
Floors	U = 0.13 W/(m²K)
Roofs	U = 0.11 W/(m²K)
Opaque door (less than 30% glazed area)	U = 1.0 W/(m²K)
Semi-glazed door (30–60% glazed area)	U = 1.0 W/(m²K)
Windows and glazed doors with greater than 60% glazed area	U = 1.2 W/(m²K) Frame factor = 0.7
Roof windows	U = 1.2 W/(m²K), when in vertical position (for correction due to angle, see specification in SAP 10 Appendix R)
Rooflights	U = 1.7 W/(m²K), when in horizontal position (for correction due to angle, see specification in SAP 10 Appendix R)
Ventilation system	Natural ventilation with intermittent extract fans
Air permeability	5 m³/(h·m²) at 50 Pa
Main heating fuel (space and water)	Mains gas
Heating system	Boiler and radiators Central heating pump 2013 or later, in heated space Design flow temperature = 55 °C
Boiler	Efficiency, SEDBUK 2009 = 89.5%
Heating system controls	Boiler interlock, ErP Class V Either: – single storey dwelling in which the living area is greater than 70% of the total floor area: programmer and room thermostat – any other dwelling: time and temperature zone control, thermostatic radiator valves
Hot water system	Heated by boiler (regular or combi as above) Separate time control for space and water heating
Wastewater heat recovery (WWHR)	All showers connected to WWHR, including showers over baths Instantaneous WWHR with 36% recovery efficiency utilisation of 0.98
Hot water cylinder	If cylinder, declared loss factor = $0.85 \times (0.2 + 0.051 V^{2/3})$ kWh/day where V is the volume of the cylinder in litres
Lighting	Fixed lighting capacity (lm) = 185 x total floor area Efficacy of all fixed lighting = 80 lm/W
Air conditioning	None
Photovoltaic (PV) system	For houses: kWp = 40% of ground floor area, including unheated spaces / 6.5 For flats: kWp = 40% of dwelling floor area / (6.5 x number of storeys in block) System facing south-east or south-west

NOTE:
1. For a dwelling connected to an existing district heat network, an alternative notional building is used. See paragraph 1.8 and SAP 10.
2. See SAP 10 for details.

SAP first creates the notional reference building, based upon the same shape and form as the proposed dwelling and applies the above the characteristics as defined in SAP10.2, prior to applying the actual construction and HVAC solution of the proposed dwellings to generate the Dwelling Emission Rate (DER).

For the Stratford Road project, a single dwelling has been selected to inform the energy strategy and inform the projected energy and CO_2 reductions.

3.2 Baseline Results

The baseline building results – the Target Emission Rate have been calculated in line with Part L2021/SAP10.2 emission standards and are presented in Table 2 below. The SAP outputs (which summarise the key data) are attached at **Appendix A**.

Table 2 – Baseline energy consumption and CO2 emissions

Unit	Target Emission Rate (regulated energy use) Kg/sqm/annum	Total baseline emissions Kg
Unit 1	25.46	4,277
Total		**4,277**

4.0 Design for energy efficiency

The first step in the 'Energy Hierarchy' as laid out under 2.2 above, requires that buildings be designed to use improved energy efficiency measures – Be Lean. This will reduce demand for heating, cooling, and lighting, and therefore reduce operational costs while also minimizing associated carbon dioxide emissions.

This section sets out the measures included within the design of the development, to reduce the demand for energy, both gas and electricity (not including energy from renewable sources). The table at the end of this section details the amount of energy used and CO_2 produced by the building after the energy efficiency measures have been included. From these figures the overall reduction in CO_2 emissions, as a result of passive design measures, can be calculated. To achieve reductions in energy demand the following measures have been included within the design and specification of the building:

4.1 Passive Design

The National Planning Policy Framework emphasises the need to take account of climate change over the longer term and plan new developments to avoid increased vulnerability to the range of impacts arising from climate change. The UK Climate Impacts Programme 2009 projections suggest that by the 2080's the UK is likely to experience summer temperatures that are up to 4.2°C higher than they are today.

Accordingly, designers are to ensure buildings are designed and constructed to be comfortable in higher temperatures, without resorting to energy intensive air conditioning.

The project at 40 Stratford Road has had been designed to ensure the building is not vulnerable to overheating; to instigate consideration of the risk of overheating within the proposed development, the design team have followed the guidance within the Cooling Hierarchy:-

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

The project will be designed to best practice thermal insulation levels as noted, full details of which are noted under 4.3 below.

Not only does good insulation assist in reducing heat losses in the winter, but it also has a significant impact on preventing heat travelling through the build fabric during the summer.

2. **reduce the amount of heat entering a building in summer through orientation, shading, albedo, fenestration, insulation and green roofs and wall**

The Stratford Road site is located on a corner plot with an south east/north east aspect in a low rise suburban context – with very little benefit from topographical shading.

The houses are orientated to the aspects as above, with the main livings areas having dual aspects; the lack of a truly southern aspect will limit the levels of excessive mid-summer solar gains, yet large glazed area are able to harvest useful solar gain.

All other areas – bedrooms and bathrooms – have reduced glazing areas to limit heat losses.

Glazing specification has been considered as part of the overheating risk and the specified new glazing will achieve a g-value of 0.57 or better in order to assist in further reducing overheating risk from excessive solar gain.

3. **manage the heat within the building through exposed internal thermal mass and high ceilings**

The new build structures will be of a brick/block construction offering significant thermal mass able to absorb heat during the summer months, which can then be ventilated during the evening or overnight via the above ventilation strategy.

4. **passive ventilation**

All glazing across the scheme is designed to have opening areas to introduce high levels of natural levels of "purge" ventilation to further assist in the reduction of overheating risks in appropriate areas.

All the properties are able to fully cross – ventilate and as all bedrooms are at first floor level, there will be no opening restrictions associated with AD Part O.

5. **mechanical ventilation**

Given the passive design strategy highlighted above, combined with the project location, a natural ventilation strategy is to be employed.

4.2 Heating System

The "notional" heating system considered under the "be lean – use less energy" section of the Energy Hierarchy, will assume the use of gas fired LTHW systems, assuming the Part L minimum efficiency at 92% whilst also providing the domestic hot water (DHW)

4.3 Fabric heat loss

Insulation measures will be utilised to ensure the calculated U-values exceed the Building Regulations minima, with specific guidance taken from the design team: -

- New wall constructions will target a U-Value of 0.15W/m^{2}k or better.
- New pitched roof constructions are to be of a warm-roof type, achieving a U-Value of 0.11W/m^{2}k.
- The newly laid floors will achieve a minimum u value of 0.12W/m^{2}k subject to perimeter/area ratios

Glazing

- The new glazing for windows and doors will be triple glazed with an area weighted average U-Value of 1.0W/m^{2}K or better.

Air Tightness

- The project be tested to 4m^3/hr/m^2 in line with best practice for naturally ventilated buildings.

Construction Details

- Heat loss via non-repeating thermal bridging within the new build elements will be minimised by the use of approved construction details. An overall Y-Value <0.05 is targeted.

The above passive design measures and fabric standards achieve an improvement in dwelling fabric efficiency at **35%** over the Part L2021 minimum standard.

4.4 Ventilation

As noted above, the project will assume a natural ventilation – using trickle vents and opening windows, with wet room extraction.

4.5 Lighting and appliances

The development will incorporate high efficiency light fittings utilising LED lamps.

The use of LED lighting will also minimise the internal gains commonly associated with tungsten and fluorescent lighting systems and thereby further reduce the potential for the residential units to overheat.

External lighting will utilise daylight controls to ensure lights are not active during the day.

5.0 Supplying Energy Efficiently

5.1 Community Heating/Combined Heat and Power (CHP)

The second stage in the Energy Hierarchy is to ensure efficient and low carbon energy supply – Be Clean. In particular, this concerns provision of decentralised energy where practical and appropriate.

This report must consider the availability – now or in the future – of heat networks in the Stratford Road area.

At time of writing, there is no proposed heat network for this location, nor is there any awareness of likelihood of same, given the location remote from central Watford and the low rise housing density.

Clearly there is very little to no potential for the project site to connect to a DEN in the future, however, consideration should be given to the potential for an on-site solution.

5.2 On-site CHP/District Heating

A community heating network comprises a series of insulated pipes used to deliver heat, in the form of hot water or steam, to a number of different locations or dwellings. They range from small, providing heat to a house and a couple of holiday cottages for example, to large scale systems supplying housing estates or blocks of flats.

The heat production facility for a DH scheme is generally considered to include heat only boilers (HOB) and/or the production of both electricity and heat i.e. CHP.

CHP systems are essentially biomass or fossil fuel fired electricity generators that use the heat by-product to provide space and water heating. The electricity generated can be used directly within the host buildings or sold to electricity suppliers on the national grid.

CHP is, as a rule of thumb, is only operated as a base load as, depending on the technology, it may be difficult and/or inefficient to operate according to daily variations in demand. In a well-designed district heating network heat from CHP will provide between 60% and 80% of the annual baseline heat (heating and hot water) requirement with heat-only boiler plants providing the peak load and back-up. To maximise efficiency of the engine it needs to run for at least 17 hours a day; therefore, the heat load needs to be present for this period.

Clearly, as a small scale residential development, with only the limited year round DHW demand to support a CHP installation (approx. 2-4 hours per day in the May – October period), the economy of scale, in terms of year-round demand, simply isn't present and as such the potential use of on-site CHP is very limited.

6.0 Renewable Energy Options

The final element of the Mayor's 'Energy Hierarchy' requires development proposals should provide a reduction in expected carbon dioxide emissions through the use of on-site renewable energy generation, where feasible – Be Green.

Renewable energy can be defined as energy taken from naturally occurring or renewable sources, such as sunlight, wind, wave's tides, geothermal etc. Harnessing these energy sources can involve a direct use of natural energy, such as solar water heating panels, or it can be a more indirect process, such as the use of Biofuels produced from plants, which have harnessed and embodied the suns energy through photosynthesis.

The energy efficiency measures and the sourcing the energy efficiently outlined above have the most significant impact on the heating and hot water energy requirements for the development, and the associated reduction in energy consumption.

This section then sets out the feasibility of implementing different energy technologies in consideration of: -

- Potential for Carbon savings
- Capital costs
- Running costs
- Payback period as a result of energy saved/Government incentives
- Maturity/availability of technology
- Reliability of the technology and need for back up or alternative systems.

6.1 Government incentives

6.1.1 Smart Export Guarantee (SEG)

Introduced in 2020, the SEG will enable solar photovoltaic (PV), wind, hydro and anaerobic digestion (AD) installations up to 5MW and micro-combined heat and power (micro-CHP) up to 50kW will be able to receive an export tariff under the policy.

The SEG is a market-led initiative, requiring electricity supply licensees to offer export tariffs to eligible generators. Suppliers are free to set their own SEG compliant tariff price (provided it is above zero pence at all times) and decide how their tariffs work.

Installation owners are able to shop around and select the Licensee of their choice based upon an offer of the most appropriate tariff.

Payment are made against metered exports only.

6.1.1 Renewable Heat Incentive

The Renewable Heat Incentive (RHI) was formally withdrawn for all new projects in March 2022.

6.2 Wind turbines

Wind turbines come in two main types'- horizontal axis and vertical axis. The more traditional horizontal axis systems rotate around the central pivot to face into the wind, whilst vertical axis systems work with wind from all directions.

The potential application of wind energy technologies at a particular site is dependent upon a variety of factors. But mainly these are: -

- Wind speed
- Wind turbulence
- Visual impact
- Noise impact
- Impact upon ecology

The availability and consistency of wind in urban environments is largely dependent upon the proximity, scale and orientation of surrounding obstructions. The site has a relatively open aspect, but does have dwellings on the boundaries.

However, the visual impact of large scale wind turbines would be considered unacceptable when proposed in an ad-hoc manner and it is inconceivable that any wind turbines of this size would be considered acceptable in this location.

6.3 Solar Energy

The proposed development has areas of pitched roof that could accommodate solar panels orientated to the south west.

In general, the roofs will have an unrestricted aspect, so there is scope therefore to site solar photovoltaic (PV) or water heating equipment at roof level.

6.3.1 Solar water heating

Solar water heating panels come in two main types; flat plate collectors and evacuated tubes. Flat plate collectors feed water, or other types of fluid used specifically to carry heat, through a roof mounted collector and into a hot water storage tank. Evacuated tube collectors are slightly more advanced as they employ sealed vacuum tubes, which capture and harness the heat more effectively.

Both collector types can capture heat whether the sky is overcast or clear. Depending on location, approximately 900–1100 kWh of solar energy falls on each m^2 of unshaded UK roof surface annually. The usable energy output per m^2 of solar panel as a result of this amount of insolation ranges from between 380 – 550 kWh/yr.

Solar hot water systems are of course, displacing heat pumps for DHW provision (as noted below), and due to the efficiency as a source of energy, solar thermal systems tend to have a very poor pay back model unless there is a reliable and consultant demand for hot water; a medium size residential led scheme simply does not provide this.

Accordingly, given the limited roof space available and the strategy to off-set the electrical use, solar PV may be a stronger candidate (see below) and offer a greater return in terms of a return on investment.

6.3.2 Photovoltaics (PV)

A 1kWp (1 kilowatt peak) system in the UK could be expected to produce between 790-800kWh of electricity per year based upon a south east orientation according to SAP2005 methodology used by the Microgeneration Certification Scheme (MCS). The figure given in the London Renewables Toolkit is 783 kWh per year for a development in London.

Despite the withdrawal of the Feed in Tariff, the returns on PV installations are still able to achieve 6-7% returns via the reduction in (ever more expensive) electricity consumption.

Accordingly, the design team are proposing a 4 panel PV for each dwelling – the total array generating some 4,000kWh/annum.

6.4 Biomass heating

Biomass is a term given to fuel derived directly from biological sources for example rapeseed oil, wood chip/pellets or gas from anaerobic digestion. It can only be considered as a renewable energy source if the carbon dioxide emitted from burning the fuel is later recaptured in reproducing the fuel source (i.e. trees that are grown to become wood fuel, capture carbon as they grow).

Biomass heating systems require space to site a boiler and fuel hopper along with a supply of fuel – which can be very bulky items. There also needs to be a local source of biomass fuel that can be delivered on a regular basis. There are also issues with fuel storage and delivery which mitigate against this technology.

Additionally, a boiler of this type would replace the need for a conventional gas boiler and therefore offset all the gas energy typically used for space and water heating. However, biomass releases high levels of NO_x emissions and particulate matters, as well as other pollutants and would therefore have to be considered carefully against the high standard of air quality requirements within the locality – a matter of increasing sensitivity. Accordingly, the use of biomass is not considered appropriate for this project.

6.5 Ground source heat pump

All heat pump technologies utilise electricity as the primary fuel source – in this case displacing gas, as such, the overall reduction in emissions when using this technology can be less effective when opposed to a technology that is actually displacing electricity.

Ground source heating or cooling requires a source of consistent ground temperature, which could be a vertical borehole or a spread of pipework loops and a 'heat pump'. The system uses a loop of fluid to collect the more constant temperature in the ground and transport it to a heat pump. In a cooling system this principle works in reverse and the heat is distributed into the ground.

The heat pump then generates increased temperatures by 'condensing' the heat taken from the ground, producing hot water temperatures in the region of 45°C. This water can then be used as pre-heated water for a conventional boiler or to provide space heating with an under-floor heating system.

The use of a ground source heating/cooling system will therefore require:

- Vertical borehole or ground loop
- Use of under floor heating
- Space for heat pump unit

The new dwellings at Stratford Road do not have the available external space to install low level ground collectors and deep bore solutions are highly expensive given the heat load required for this small residential scheme.

Accordingly, ground source heating would be considered inappropriate, particularly in light of the more flexible option offered by air source heating:-

6.6 Air source heat pump

Air source heating or cooling also employs the principle of a heat pump. This time either, upgrading the ambient external air temperature to provide higher temperatures for water and space heating, or taking warmth from within the building and dissipating it to the outdoor air.

It must be remembered that heat pumps utilise grid based electricity, so calculations base the benefits on SAP10.2 emissions data

Assuming a seasonal system efficiency of 320% (Coefficient of Performance of 3.2) and that the air source heat pump will replace 100% of the space heating/hot water demand, then the system would reduce the overall CO_2 emissions by approximately 70%. The table below demonstrates, on the assumption of a demand of 1000Kwh/year for heating and hot water.

Table 4 – Air Source Heat Pump Performance

Type of Array	Energy Consumption (kWh/yr.)	Emission factor ($kgCO_2/h$)	Total CO_2 emissions (kg/annum)
90% efficient gas boiler	11111	0.210	2333
320% efficient ASHP	2813	0.136	383
100% efficient immersion (back-up)	1000	0.136	136

A theoretical carbon saving of 77%

With the above data in mind, clearly an ASHP could be an option and the "be green" proposals include the use of air source heat pumps to provide the heat source for the dwellings' LTHW heating and DHW systems.

Overall system efficiency has been advised at 350% and this figure has been used for the communal heating systems within the final energy calculations.

6.7 Final Emissions Calculation

Given the outcome of the feasibility study above, the developer is proposing the use the above noted air source heat pump system to deliver the heating and hot water demands to the development, as well as 4 panel PV arrays to each dwelling.

The final table – Table 2 – summarises the final outputs from the SAP models; attached at **Appendix C.**

Table 2 – "Be Green" emission levels

Unit	Emission Rate (regulated energy use) Kg/sqm/annum	Total "be green "emissions Kg
Unit 1	3.99	670
Total		**670**

The data at Table 2 confirms that overall emissions have been reduced by **84%** over and above the baseline building regulations compliant model.

7.0 Sustainable Design & Construction

The Sustainability credentials of the proposed residential development at Stratford Road are set out below; based on the assessment criteria developed by the Building Research Establishment

Materials

New build construction techniques will be considered against the BRE Green Guide to ensure that, where practical, the most environmentally friendly construction techniques are deployed.

Construction materials will be sourced from suppliers capable of demonstrating a culture of responsible sourcing via environmental management certification, such as BES6001

Insulation materials will be selected that demonstrate the use of blowing agents with a low global warming potential, specifically, a rating of 5 or less. Additionally, all insulants used will demonstrate responsible sourcing of material and key processes.

The principle contractor with be required to produce a site waste management plan and sustainable procure plan, in line with BREEAM standards. The procurement plan will follow the waste hierarchy Reduce; Reuse & Recycle.

The Site Waste Management Plan (SWMP) will be developed prior to commencement of development stage will inform the adoption of good practice waste minimisation in design. This will set targets to minimise the generation of non-hazardous construction waste using the sustainable procurement plan to avoid over-ordering and to use just-in-time delivery policies.

Operational waste and recycling – appropriate internal and external storage space will be provided to ensure that residents can sort, store and dispose of waste and recyclable materials in line with local collection policies.

Pollution

The contractor will also monitor the use of energy and water use during the construction phase and incorporate best site practices to reduce the potential for air (dust) and ground water pollution.

The completed development will use zero emission heat pump systems for heating and hot water.

The main contractor will be required to register the site with the Considerate Constructors Scheme and achieve a best practice score of 33 or more.

To avoid the issue of noise pollution, the development will comply with Building Regulations Part E, providing a good level of sound insulation between the proposed development and surrounding buildings.

Energy

The development will incorporate renewables technologies as noted in the main report above; air source heat pumps and PV arrays.

The completed residential units will be supplied with a Home User Guide offering practical advice on how to use the home economically and efficiently, including specific advise on how to reduce unregulated energy uses.

This will be further enhanced by the installation of smart energy metering, enabling occupants to accurately assess their energy usage and thereby, manage it.

Water

The development minimise water use as far as practicable by incorporating appropriate water efficiency and water recycling measures. The development will utilise low flow taps, dual flush toilets and minimum use urinals to minimise internal water use.

Current proposals are for:-

- Basin Taps 5l/min
- Kitchen taps 7l/min
- Showers 8l/min
- Baths Capacity 145l
- Toilets Dual Flush 5/2.5l

An overall target of 105l/person/day will be achieved.

Ecology and Biodiversity

Clearly, the existing site has significant landscaped areas, so the applicants will seek an improvement on this situation to increase biodiversity.

The development would employ an ecologist to consider the landscaping and planting regime and any other opportunities to achieve an overall improvement in the levels of fauna and flora utilising indigenous species where possible and appropriate.

It is expected to achieve an uplift in net biodiversity.

Sustainable Urban Drainage

The existing site is currently made up of building and permeable surfaces. Accordingly, the introduction of new planted areas and gardens will help to control the levels of surface water run-off.

The design team have considered the requirements of Watford policies in regard to the need to actively reduce surface water run-off rates where possible and this matter is covered under a separate report.

8.0 Conclusions

This report has detailed the baseline energy requirements for the proposed sample dwelling at Stratford Road, the reduction in energy demand as a result of energy efficiency measures and the potential to achieve further CO_2 reductions using renewable energy technologies.

The baseline results have shown that if the sample house was built to a standard to meet only the minimum requirements of current building regulations, the total amount of CO_2 emissions would be **4,277Kg/year**.

Following the introduction of passive energy efficiency measures into the development, as detailed in section 4, the total amount of CO_2 emissions would be considerably reduced via a **35%** improvement in fabric energy efficiency

There is also a requirement to reduce CO_2 emissions across the development using renewable or low-carbon energy sources. Therefore, the report has considered the feasibility of the following technologies:

- Wind turbines
- Solar hot water
- Photovoltaic systems
- Biomass heating
- CHP (Combined heat and power)
- Ground & Air source heating

The results of the assessment of suitable technologies relative to the nature, locations and type of development suggest that the most suitable solution to meeting reduction in CO_2 emissions would be via the use of heat pump driven heating and hot water systems as well as 4 panel roof mounted PV arrays.

This has been used in the SAP models (reproduced at **Appendix A**) for the development which have also been detailed above in Table 2, which show a final gross emission level of **670Kg/year**, representing a total reduction in emission over the baseline model, taking into account unregulated energy, of **84%.**

Appendix A

SAP Outputs – DER/TER "as designed"

Property Reference	Unit 1			Issued on Date	06/12/2023
Assessment Reference	Unit 1	Prop Type Ref			
Property					
SAP Rating	80 C	DER	3.99	TER	25.46
Environmental	96 A	% DER < TER			84.33
CO_2 Emissions (t/year)	0.58	DFEE	74.60	TFEE	115.24
Compliance Check	See BREL	% DFEE < TFEE			35.27
% DPER < TPER	68.18	DPER	43.11	TPER	135.50
Assessor Details	Mr. George Farr			Assessor ID	T355-0001
Client					

Full SAP Calculation Printout

SAP 10 WORKSHEET FOR New Build (As Designed) (Version 10.2, February 2022)
CALCULATION OF DWELLING EMISSIONS FOR REGULATIONS COMPLIANCE

1. Overall dwelling characteristics

	Area (m2)		Storey height (m)		Volume (m3)	
Ground floor	56.5000 (1b)	x	2.6700 (2b)	=	150.8550	(1b) - (3b)
First floor	57.8800 (1c)	x	3.0000 (2c)	=	173.6400	(1c) - (3c)
Second floor	54.0300 (1d)	x	2.8600 (2d)	=	154.5258	(1d) - (3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n) 168.4100						(4)
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	479.0208	(5)

2. Ventilation rate

		m3 per hour	
Number of open chimneys	0 * 80 =	0.0000	(6a)
Number of open flues	0 * 20 =	0.0000	(6b)
Number of chimneys / flues attached to closed fire	0 * 10 =	0.0000	(6c)
Number of flues attached to solid fuel boiler	0 * 20 =	0.0000	(6d)
Number of flues attached to other heater	0 * 35 =	0.0000	(6e)
Number of blocked chimneys	0 * 20 =	0.0000	(6f)
Number of intermittent extract fans	5 * 10 =	50.0000	(7a)
Number of passive vents	0 * 10 =	0.0000	(7b)
Number of flueless gas fires	0 * 40 =	0.0000	(7c)

		Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(6c)+(6d)+(6e)+(6f)+(6g)+(7a)+(7b)+(7c) =	50.0000 / (5) =	0.1044	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		4.0000	(17)
Infiltration rate		0.3044	(18)
Number of sides sheltered		1	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.9250	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.2816	(21)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wind speed	5.1000	5.0000	4.9000	4.4000	4.3000	3.8000	3.8000	3.7000	4.0000	4.3000	4.5000	4.7000	(22)
Wind factor	1.2750	1.2500	1.2250	1.1000	1.0750	0.9500	0.9500	0.9250	1.0000	1.0750	1.1250	1.1750	(22a)
Adj infilt rate	0.3590	0.3519	0.3449	0.3097	0.3027	0.2675	0.2675	0.2604	0.2816	0.3027	0.3167	0.3308	(22b)
Effective ac	0.5644	0.5619	0.5595	0.5480	0.5458	0.5358	0.5358	0.5339	0.5396	0.5458	0.5502	0.5547	(25)

3. Heat losses and heat loss parameter

Element	Gross m2	Openings m2	NetArea m2	U-value W/m2K	A x U W/K	K-value kJ/m2K	A x K kJ/K	
DOOR			2.5100	1.1000	2.7610			(26)
G (Uw = 1.00)			32.9600	0.9615	31.6923			(27)
GF			56.5400	0.1200	6.7848	110.0000	6219.4000	(28a)
EF			1.3500	0.2200	0.2970	20.0000	27.0000	(28b)
EW	246.1100	35.4700	210.6400	0.1500	31.5960	60.0000	12638.4000	(29a)
PR	76.4100		76.4100	0.1100	8.4051	9.0000	687.6900	(30)
Total net area of external elements Aum(A, m2)			380.4100					(31)
Fabric heat loss, W/K = Sum (A x U)				(26)...(30) + (32) =	81.5362			(33)
IW			293.6400			9.0000	2642.7600	(32c)
IF			110.5700			18.0000	1990.2600	(32d)
IF			110.5700			9.0000	995.1300	(32e)

Heat capacity Cm = Sum(A x k) (28)...(30) + (32) + (32a)...(32e) = 25200.6400 (34)
Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K 149.6386 (35)
List of Thermal Bridges

K1 Element	Length	Psi-value	Total
E2 Other lintels (including other steel lintels)	16.0500	0.0540	0.8667
E3 Sill	16.0500	0.0400	0.6420

E4 Jamb	35.0400	0.0490	1.7170	
E14 Flat roof	0.0000	0.0800	0.0000	
E16 Corner (normal)	3175.0000	0.0400	127.0000	
E17 Corner (inverted - internal area greater than external area)	2.6700	-0.0680	-0.1816	
E18 Party wall between dwellings	0.0000	0.0490	0.0000	
E11 Eaves (insulation at rafter level)	21.5100	0.0180	0.3872	
E13 Gable (insulation at rafter level)	14.2100	0.0360	0.5116	
E6 Intermediate floor within a dwelling	63.3000	0.0370	2.3421	
E5 Ground floor (normal)	32.2700	0.0380	1.2263	
E20 Exposed floor (normal)	2.8000	0.0620	0.1736	
Thermal bridges (Sum(L x Psi) calculated using Appendix K)			134.6848	(36)
Point Thermal bridges		(36a) =	0.0000	
Total fabric heat loss		(33) + (36) + (36a) =	216.2210	(37)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
[illegible]	[illegible]	[illegible]282	88.4405	86.6196	86.2790	84.6930	84.6930	84.3993	85.3039	86.2790	86.9682	87.6887	(38)
Heat transfer coeff	305.4447	305.0492	304.6615	302.8406	302.5000	300.9140	300.9140	300.6203	301.5249	302.5000	303.1892	303.9097	(39)
Average = Sum(39)m / 12 =												302.8390	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.8137	1.8113	1.8090	1.7982	1.7962	1.7868	1.7868	1.7851	1.7904	1.7962	1.8003	1.8046	(40)
HLP (average)												1.7982	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

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4. Water heating energy requirements (kWh/year)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Assumed occupancy												2.9604	(42)
Hot water usage for mixer showers	73.8567	72.7468	71.1294	68.0348	65.7511	63.2044	61.7568	63.3619	65.1214	67.8559	71.0169	73.5737	(42a)
Hot water usage for baths	31.8840	31.4105	30.7437	29.5142	28.5935	27.5727	27.0213	27.6835	28.4044	29.4968	30.7516	31.7762	(42b)
Hot water usage for other uses	44.9479	43.3134	41.6789	40.0445	38.4100	36.7755	36.7755	38.4100	40.0445	41.6789	43.3134	44.9479	(42c)
Average daily hot water use (litres/day)												138.5166	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	150.6886	147.4706	143.5520	137.5935	132.7547	127.5526	125.5536	129.4554	133.5703	139.0316	145.0819	150.2978	(44)
Energy conte	238.6538	209.9962	220.6341	188.3586	178.7133	156.8408	151.8462	160.2928	164.7056	188.6645	206.6957	235.3300	(45)
Energy content (annual)										Total = Sum(45)m =		2300.7317	
Distribution loss (46)m = 0.15 x (45)m	35.7981	31.4994	33.0951	28.2538	26.8070	23.5261	22.7769	24.0439	24.7058	28.2997	31.0044	35.2995	(46)
Water storage loss:													
Store volume												150.0000	(47)
a) If manufacturer declared loss factor is known (kWh/day):												1.6800	(48)
Temperature factor from Table 2b												0.5400	(49)
Enter (49) or (54) in (55)												0.9072	(55)
Total storage loss	28.1232	25.4016	28.1232	27.2160	28.1232	27.2160	28.1232	28.1232	27.2160	28.1232	27.2160	28.1232	(56)
If cylinder contains dedicated solar storage	28.1232	25.4016	28.1232	27.2160	28.1232	27.2160	28.1232	28.1232	27.2160	28.1232	27.2160	28.1232	(57)
Primary loss	23.2624	21.0112	23.2624	22.5120	23.2624	22.5120	23.2624	23.2624	22.5120	23.2624	22.5120	23.2624	(59)
Combi loss	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(61)
Total heat required for water heating calculated for each month	290.0394	256.4090	272.0197	238.0866	230.0989	206.5688	203.2318	211.6784	214.4336	240.0501	256.4237	286.7156	(62)
WWHRS	-65.8099	-58.2028	-60.9467	-50.4662	-47.0327	-40.2462	-37.7244	-40.1162	-41.6403	-49.0893	-55.6123	-64.5912	(63a)
PV diverter	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	(63b)
Solar input	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63c)
FGHRS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63d)
Output from w/h	224.2295	198.2062	211.0730	187.6203	183.0662	166.3226	165.5074	171.5622	172.7933	190.9608	200.8115	222.1244	(64)
								Total per year (kWh/year) = Sum(64)m =				2294.2773	(64)
12Total per year (kWh/year)												2294	(64)
Electric shower(s)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(64a)
					Total Energy used by instantaneous electric shower(s) (kWh/year) = Sum(64a)m =							0.0000	(64a)
Heat gains from water heating, kWh/month	120.4609	106.9540	114.4693	102.4116	100.5307	91.9320	91.5973	94.4058	94.5470	103.8394	108.5087	119.3557	(65)

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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	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	176.5986	195.5199	176.5986	182.4852	176.5986	182.4852	176.5986	176.5986	182.4852	176.5986	182.4852	176.5986	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	339.9246	343.4519	334.5631	315.6399	291.7527	269.3021	254.3037	250.7764	259.6652	278.5884	302.4756	324.9262	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	(69)
Pumps, fans	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(70)
Losses e.g. evaporation (negative values) (Table 5)	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	(71)
Water heating gains (Table 5)	161.9098	159.1577	153.8566	142.2384	135.1218	127.6833	123.1147	126.8896	131.3153	139.5691	150.7066	160.4243	(72)
Total internal gains	745.8396	765.5362	732.4249	707.7701	670.8798	646.8772	621.4237	621.6712	640.8723	662.1628	703.0740	729.3558	(73)

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6. Solar gains

[Jan]	Area m2	Solar flux Table 6a W/m2	g Specific data or Table 6b	FF Specific data or Table 6c	Access factor Table 6d	Gains W	
North	18.8100	10.6334	0.5700	0.7000	0.7700	55.3053	(74)
South	12.2100	46.7521	0.5700	0.7000	0.7700	157.8420	(78)
West	1.9400	19.6403	0.5700	0.7000	0.7700	10.5355	(80)

Solar gains	223.6828	384.8055	542.8254	710.1453	837.0913	851.3397	812.1883	713.0720	599.3879	429.0881	268.4593	191.1591	(83)
Total gains	969.5224	1150.3416	1275.2503	1417.9153	1507.9711	1498.2170	1433.6119	1334.7432	1240.2602	1091.2509	971.5334	920.5149	(84)

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7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (C) 21.0000 (85)
Utilisation factor for gains for living area, ni1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
tau	22.9180	22.9477	22.9769	23.1151	23.1411	23.2630	23.2630	23.2858	23.2159	23.1411	23.0885	23.0337	
alpha	2.5279	2.5298	2.5318	2.5410	2.5427	2.5509	2.5509	2.5524	2.5477	2.5427	2.5392	2.5356	
util living area													
	0.9878	0.9804	0.9690	0.9431	0.8932	0.8017	0.6893	0.7311	0.8714	0.9547	0.9814	0.9893	(86)
[illegible]	[illegible]	[illegible]301	18.9868	19.4922	20.0051	20.4468	20.6793	20.6368	20.2828	19.6246	18.9363	18.3819	
Non living	16.5028	16.7745	17.2294	17.8715	18.5041	19.0164	19.2380	19.2090	18.8466	18.0468	17.1723	16.4614	
24 / 16	0	0	0	0	0	0	0	0	0	0	0	0	
24 / 9	31	28	31	30	31	30	31	31	30	31	30	31	
16 / 9	0	0	0	0	0	0	0	0	0	0	0	0	
MIT	21.0000	21.0000	21.0000	21.0000	21.0000	21.0000	21.0000	21.0000	21.0000	21.0000	21.0000	21.0000	(87)
Th 2	19.4604	19.4621	19.4637	19.4712	19.4727	19.4793	19.4793	19.4805	19.4767	19.4727	19.4698	19.4668	(88)
util rest of house													
	0.9848	0.9755	0.9606	0.9255	0.8538	0.7111	0.5249	0.5789	0.8064	0.9372	0.9758	0.9867	(89)
MIT 2	19.4604	19.4621	19.4637	19.4712	19.4727	19.4793	19.4793	19.4805	19.4767	19.4727	19.4698	19.4668	(90)
Living area fraction									fLA = Living area / (4) =			0.2524	(91)
MIT	19.8490	19.8502	19.8514	19.8570	19.8581	19.8630	19.8630	19.8639	19.8611	19.8581	19.8560	19.8537	(92)
Temperature adjustment												0.0000	
adjusted MIT	19.8490	19.8502	19.8514	19.8570	19.8581	19.8630	19.8630	19.8639	19.8611	19.8581	19.8560	19.8537	(93)

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8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9856	0.9769	0.9630	0.9306	0.8653	0.7380	0.5737	0.6249	0.8262	0.9424	0.9774	0.9874	(94)
Useful gains	955.5723	1123.7567	1228.0304	1319.4637	1304.8793	1105.7074	822.4977	834.0240	1024.6477	1028.3892	949.5730	908.9475	(95)
Ext temp.	4.3000	4.9000	6.5000	8.9000	11.7000	14.6000	16.6000	16.4000	14.1000	10.6000	7.1000	4.2000	(96)
Heat loss rate W													
	4749.3462	4560.5407	4067.6526	3318.2357	2467.8234	1583.7205	981.8925	1041.3335	1737.1241	2800.5733	3867.4665	4757.3155	(97)
Space heating kWh													
	2822.5677	2309.5189	2112.6789	1439.1159	865.2304	0.0000	0.0000	0.0000	0.0000	1318.5050	2100.8833	2863.1858	(98a)
Space heating requirement - total per year (kWh/year)												15831.6859	
Solar heating kWh													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(98b)
Solar heating contribution - total per year (kWh/year)												0.0000	
Space heating kWh													
	2822.5677	2309.5189	2112.6789	1439.1159	865.2304	0.0000	0.0000	0.0000	0.0000	1318.5050	2100.8833	2863.1858	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												15831.6859	
Space heating per m2										(98c) / (4) =		94.0068	(99)

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

Fraction of space heat from secondary/supplementary system (Table 11)	0.0000	(201)
Fraction of space heat from main system(s)	1.0000	(202)
Efficiency of main space heating system 1 (in %)	394.2166	(206)
Efficiency of main space heating system 2 (in %)	0.0000	(207)
Efficiency of secondary/supplementary heating system, %	0.0000	(208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Space heating requirement													
	2822.5677	2309.5189	2112.6789	1439.1159	865.2304	0.0000	0.0000	0.0000	0.0000	1318.5050	2100.8833	2863.1858	(98)
Space heating efficiency (main heating system 1)													
	394.2166	394.2166	394.2166	394.2166	394.2166	0.0000	0.0000	0.0000	0.0000	394.2166	394.2166	394.2166	(210)
Space heating fuel (main heating system)													
	715.9942	585.8503	535.9183	365.0572	219.4810	0.0000	0.0000	0.0000	0.0000	334.4621	532.9262	726.2976	(211)
Space heating efficiency (main heating system 2)													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(212)
Space heating fuel (main heating system 2)													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(213)
Space heating fuel (secondary)													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(215)
Water heating													
Water heating requirement													
	224.2295	198.2062	211.0730	187.6203	183.0662	166.3226	165.5074	171.5622	172.7933	190.9608	200.8115	222.1244	(64)
Efficiency of water heater												188.9550	(216)
(217)m	188.9550	188.9550	188.9550	188.9550	188.9550	188.9550	188.9550	188.9550	188.9550	188.9550	188.9550	188.9550	(217)
Fuel for water heating, kWh/month													
	118.6682	104.8960	111.7054	99.2937	96.8835	88.0223	87.5909	90.7953	91.4468	101.0615	106.2748	117.5541	(219)
Space cooling fuel requirement													
(221)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(221)
Pumps and Fa	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(231)
Lighting	39.4495	31.6479	28.4954	20.8769	16.1259	13.1750	14.7106	19.1214	24.8368	32.5873	36.8073	40.5459	(232)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233a)m	-24.0888	-41.0409	-71.9638	-95.1571	-110.7241	-94.9757	-93.1646	-82.9707	-66.0607	-50.8111	-28.3401	-19.9090	(233a)
Electricity generated by wind turbines (Appendix M) (negative quantity)													
(234a)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(234a)
Electricity generated by hydro-electric generators (Appendix M) (negative quantity)													
(235a)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235a)
Electricity used or net electricity generated by micro-CHP (Appendix N) (negative if net generation)													
(235c)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235c)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233b)m	-3.7836	-9.8559	-25.4022	-49.2436	-78.5831	-95.3303	-92.8781	-72.5187	-45.7937	-17.2508	-5.6090	-2.8034	(233b)
Electricity generated by wind turbines (Appendix M) (negative quantity)													
(234b)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(234b)
Electricity generated by hydro-electric generators (Appendix M) (negative quantity)													
(235b)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235b)
Electricity used or net electricity generated by micro-CHP (Appendix N) (negative if net generation)													
(235d)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235d)

Annual totals kWh/year		
Space heating fuel - main system 1	4015.9868	(211)
Space heating fuel - main system 2	0.0000	(213)
Space heating fuel - secondary	0.0000	(215)
Efficiency of water heater	188.9550	
Water heating fuel used	1214.1924	(219)

Space cooling fuel	0.0000	(221)
Electricity for pumps and fans:		
Total electricity for the above, kWh/year	0.0000	(231)
Electricity for lighting (calculated in Appendix L)	318.3800	(232)
Energy saving/generation technologies (Appendices M ,N and Q)		
PV generation	-1278.2588	(233)
Wind generation	0.0000	(234)
Hydro-electric generation (Appendix N)	0.0000	(235a)
Electricity generated - Micro CHP (Appendix N)	0.0000	(235)
Appendix Q - special features		
Energy saved or generated	-0.0000	(236)
Energy used	0.0000	(237)
Total delivered energy for all uses	4270.3005	(238)

12a. Carbon dioxide emissions - Individual heating systems including micro-CHP

	Energy kWh/year	Emission factor kg CO2/kWh	Emissions kg CO2/year	
Space heating - main system 1	4015.9868	0.1539	617.9585	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	1214.1924	0.1406	170.7688	(264)
Space and water heating			788.7273	(265)
Pumps, fans and electric keep-hot	0.0000	0.0000	0.0000	(267)
Energy for lighting	318.3800	0.1443	45.9521	(268)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-779.2064	0.1325	-103.2518	
PV Unit electricity exported	-499.0523	0.1183	-59.0432	
Total			-162.2950	(269)
Total CO2, kg/year			672.3844	(272)
EPC Dwelling Carbon Dioxide Emission Rate (DER)			3.9900	(273)

13a. Primary energy - Individual heating systems including micro-CHP

	Energy kWh/year	Primary energy factor kg CO2/kWh	Primary energy kWh/year	
Space heating - main system 1	4015.9868	1.5697	6303.8191	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	1214.1924	1.5200	1845.6177	(278)
Space and water heating			8149.4369	(279)
Pumps, fans and electric keep-hot	0.0000	0.0000	0.0000	(281)
Energy for lighting	318.3800	1.5338	488.3419	(282)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-779.2064	1.4896	-1160.7339	
PV Unit electricity exported	-499.0523	0.4337	-216.4460	
Total			-1377.1799	(283)
Total Primary energy kWh/year			7260.5989	(286)
Dwelling Primary energy Rate (DPER)			43.1100	(287)

SAP 10 WORKSHEET FOR New Build (As Designed) (Version 10.2, February 2022)
CALCULATION OF TARGET EMISSIONS

1. Overall dwelling characteristics

	Area (m2)		Storey height (m)		Volume (m3)	
Ground floor	56.5000 (1b)	x	2.6700 (2b)	=	150.8550	(1b) - (3b)
First floor	57.8800 (1c)	x	3.0000 (2c)	=	173.6400	(1c) - (3c)
Second floor	54.0300 (1d)	x	2.8600 (2d)	=	154.5258	(1d) - (3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n) 168.4100						(4)
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	479.0208	(5)

2. Ventilation rate

		m3 per hour	
Number of open chimneys	0 * 80 =	0.0000	(6a)
Number of open flues	0 * 20 =	0.0000	(6b)
Number of chimneys / flues attached to closed fire	0 * 10 =	0.0000	(6c)
Number of flues attached to solid fuel boiler	0 * 20 =	0.0000	(6d)
Number of flues attached to other heater	0 * 35 =	0.0000	(6e)
Number of blocked chimneys	0 * 20 =	0.0000	(6f)
Number of intermittent extract fans	4 * 10 =	40.0000	(7a)
Number of passive vents	0 * 10 =	0.0000	(7b)
Number of flueless gas fires	0 * 40 =	0.0000	(7c)
		Air changes per hour	
Infiltration due to chimneys, flues and fans = (6a)+(6b)+(6c)+(6d)+(6e)+(6f)+(6g)+(7a)+(7b)+(7c) =	40.0000 / (5) =	0.0835	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		5.0000	(17)
Infiltration rate		0.3335	(18)
Number of sides sheltered		1	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.9250	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.3085	(21)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Wind speed	5.1000	5.0000	4.9000	4.4000	4.3000	3.8000	3.8000	3.7000	4.0000	4.3000	4.5000	4.7000	(22)
Wind factor	1.2750	1.2500	1.2250	1.1000	1.0750	0.9500	0.9500	0.9250	1.0000	1.0750	1.1250	1.1750	(22a)
Adj infilt rate	0.3933	0.3856	0.3779	0.3393	0.3316	0.2931	0.2931	0.2854	0.3085	0.3316	0.3471	0.3625	(22b)
Effective ac	0.5774	0.5743	0.5714	0.5576	0.5550	0.5429	0.5429	0.5407	0.5476	0.5550	0.5602	0.5657	(25)

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3. Heat losses and heat loss parameter

Element	Gross m2	Openings m2	NetArea m2	U-value W/m2K	A x U W/K	K-value kJ/m2K	A x K kJ/K	
[illegible]			2.5100	1.0000	2.5100			(26)
TER Opening Type (Uw = 1.20)			32.9600	1.1450	37.7405			(27)
GF			56.5400	0.1300	7.3502			(28a)
EF			1.3500	0.1300	0.1755			(28b)
EW	246.1100	35.4700	210.6400	0.1800	37.9152			(29a)
PR	76.4100		76.4100	0.1100	8.4051			(30)
Total net area of external elements Aum(A, m2)			380.4100					(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		94.0965			(33)

Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K 149.6386 (35)

List of Thermal Bridges

K1 Element	Length	Psi-value	Total
E2 Other lintels (including other steel lintels)	16.0500	0.0500	0.8025
E3 Sill	16.0500	0.0500	0.8025
E4 Jamb	35.0400	0.0500	1.7520
E14 Flat roof	0.0000	0.0800	0.0000
E16 Corner (normal)	3175.0000	0.0900	285.7500
E17 Corner (inverted - internal area greater than external area)	2.6700	-0.0900	-0.2403
E18 Party wall between dwellings	0.0000	0.0600	0.0000
E11 Eaves (insulation at rafter level)	21.5100	0.0400	0.8604
E13 Gable (insulation at rafter level)	14.2100	0.0800	1.1368
E6 Intermediate floor within a dwelling	63.3000	0.0000	0.0000
E5 Ground floor (normal)	32.2700	0.1600	5.1632
E20 Exposed floor (normal)	2.8000	0.3200	0.8960

Thermal bridges (Sum(L x Psi) calculated using Appendix K) 296.9231 (36)
Point Thermal bridges (36a) = 0.0000
Total fabric heat loss (33) + (36) + (36a) = 391.0196 (37)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m	91.2661	90.7913	90.3259	88.1398	87.7308	85.8269	85.8269	85.4743	86.5603	87.7308	88.5582	89.4232	(38)
Heat transfer coeff	482.2857	481.8108	481.3454	479.1594	478.7504	476.8464	476.8464	476.4938	477.5798	478.7504	479.5778	480.4428	(39)
Average = Sum(39)m / 12 =												479.1574	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	2.8638	2.8609	2.8582	2.8452	2.8428	2.8315	2.8315	2.8294	2.8358	2.8428	2.8477	2.8528	(40)
HLP (average)												2.8452	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

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4. Water heating energy requirements (kWh/year)

Assumed occupancy 2.9604 (42)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage for mixer showers	73.8567	72.7468	71.1294	68.0348	65.7511	63.2044	61.7568	63.3619	65.1214	67.8559	71.0169	73.5737	(42a)
Hot water usage for baths	31.8840	31.4105	30.7437	29.5142	28.5935	27.5727	27.0213	27.6835	28.4044	29.4968	30.7516	31.7762	(42b)
Hot water usage for other uses	44.9479	43.3134	41.6789	40.0445	38.4100	36.7755	36.7755	38.4100	40.0445	41.6789	43.3134	44.9479	(42c)

Average daily hot water use (litres/day) 138.5166 (43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	150.6886	147.4706	143.5520	137.5935	132.7547	127.5526	125.5536	129.4554	133.5703	139.0316	145.0819	150.2978	(44)
Energy conte	238.6538	209.9962	220.6341	188.3586	178.7133	156.8408	151.8462	160.2928	164.7056	188.6645	206.6957	235.3300	(45)
Energy content (annual)										Total = Sum(45)m =		2300.7317	
Distribution loss (46)m = 0.15 x (45)m	35.7981	31.4994	33.0951	28.2538	26.8070	23.5261	22.7769	24.0439	24.7058	28.2997	31.0044	35.2995	(46)

Water storage loss:
Store volume 150.0000 (47)
a) If manufacturer declared loss factor is known (kWh/day): 1.3938 (48)
Temperature factor from Table 2b 0.5400 (49)
Enter (49) or (54) in (55) 0.7527 (55)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Total storage loss	23.3325	21.0745	23.3325	22.5798	23.3325	22.5798	23.3325	23.3325	22.5798	23.3325	22.5798	23.3325	(56)
If cylinder contains dedicated solar storage	23.3325	21.0745	23.3325	22.5798	23.3325	22.5798	23.3325	23.3325	22.5798	23.3325	22.5798	23.3325	(57)
Primary loss	23.2624	21.0112	23.2624	22.5120	23.2624	22.5120	23.2624	23.2624	22.5120	23.2624	22.5120	23.2624	(59)
Combi loss	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(61)
Total heat required for water heating calculated for each month	285.2487	252.0819	267.2290	233.4504	225.3082	201.9326	198.4411	206.8877	209.7974	235.2594	251.7876	281.9249	(62)
WWHRS	-33.7642	-29.8613	-31.2691	-25.8920	-24.1304	-20.6486	-19.3548	-20.5818	-21.3638	-25.1856	-28.5322	-33.1389	(63a)
PV diverter	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000	(63b)
Solar input	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63c)
FGHRS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(63d)
Output from w/h	251.4845	222.2206	235.9599	207.5584	201.1778	181.2841	179.0864	186.3059	188.4336	210.0739	223.2554	248.7860	(64)

Total per year (kWh/year) = Sum(64)m = 2535.6263 (64)
12Total per year (kWh/year) 2536 (64)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Electric shower(s)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(64a)

Total Energy used by instantaneous electric shower(s) (kWh/year) = Sum(64a)m = 0.0000 (64a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Heat gains from water heating, kWh/month	116.6283	103.4923	110.6367	98.7027	96.6981	88.2230	87.7648	90.5733	90.8381	100.0069	104.7998	115.5232	(65)

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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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	148.0220	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
	173.0767	191.6207	173.0767	178.8460	173.0767	178.8460	173.0767	173.0767	178.8460	173.0767	178.8460	173.0767	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
	339.9246	343.4519	334.5631	315.6399	291.7527	269.3021	254.3037	250.7764	259.6652	278.5884	302.4756	324.9262	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	37.8022	(69)
Pumps, fans	3.0000	3.0000	3.0000	3.0000	3.0000	0.0000	0.0000	0.0000	0.0000	3.0000	3.0000	3.0000	(70)
Losses e.g. evaporation (negative values) (Table 5)													
	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	-118.4176	(71)
Water heating gains (Table 5)													
	156.7585	154.0064	148.7053	137.0871	129.9706	122.5320	117.9634	121.7383	126.1640	134.4178	145.5553	155.2731	(72)
Total internal gains													
	740.1664	759.4856	726.7518	701.9795	665.2066	638.0867	612.7505	612.9980	632.0818	656.4896	697.2835	723.6826	(73)

6. Solar gains

[Jan]	Area m2	Solar flux Table 6a W/m2	g Specific data or Table 6b	FF Specific data or Table 6c	Access factor Table 6d	Gains W	
North	18.8100	10.6334	0.6300	0.7000	0.7700	61.1269	(74)
South	12.2100	46.7521	0.6300	0.7000	0.7700	174.4570	(78)
West	1.9400	19.6403	0.6300	0.7000	0.7700	11.6445	(80)

Solar gains	247.2284	425.3113	599.9649	784.8974	925.2062	940.9545	897.6818	788.1322	662.4814	474.2553	296.7182	211.2811	(83)
Total gains	987.3948	1184.7970	1326.7167	1486.8769	1590.4128	1579.0411	1510.4323	1401.1302	1294.5631	1130.7449	994.0017	934.9638	(84)

7. Mean internal temperature (heating season)

Temperature during heating periods in the living area from Table 9, Th1 (C) 21.0000 (85)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
tau	14.5146	14.5289	14.5429	14.6093	14.6218	14.6802	14.6802	14.6910	14.6576	14.6218	14.5965	14.5703	
alpha	1.9676	1.9686	1.9695	1.9740	1.9748	1.9787	1.9787	1.9794	1.9772	1.9748	1.9731	1.9714	
util living area													
	0.9859	0.9790	0.9690	0.9484	0.9117	0.8476	0.7658	0.7980	0.8980	0.9581	0.9800	0.9874	(86)
MIT	16.4748	16.7815	17.3572	18.1860	19.0735	19.8982	20.3947	20.3092	19.6296	18.5004	17.3511	16.4221	(87)
Th 2	18.8197	18.8211	18.8226	18.8294	18.8307	18.8366	18.8366	18.8377	18.8343	18.8307	18.8281	18.8254	(88)
util rest of house													
	0.9817	0.9727	0.9589	0.9285	0.8682	0.7421	0.5446	0.6005	0.8248	0.9379	0.9729	0.9837	(89)
MIT 2	13.9350	14.3210	15.0458	16.0843	17.1773	18.1449	18.6377	18.5766	17.8624	16.4885	15.0443	13.8694	(90)
Living area fraction									fLA = Living area / (4) =			0.2524	(91)
MIT	14.5759	14.9420	15.6291	16.6147	17.6558	18.5874	19.0811	19.0139	18.3084	16.9962	15.6264	14.5136	(92)
Temperature adjustment												0.0000	
adjusted MIT	14.5759	14.9420	15.6291	16.6147	17.6558	18.5874	19.0811	19.0139	18.3084	16.9962	15.6264	14.5136	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9662	0.9519	0.9321	0.8939	0.8305	0.7238	0.5808	0.6246	0.7957	0.9070	0.9528	0.9695	(94)
Useful gains	954.0496	1127.8503	1236.5814	1329.1100	1320.8930	1142.8697	877.1952	875.1296	1030.1065	1025.5942	947.1198	906.4347	(95)
Ext temp.	4.3000	4.9000	6.5000	8.9000	11.7000	14.6000	16.6000	16.4000	14.1000	10.6000	7.1000	4.2000	(96)
Heat loss rate W													
	4955.9328	4838.3228	4394.2517	3696.5536	2851.3594	1901.3622	1183.1079	1245.4925	2009.8373	3062.1898	4089.0875	4955.1064	(97)
Space heating kWh													
	2977.4011	2493.4375	2349.3067	1704.5594	1138.6670	0.0000	0.0000	0.0000	0.0000	1515.2271	2262.2168	3012.2118	(98a)
Space heating requirement - total per year (kWh/year)												17453.0274	
Solar heating kWh													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(98b)
Solar heating contribution - total per year (kWh/year)												0.0000	
Space heating kWh													
	2977.4011	2493.4375	2349.3067	1704.5594	1138.6670	0.0000	0.0000	0.0000	0.0000	1515.2271	2262.2168	3012.2118	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												17453.0274	
Space heating per m2											(98c) / (4) =	103.6342	(99)

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

Fraction of space heat from secondary/supplementary system (Table 11)	0.0000	(201)
Fraction of space heat from main system(s)	1.0000	(202)
Efficiency of main space heating system 1 (in %)	92.3000	(206)
Efficiency of main space heating system 2 (in %)	0.0000	(207)
Efficiency of secondary/supplementary heating system, %	0.0000	(208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Space heating requirement													
	2977.4011	2493.4375	2349.3067	1704.5594	1138.6670	0.0000	0.0000	0.0000	0.0000	1515.2271	2262.2168	3012.2118	(98)
Space heating efficiency (main heating system 1)													
	92.3000	92.3000	92.3000	92.3000	92.3000	0.0000	0.0000	0.0000	0.0000	92.3000	92.3000	92.3000	(210)
Space heating fuel (main heating system)													
	3225.7867	2701.4491	2545.2943	1846.7599	1233.6587	0.0000	0.0000	0.0000	0.0000	1641.6329	2450.9391	3263.5014	(211)
Space heating efficiency (main heating system 2)													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(212)
Space heating fuel (main heating system 2)													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(213)
Space heating fuel (secondary)													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(215)
Water heating													
Water heating requirement													
	251.4845	222.2206	235.9599	207.5584	201.1778	181.2841	179.0864	186.3059	188.4336	210.0739	223.2554	248.7860	(64)
Efficiency of water heater												79.8000	(216)
(217)m	88.0268	87.9880	87.8952	87.7260	87.3213	79.8000	79.8000	79.8000	79.8000	87.5971	87.9094	88.0425	(217)
Fuel for water heating, kWh/month													
	285.6910	252.5580	268.4559	236.5984	230.3880	227.1730	224.4190	233.4660	236.1323	239.8183	253.9607	282.5750	(219)

Space cooling fuel requirement

(221)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(221)
Pumps and Fa	7.3041	6.5973	7.3041	7.0685	7.3041	7.0685	7.3041	7.3041	7.0685	7.3041	7.0685	7.3041	(231)
Lighting	35.9619	28.8500	25.9762	19.0313	14.7003	12.0103	13.4101	17.4310	22.6411	29.7064	33.5533	36.9614	(232)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233a)m	-53.4106	-75.5870	-109.0240	-122.9513	-132.7851	-123.8828	-122.2180	-115.2042	-102.9806	-86.4588	-58.7684	-46.1317	(233a)
Electricity generated by wind turbines (Appendix M) (negative quantity)													
(234a)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(234a)
Electricity generated by hydro-electric generators (Appendix M) (negative quantity)													
(235a)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235a)
Electricity used or net electricity generated by micro-CHP (Appendix N) (negative if net generation)													
(235c)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235c)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233b)m	-29.3166	-61.7671	-122.9871	-185.0884	-245.1629	-246.6064	-243.8392	-206.3814	-151.0765	-88.6164	-39.2227	-23.1870	(233b)
Electricity generated by wind turbines (Appendix M) (negative quantity)													
(234b)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(234b)
Electricity generated by hydro-electric generators (Appendix M) (negative quantity)													
(235b)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235b)
Electricity used or net electricity generated by micro-CHP (Appendix N) (negative if net generation)													
(235d)m	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(235d)

Annual totals kWh/year		
Space heating fuel - main system 1	18909.0221	(211)
Space heating fuel - main system 2	0.0000	(213)
Space heating fuel - secondary	0.0000	(215)
Efficiency of water heater	79.8000	
Water heating fuel used	2971.2356	(219)
Space cooling fuel	0.0000	(221)
Electricity for pumps and fans:		
Total electricity for the above, kWh/year	86.0000	(231)
Electricity for lighting (calculated in Appendix L)	290.2334	(232)
Energy saving/generation technologies (Appendices M ,N and Q)		
PV generation	-2792.6541	(233)
Wind generation	0.0000	(234)
Hydro-electric generation (Appendix N)	0.0000	(235a)
Electricity generated - Micro CHP (Appendix N)	0.0000	(235)
Appendix Q - special features		
Energy saved or generated	-0.0000	(236)
Energy used	0.0000	(237)
Total delivered energy for all uses	19463.8370	(238)

12a. Carbon dioxide emissions - Individual heating systems including micro-CHP

	Energy kWh/year	Emission factor kg CO2/kWh	Emissions kg CO2/year	
Space heating - main system 1	18909.0221	0.2100	3970.8946	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	2971.2356	0.2100	623.9595	(264)
Space and water heating			4594.8541	(265)
Pumps, fans and electric keep-hot	86.0000	0.1387	11.9293	(267)
Energy for lighting	290.2334	0.1443	41.8896	(268)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1149.4024	0.1345	-154.6407	
PV Unit electricity exported	-1643.2517	0.1258	-206.7600	
Total			-361.4007	(269)
Total CO2, kg/year			4287.2723	(272)
EPC Target Carbon Dioxide Emission Rate (TER)			25.4600	(273)

13a. Primary energy - Individual heating systems including micro-CHP

	Energy kWh/year	Primary energy factor kg CO2/kWh	Primary energy kWh/year	
Space heating - main system 1	18909.0221	1.1300	21367.1950	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	2971.2356	1.1300	3357.4962	(278)
Space and water heating			24724.6912	(279)
Pumps, fans and electric keep-hot	86.0000	1.5128	130.1008	(281)
Energy for lighting	290.2334	1.5338	445.1696	(282)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1149.4024	1.4972	-1720.9256	
PV Unit electricity exported	-1643.2517	0.4619	-758.9439	
Total			-2479.8695	(283)
Total Primary energy kWh/year			22820.0922	(286)
Target Primary Energy Rate (TPER)			135.5000	(287)