Energy Assessment
13-15 John's Mews

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Executive summary

About the Scheme
The proposal comprises the refurbishment with new roof extension of two dwellings at 13-15 John's Mews. The development is located in the London Borough of Camden with a total GIA of approximately 280 sqm.

Planning policy
The scheme has been developed in accordance with the London Plan 2021 "The Spatial Development Strategy for Greater London, March 2021" and with the Sustainable, Design and Construction SPG. According to the planning policies, the scheme should show how the Energy Hierarchy has been incorporated in the design.

As best practice, a 19% reduction of CO_2 emissions as compared to the baseline (GLA guidance for energy assessments – Appendix 3) has been targeted.

Summary
Only one dwelling has been modelled, as the two dwellings are identical. Results shown below have been extrapolated to take into account the emissions of both dwellings.

The scheme complies with the 2021 Building Regulations Part L and the minimum energy efficiency targets in the following documents have been followed:

- CO_2 emissions – The actual CO_2 Dwelling Emissions Rate (DER) is no greater than the baseline (GLA guidance for energy assessment – Appendix 3) CO_2 Dwelling Emissions Rate (Baseline DER).
- Dwelling Fabric efficiency – The Dwelling Fabric Energy Efficiency (DFEE) is not greater than the baseline Dwelling Fabric Energy Efficiency (Baseline DFEE).
- Primary energy – The Dwelling Primary Energy Rate (DPER) is no greater than the baseline Dwelling Primary Energy Rate (Baseline DPER).
- Refurbishment - Consequential improvements to refurbished areas have been made to ensure that the building complies with Part L, to the extent that such improvements are technically, functionally, and economically feasible.

In addition, the CO_2 emissions of the scheme have been calculated using the SAP 10.2 carbon emission factors, and the scheme can achieve:

- An on-site CO_2 reduction of 32% beyond Building Regulations through energy efficiency measures and inclusion of renewable technologies (PV panels)
- a 19% reduction in CO_2 emissions through energy efficiency measures, 'Be Lean' stage
- An EPC rating of A

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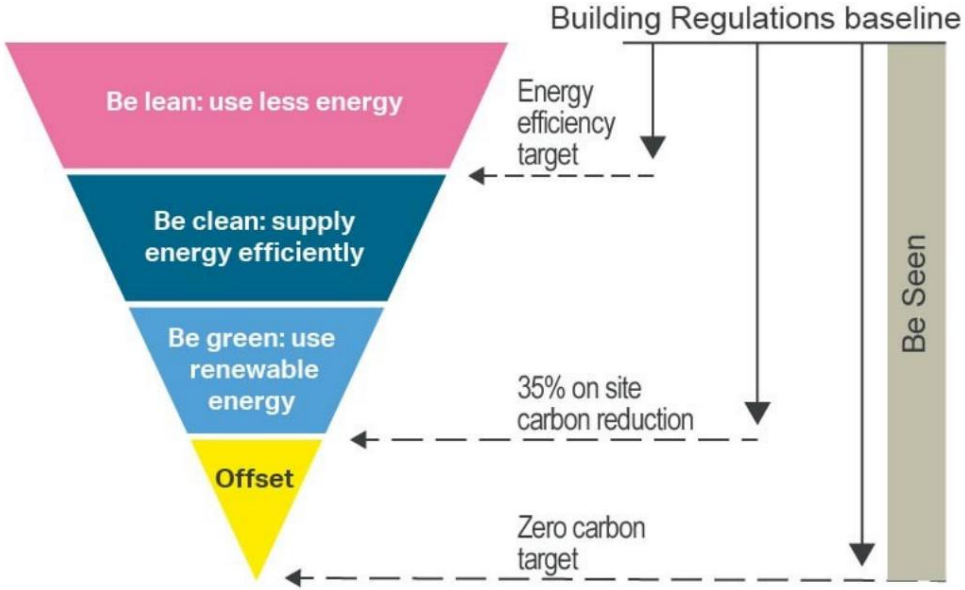
Energy hierarchy
The proposed scheme has followed the energy hierarchy that is illustrated below:



Source: Greater London Authority

Key measures
Key measures identified for each stage are shown below:

- Be Lean:
  - Low U-values for opaque elements and fenestration for new elements
  - Low g-value for new elements
  - High efficiency lighting and sensors
  - Wastewater heat recovery
- Be Clean:
  - Not applicable
- Be Green:
  - Photovoltaic panels

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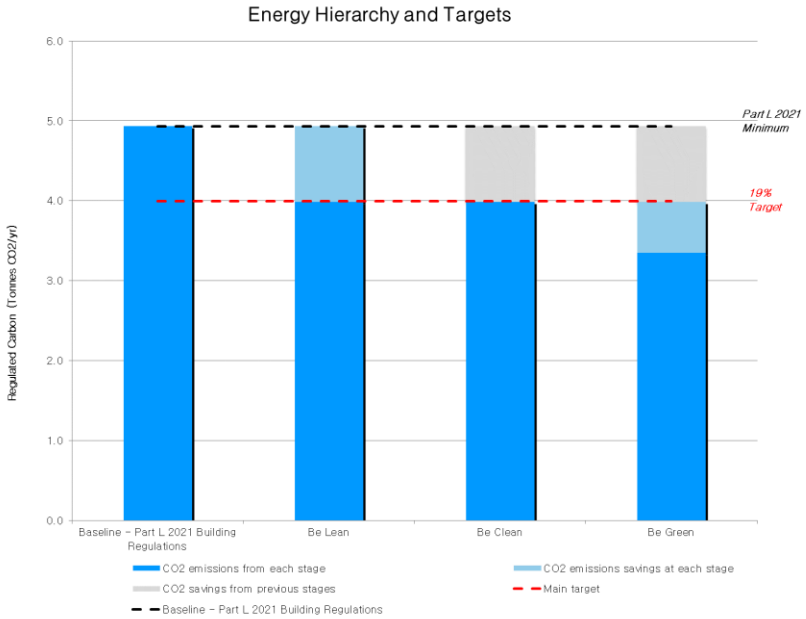
Energy Hierarchy: Regulated carbon emissions

The proposed scheme has followed the energy hierarchy. A graphical illustration of how the scheme performs in relation to Building Regulations and the Energy Hierarchy is shown below. Carbon dioxide emission factors for SAP 10.2 have been used for the calculation.

As demonstrated in the figure the proposed scheme will reduce carbon emissions by 19% from the fabric energy efficiency measures described in the 'Be Lean' section and will reduce total carbon emissions by 32% over Building Regulations (using SAP 10.2 carbon dioxide emission factors) with the further inclusion of low and zero carbon technology (photovoltaic panels).

Therefore, the scheme meets and exceeds the planning policy carbon reduction target and complies with London Plan 2021 Policy SI2 and Part L 2021.



Regulated CO_2 emissions

Site-wide				
Energy Hierarchy: Regulated CO_2 - Calculated using SAP 10.2 CO_2 factors				
	Baseline:	Be lean:	Be clean:	Be green:
CO_2 emissions (tCO_2/yr)	4.93	3.99	-	3.35
CO_2 emissions saving (tCO_2/yr)	-	0.95	-	0.64
Saving from each stage (%)	-	19.2	-	12.9
Total CO_2 emissions saving (tCO_2/yr)	1.58			
32.1% total CO_2 savings over 2021 Building Regulations Part L achieved				

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Establishing Carbon Emissions

Methodology

The purpose of an energy assessment is to demonstrate that climate change mitigation measures comply with London Plan energy policies, including the energy hierarchy. It also ensures energy remains an integral part of the scheme's design and evolution.

The methodology followed in this report follows the guidance set out by the Greater London Authority (GLA) for developing energy strategies as detailed in the document. "Energy Assessment Guidance: Greater London Authority guidance on preparing energy assessments as part of planning applications (June 2022)". The scheme has been developed in accordance with the London Plan 2021.

This report has followed these documents and comprises the following components:

- Baseline: A calculation of the Part L 2021 Building Regulations compliant CO_2 emission baseline using approved software. Appendix 3 of GLA's Guidance has been used.
- Be Lean: A calculation of the impact of demand reduction measures. For example, passive design measures, including optimising orientation and site layout, natural ventilation and lighting, thermal mass and solar shading, and active design measures such as high efficacy lighting and efficient mechanical ventilation with heat recovery.
- Cooling Hierarchy: In accordance with London Plan 2021Policy SI4, measures that are proposed to reduce the demand for cooling have been set out such as minimisation of solar and internal gains and night cooling strategies.
- Be Clean: In accordance with London Plan 2021 Policy SI3, this report has demonstrated how the scheme has selected heating, cooling and power systems to minimise carbon emissions. This comprises an evaluation of the feasibility of connecting to existing low carbon heat networks, planned networks, site-wide and communal heat networks, and CHP.
- Be Green: In accordance with London Plan 2021 Policy SI2, this report has conducted a feasibility assessment of renewable energy technologies. This comprised a site-specific analysis of the technologies and, if applicable, how they would be integrated into the heating and cooling strategy for the scheme.

Establishing CO_2 emissions

As required by the GLA both the regulated and unregulated emissions of the development must be quantified and demonstrated. The total emissions for the scheme are shown below.

CO_2 Emissions – Regulated and Unregulated (tonnes CO_2/yr) - SAP 10.2			
	Regulated Emissions	Unregulated Emissions	Total Emissions
Baseline: Part L 2021	4.93	1.02	7.70
Be Lean: Use less energy	3.99	1.02	6.75
Be Clean: Supply energy efficiently	-	-	-
Be Green: Use renewable energy	3.35	1.02	6.12

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Demand Reduction

Be Lean: summary
Demand reduction measures have reduced the scheme's carbon emissions by 19% (using SAP 10.2 figures) over the baseline (Appendix 3 of GLA's Guidance).

U-values

	Domestic Refurbishment		
Element	Limiting U-values for refurbished and new elements W/m^{2}K	Existing Building U-value W/m^{2}K Appendix 3 (GLA guidance 2022)	Proposed U-value W/m^{2}K
New roof	0.15	0.16	0.15
Refurbished External Walls	0.30	0.30	0.30
New Mansard walls	0.18	0.30	0.18
New Ground floor	0.18	0.25	0.18
New Windows	1.40 (g value 0.63)	1.60	1.10
New Rooflights	2.20 (g value 0.63)	1.60	2.20
New Doors	1.40	1.40	1.40

Party walls will be solid.

Air permeability
A reduced air permeability has been targeted as per the table below:

Air permeability (m^3/hm^2 @50 Pa)	Minimum 2021 Building Regulations	Existing Building Appendix 3 (GLA guidance 2022)	Proposed
Domestic	8	10	5

This will require careful attention to two key areas:

- Structural leakage
- Services leakage

Structural leakage occurs at joints in the building fabric and around window and door openings, loft hatches and access openings. There will also be some diffusion through materials such and cracks in masonry walls typically caused by poor perpends in the blockwork or brickwork. Structural leakage is hard to remedy retrospectively therefore good detailing at the design stage is essential.

Services leakage occurs at penetrations from pipes and cables entering the building. These can be sewerage pipes, water pipes and heating pipes. As well as electricity cables there may also be telecommunication cables. Attention, therefore, needs to be paid to sealing all penetrations during construction.

Thermal Bridging:
The default psi-value has been used.

Thermal Mass:
Thermal mass of the scheme has been indicatively modelled as 250 kJ/m^{2}K (medium).

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Heating
For both the 'Be Lean' and 'Be Green' scenarios, the scheme has been modelled with a newly fitted gas boiler (IDEAL Logic Combi ESP1 35 or similar).

Hot Water
For both the 'Be Lean' and 'Be Green' scenarios, the hot water will be provided by the main gas heating system (IDEAL Logic Combi ESP1 35 or similar).

A waste water heat recovery has been specified with a heat recovery efficiency of at least 0.35 to all showers and baths.

Ventilation
Natural ventilation has been specified for the dwellings with extract fans for the toilets and kitchen (4 in total).

Cooling
No cooling has been specified.

Lighting
High efficiency lighting has been specified for the development with a minimum efficacy of 100 lumens/W. 20 luminaires of 6W have been assumed for this stage.

Fabric energy efficiency

	Target Fabric Energy Efficiency (kWh/year)	Design Fabric Energy Efficiency (kWh/year)	Improvement (%)
Domestic	59.48	48.96	18%

Primary Energy

	Target Primary Energy Rate (MWh/year)	Dwelling Primary Energy Rate (MWh/year)	Improvement (%)
Domestic	13.58	8.80	35%

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Cooling and Overheating

Overheating and cooling

The aim of this section is to reduce the impact of the urban heat island effect in London and encourage the design of spaces to avoid overheating and excessive heat generation, and to mitigate overheating due to the impact of climate change.

Where design measures and the use of natural and/or mechanical ventilation are not enough to guarantee the occupant's comfort, in line with the cooling hierarchy the development's cooling strategy must include details of the active cooling plant being proposed, including efficiencies, and the ability to take advantage of free cooling and/or renewable cooling sources.

Where appropriate, the cooling strategy should investigate the opportunities to improve cooling efficiencies through the use of locally available sources such as ground cooling and river/dock water-cooling.

The Cooling Hierarchy in Policy SI4

Developments should reduce potential overheating and reliance on air conditioning systems and demonstrate this with the Cooling Hierarchy:

1. Reduce the amount of heat entering the building through orientation, shading, high albedo materials, fenestration, insulation, and the provision of green infrastructure
2. Minimise internal heat generation through energy efficient design
3. Manage the heat within the building through exposed internal thermal mass and high ceilings
4. Provide passive ventilation
5. Provide mechanical ventilation
6. Provide active cooling systems

Avoiding overheating: measures taken

The following measures have been taken in accordance with the cooling hierarchy to reduce overheating and the need for cooling:

1. Reduce the amount of heat entering the building through orientation, shading, high albedo materials, fenestration, insulation, and the provision of green infrastructure
    - Orientation of building – the scheme has been orientated East/West to reduce excessive solar gain and openable windows have been specified to facilitate natural ventilation.
    - Solar control – all methods controlling solar gain to within tolerable limits have been considered. The design and type of window openings and glazing have been optimised and reduced solar gain factors from low emissivity windows have been specified.
    - Dark-coloured curtain/roller blinds will be specified to limit solar gain. The shading has also been optimised to avoid substantially reducing daylighting or increasing the requirement for electric lighting.
    - Insulation levels have been maximised and the resulting U-values are lower than required by Building Regulations. The build-ups therefore prevent the penetration of heat as much as practically possible. See the 'Be Lean' section of this report for target U-values.
    - A reduced air permeability rate has been targeted to minimise uncontrolled air infiltration. This will require attention to detailing and sealing. See 'Be Lean' section of this report for details of how this will be achieved.

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2. Minimise internal heat generation through energy efficient design
    - Internal heat gains have been minimised where possible.
    - Energy efficient lighting will also be specified as per the 'Be Lean' section.
3. Manage the heat within the building through exposed internal thermal mass and high ceilings
    - High thermal mass – exposed building fabric materials such as masonry or concrete have been utilised in the form of concrete floors and dense masonry external walls. These materials act as 'thermal batteries'; they absorb heat gains during the day when the building is occupied and 'store' it for an extended period, thereby helping to stabilise daytime temperatures. At night this heat can be dissipated, which 'resets' the heating cycle. Ventilation will also be used at night to purge the stored heat within the structure. A 'ground coupled' system that uses the thermal storage capacity of the ground has not been specified as the passive ventilation option has been selected instead.
    - Room heights – high ceilings are traditionally used in hot climates to allow thermal stratification so that occupants can inhabit the lower cooler space, and to decrease the transfer of heat gain through the roof. The proposed building has floor to ceiling heights of more than 2.5m. As the roof will be well insulated to below building regulations, there will be minimal penetration of heat through the roof.
4. Provide passive ventilation
    - Openable windows are specified on all facades of the building.
    - Shallow floorplates have been specified with dual aspect units to allow for cross ventilation. Cross ventilation will be achieved by opening windows on two facades and ensuring there is a clear path for airflow.
    - Night time cooling will also be utilised. This will work in tandem with high thermal mass materials specified. The larger temperature differential that exists between internal and external temperatures at night will allow effective stack ventilation and purging of heat accumulated within the structure during the day.
5. Provide mechanical ventilation
    - N/A

Overheating risk

The overheating risk considering all the above-described passive measures have been assessed for the scheme:

Areas	Overheating risk from SAP
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Active cooling

Air conditioning has not been specified for the scheme, since the overheating analysis demonstrates the there is no significant risk of overheating and the passive design measured are enough to guarantee the occupant's comfort.

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Heating Infrastructure

Heating infrastructure including CHP

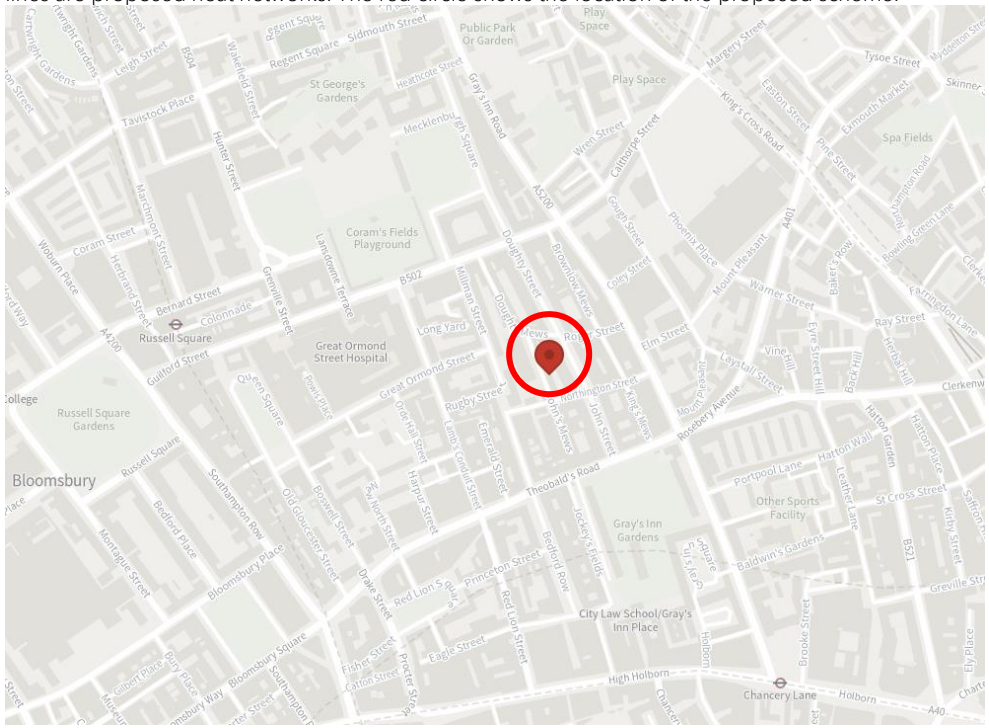
Once demand for energy has been minimised, schemes must demonstrate how their energy systems have been selected in accordance with the order of preference in Policy SI3 of London Plan 2021. This has involved a systematic appraisal of the potential to connect to existing or planned heating networks and on site communal and CHP systems.

To comply with London Plan 2021 Policy SI 3, developments in Heat Network Priority Areas (HNPAs) should have a communal low-temperature heating system and should select a heat source in accordance with the following heating hierarchy:

- connect to local existing or planned heat networks
- use zero-emission or local secondary heat sources (in conjunction with heat pump, if required)
- use low-emission combined heat and power (only where there is a case for CHP to enable the delivery of an area-wide heat network, meet the development's electricity demand and provide demand response to the local electricity network)
- use ultra-low NOx gas boilers

Connect to local existing or planned heat network

The illustration below shows the London heat map. Red lines are existing heat networks and orange lines are proposed heat networks. The red circle shows the location of the proposed scheme.



A review of the London Heat Map demonstrates that there are no existing or proposed networks present within connectable range of the scheme. Therefore, a connection is not possible.

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Use zero-emission and/or local secondary heat sources

According to the GLA and London Plan 2021 Policy SI3, the exploitation of local energy opportunities to maximise the use of locally available energy sources whilst minimising primary energy demand and carbon emissions is encouraged. Secondary heat includes environmental sources such as air, water and ground; and waste sources such as heat from the sewerage system, sewage treatment plants, the tube network, data centres and chiller systems.

There are no local available waste heat sources for the scheme.

Use low-emission combined heat and power (CHP)

In accordance with section 9 of the GLA guidance for Energy Planning where connection to an area wide heat network will not be available in the foreseeable future i.e. 5 years following completion, or the development is of such a scale that it could be the catalyst for an area wide heat network, applicants should evaluate the feasibility of on-site CHP

GLA guidance stipulates that small, or purely residential developments of less than 350 dwellings will not be expected to include on-site CHP. CHP systems are best utilised where there is a consistent and high demand for heat. Because of the small electricity supplies and demand of this scheme, a CHP installed to meet the base heat load would typically require the export of electricity to the grid. The administrative burden of managing CHP electricity sales at a small scale without an active energy service companies (ESCOs) is prohibitive for smaller operators of residential developments.

The heat demand profile of this residential scheme is not suitable to CHP. The implemented fabric improvements from the 'Be Lean' scenario have also reduced the energy demand from space heating to hot water. For CHP systems to be economically viable they need to run for at least 5,000 hours per year. Therefore, a CHP system would most likely be oversized, and as a result less efficient and economic.

Use ultra-low NOx gas boilers

Where it is clearly demonstrated that the above heating options (District heating, local secondary heat source and CHP) have been fully investigated and ruled out, then a site-wide heating strategy led by ultra-low NOx gas boilers can be considered.

In accordance with section 9 of the GLA guidance for Energy Planning, where it is demonstrable that a site wide network is not feasible then an individual heating strategy can be implemented. A site wide network will not be adopted because there are only two dwellings on site which will not have adequate density and local conditions are not favourable to centralised distribution.

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Renewable Energy

Renewable Energy Feasibility:
In line with Policy SI2 of the London Plan 2021 the feasibility of renewable energy technologies has been considered. A detailed site-specific analysis and associated carbon saving calculations has also been provided for renewable energy technologies considered feasible.

Each technology has been assessed under 3 broader categories. There are key criteria for each category on which the technology is evaluated. The key criteria have been given a weighting based on a tick-system, a graphical representation of this is shown below:

The weighting of each of the criteria within the categories is shown below:

- Local, site-specific impact: (Maximum score of 5)
  - Local planning criteria = ✓
  - Land used by all components = ✓
  - Noise impact from operation = ✓
  - Interaction on the current building design = ✓
  - Buildability of installation = ✓

- Economic viability: (Maximum score of 5)
  - Capital cost of all components = ✓
  - Grants and funding available = ✓
  - Payback periods (years) 3-5, 5-10, 10-15 = ✓
  - Servicing requirements (low or high) = ✓
  - Maintenance costs (low or high) = ✓

- CO_2 and sustainability: (Maximum score of 10)
  - Carbon saving per year = ✓✓✓✓
  - Impact of future grid decarbonisation (gas vs. electric) = ✓✓
  - Local air quality/pollution = ✓✓
  - Resource use of installation = ✓✓

Key comments on each of the criteria and the corresponding score will be provided in a table for each of the technologies. The score for each of the criteria will be summed and each of the technologies will then be ranked. The assessment of each technology is undertaken on the following pages.

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Biomass & Biofuel - Rejected

Biomass is normally considered a carbon 'neutral' fuel, as the carbon dioxide emitted on burning has been recently absorbed from the atmosphere by photosynthesis. Although some form of fossil fuel derived inputs are required in the production and transportation of the fuel.

Wood is seen as a by-product of other industries and the small quantity of energy for drying, sawing, pelleting and delivery are typically discounted. Biomass from coppicing is likely to have external energy inputs from fertiliser, cutting, drying etc. and these may need to be considered. In this toolkit, all biomass fuels are considered to have zero net carbon emissions.

Biomass can be burnt directly to provide heat in buildings. Wood from forests, urban tree pruning, farmed coppices or farm and factory waste, is the most common fuel and is used commercially in the form of wood chips or pellets. Biomass boilers can also be designed to burn smokeless to comply with the Clean Air Acts.

Boilers can be fed automatically by screw drives from fuel hoppers. This typically involves daily addition of bagged fuels.

A biomass boiler could be installed on site for supplementary LTHW heating; however, a major factor influencing the suitability of a biomass boiler is the availability of the biomass fuel. A local and reliable fuel source would be essential for the biomass boiler to be an efficient replacement for a conventional boiler system. Therefore, a very comprehensive feasibility assessment needs to be undertaken to understand the practicalities of such a system.

The site is likely to be unsuitable for biomass boilers due to site constraints such as limited transport/access issues, and storage of the biomass fuel.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO_2 and sustainability (out of 10)
✓	✓✓✓	✓✓✓✓✓
Local air quality impacts, increased transport usage, increased plant space, slightly increased buildability issues.	Increased capital costs of installation, typical payback of 8 years, Increased maintenance relative to gas boiler, resource use not significantly increased if well serviced.	Very low carbon intensity of feedstock if properly procured. Decarbonisation impact not applicable, air quality issues.

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Photovoltaic Panels (PV) - Accepted

Photovoltaic systems convert energy from the sun into electricity through semi-conductor cells. Systems consist of semi-conductor cells connected together and mounted into modules. Modules are connected to an inverter to turn the direct current (DC) output into alternating current (AC) electricity for use in buildings.

Photovoltaic panels supply electricity to the building and are attached to electricity gird or to any other electrical load. Excess electricity can be sold to the National Grid when the generated power exceeds the local need. PV systems require only daylight, not sunlight to generate electricity (although more electricity is produced with more sunlight), so energy can still be produced in overcast or cloudy conditions.

The cost of PV cells is heavily dependent on the size of the array. There are significant cost reductions available for larger installations.

The most suitable location for mounting photovoltaic panels is on roofs as they usually have the greatest exposure to the sun. The proposed site has a potential useable roof area on the new roof extension where solar PV can be accommodated.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO_2 and sustainability (out of 10)
✓✓✓✓ No local air quality impacts, use of unutilised roof space, no noise issues, good orientation, and slightly increased buildability issues for wiring and metering.	✓✓ Increased capital costs of installation, typical payback of 10-15 years, Feed in Tariff available, limited servicing and maintenance i.e. 1 visit per year, inverter will require replacement.	✓✓✓✓✓ ✓✓✓ High carbon saving from electricity, uses minimal grid electricity, no local air impact, high embodied energy of panels.

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Solar Thermal – Rejected

Solar water heating systems use the energy from the sun to heat water for domestic hot water needs. The systems use a heat collector, generally mounted on the roof in which a fluid is heated by the sun. This fluid is used to heat up water that is stored in either a separate hot water cylinder or a twin coil hot water cylinder inside the building. The systems work very successfully in all parts of the UK, as they can work in diffuse light conditions.

Like photovoltaic panels the most suitable location for mounting solar hot water panels is on roofs as they usually have the greatest exposure to the sun.

It is estimated that the CO_2 emissions reduction that would be produced by solar hot water as a standalone system would not be adequate to achieve the required CO_2 emissions reduction target. Therefore, a solar hot water system would need to be combined with more energy efficiency strategies, a CHP, or additional renewable technologies to achieve the carbon reduction target.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO_2 and sustainability (out of 10)
✓✓✓✓ No local air quality impacts, use of unutilised roof space, no noise issues, good orientation, slightly increased buildability issues for piping and cylinders.	✓✓✓ Increased capital costs of installation, typical payback of 8-10 years, Heat Incentive available, limited servicing and maintenance i.e. 1 visit per year, heat transfer fluid requires replacing every 10 years.	✓✓✓✓✓ ✓ Lower carbon saving as primarily displacing gas, uses minimal grid electricity, no local air impact, medium embodied energy of panels.

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Wind Energy – Rejected

Wind energy is a cost-effective method of renewable power generation. Wind turbines can produce electricity without carbon dioxide emissions in ranges from watts to megawatt outputs. The most common design is for three blades mounted on a horizontal axis, which is free to rotate into the wind on a tall tower.

The blades drive a generator either directly or via a gearbox to produce electricity. The electricity can either be linked to the grid or charge batteries. An inverter is required to convert the electricity from direct current (DC) to alternating current (AC) for feeding into the grid.

Modern quiet wind turbines are becoming viable in low density areas where ease of maintenance and immediate connection to the grid or direct use of the electricity in a building, may make them cost effective, despite lower wind speeds than open areas.

Wind turbines are generally less suited to dense urban areas as their output will be affected by potentially lower and more disrupted wind speeds, and their use of much more cost-effective machines may be prohibited by their proximity to some building types. Small turbines can be used in inner city areas mounted on buildings, although there are relatively few installations.

A detailed wind resource evaluation would be required for the site to fully understand the generation potential and payback period. Also, it is likely that planning restrictions and resistance from groups within the local community could also affect the viability of wind energy for the project.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO_2 and sustainability (out of 10)
✓	✓✓✓✓	✓✓✓✓✓
No local air quality impacts, use of unutilised roof space, medium noise issues, relatively limited wind speeds in local area, increased buildability issues for wiring and metering.	Medium capital costs of installation, typical payback of 5 years, Feed in Tariff available, limited servicing and maintenance, costs of 2-3% typical.	High carbon saving from electricity, output limited from urban installation, consumes little grid electricity, no local air impact, low embodied energy of panels

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Ground Source Heat Pump (GSHP) – Rejected

Geo-thermal energy is essentially heat collected from the ground. Heat obtained from the ground may be considered it as a source of heating and cooling within the UK by the use of a geo-thermal heat pump or ground source heat pumps.

A ground source heat pump is a device for converting energy in the form of low-level heat to heat at a usable temperature. The heat pump consists of five main parts: ground collector loop/or boreholes, heat exchanger, compressor, condenser heat exchanger and expansion valve.

At approximately 1.2-1.5 metres down below ground level the temperature is a constant 10 to 12°C. Any boreholes would need to be sunk to an effective depth of 50 – 120m and a ground feasibility report would be required to ascertain if this method of heat source were viable.

From the boreholes pre-insulated pipework is laid in the ground to the heat exchanger device. The system is filled with water and antifreeze. The cooled water is pumped around the loop / borehole gathering energy as it circulates. The water that has been heated to 10-12°C is returned to the ground source heat exchanger where the energy is transferred to the refrigerant gas. For every 1kW of energy used to compress the refrigerant, the process 'gives up' 4 kW of energy for use in the system being used to heat the building.

The installation cost for a Ground Source Heat pump is typically high compared to a gas-boiler installation. Moreover, the proposal comprises the refurbishment and extension of an existing building, therefore, accommodating a ground source heat pump is not considered to be feasible for the site.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO_2 and sustainability (out of 10)
✓✓ No local air quality impacts, no visual impact, no noise issues, however the constrained site may prohibit its installation. Increased buildability issues for pipework and heating emitters internally.	✓ High capital costs of installation, typical payback >15 years where gas is displaced, Renewable Heat Incentive available, limited servicing and maintenance i.e. 1 visit per year, mechanical parts may require replacement over lifespan.	✓✓✓✓✓ ✓✓✓ Medium carbon saving from gas displacement, consumes some electricity so benefits from decarbonisation, no local air impact, high embodied energy of equipment.

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Air Source Heat Pump (ASHP) – Rejected

Air source heat pump systems work on the same principle as a ground source heat pump although they use the outside air as the heat source.

The coefficients of performance given by air source heat pump systems are inferior to that of ground source systems due to varying air temperatures. In the depth of winter, the energy efficiency of an air source system will be lower than that of a ground source system, and it is likely that more back-up heat will be required if an air source unit is fitted. This back-up heat often comes from a direct electric heater. They operate over a varying temperatures range of -15°C to +25°C, however, the performance will reduce to below the required 3 to 1 carbon saving ratio in winter, and they also require a defrosting mechanism to melt ice that forms on the air heat exchanger.

Air source heat pumps would provide a suitable HVAC solution for commercial spaces which have relatively low heating demands as well as a regular need for cooling given the higher internal gains of these use classes. Having a system which is able to both, heat and cool provides versatility and reduces the amount installed plant.

No suitable space is available for the installation of an ASHP on site. As there is no garden to the property, the only places the ASHPs could be placed would be the on the first-floor roofs and the mansard roof. The former is too exposed, and the ASHPs would be too visible, while for the latter, the height limit has been reached and for this reason ASHPs cannot be placed there.

Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO_2 and sustainability (out of 10)
✓✓ No local air quality impacts, use of unutilised roof space, over visual impact, low noise issues, increased buildability issues for pipework and heating emitters internally.	✓✓ Medium- high capital costs of installation, typical payback >15 years where gas is displaced, Renewable Heat Incentive available Limited servicing and maintenance i.e. 1 visit per year, mechanical parts may require replacement over lifespan.	✓✓✓✓✓ ✓✓ Medium carbon saving from gas displacement, less efficient in winter, consumes electricity so benefits from decarbonisation, no local air impact, high embodied energy of equipment.

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Summary comparison matrix
An assessment of the feasibility of each of the technologies is shown below.

Renewable Technology	Comments	Local, site-specific impact (out of 5)	Economic viability (out of 5)	CO_2 and sustainability (out of 10)	Total Score
Biomass Boiler	High air quality impact	✓	✓✓✓	✓✓✓✓✓	9
Photovoltaic	High CO_2 savings and low visual impact	✓✓✓✓	✓✓	✓✓✓✓✓ ✓✓✓	14
Solar Thermal	Low CO_2 savings compared to PV panels	✓✓✓✓	✓✓✓	✓✓✓✓✓ ✓	13
Wind Energy	High visual and noise impact	✓	✓✓✓✓	✓✓✓✓✓	10
GSHP	High capital cost	✓✓	✓	✓✓✓✓✓ ✓✓✓	11
ASHP	Low capital cost but low CO_2 savings compared to GSHP	✓✓	✓✓	✓✓✓✓✓✓ ✓	11

Photovoltaic panels and solar thermal panels have scored the best.

Due to the limited roof space, photovoltaic panels have been specified as they can provide higher CO_2 savings compared to the solar thermal panels.

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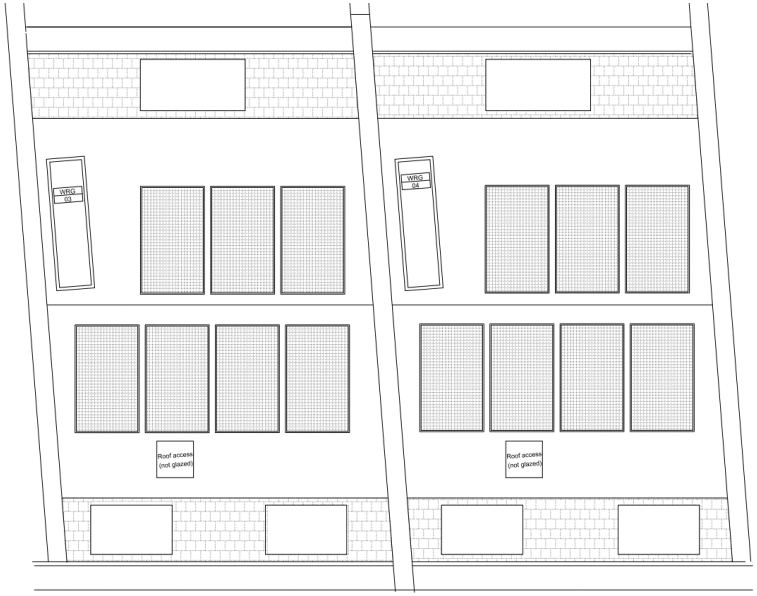
Photovoltaic panels (PV) - Performance

A photovoltaic panel system of 6.02 kWp (7 panels of 430W each on each dwelling) has been specified for the whole development, a detailed summary of the lifecycle cost, revenue and payback for the photovoltaic panels is presented in this section.

PV panels will be placed with 30° tilt, oriented southeast, with very little overshading.



Energy and Carbon Performance Criteria	Value
Predicted Annual Energy Saved (kWh/yr)	4,956.56
Annual Carbon Emissions Reductions (kg CO_2/year) using SAP10.2 carbon factors	644.35
CO_2 Emissions Reduction (%) with SAP10.2	13.1%

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Conclusion

Summary

The scheme complies with the 2021 Building Regulations Part L and the minimum energy efficiency targets in the following documents have been followed:

- CO_2 emissions – The actual CO_2 Dwelling Emissions Rate (DER) is no greater than the baseline (GLA guidance for energy assessment – Appendix 3) CO_2 Dwelling Emissions Rate (Baseline DER).
- Dwelling Fabric efficiency – The Dwelling Fabric Energy Efficiency (DFEE) is not greater than the baseline Dwelling Fabric Energy Efficiency (Baseline DFEE).
- Primary energy – The Dwelling Primary Energy Rate (DPER) is no greater than the baseline Dwelling Primary Energy Rate (Baseline DPER).
- Refurbishment - Consequential improvements to refurbished areas have been made to ensure that the building complies with Part L, to the extent that such improvements are technically, functionally, and economically feasible.

In addition, the CO_2 emissions of the scheme have been calculated using the SAP 10.2 carbon emission factors, and the scheme can achieve:

- An on-site CO_2 reduction of 32% beyond Building Regulations through energy efficiency measures and inclusion of renewable technologies (PV panels)
- a 19% reduction in CO_2 emissions through energy efficiency measures, 'Be Lean' stage
- An EPC rating of A

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Appendix A

PEA files

The draft EPC of one dwelling is presented below.

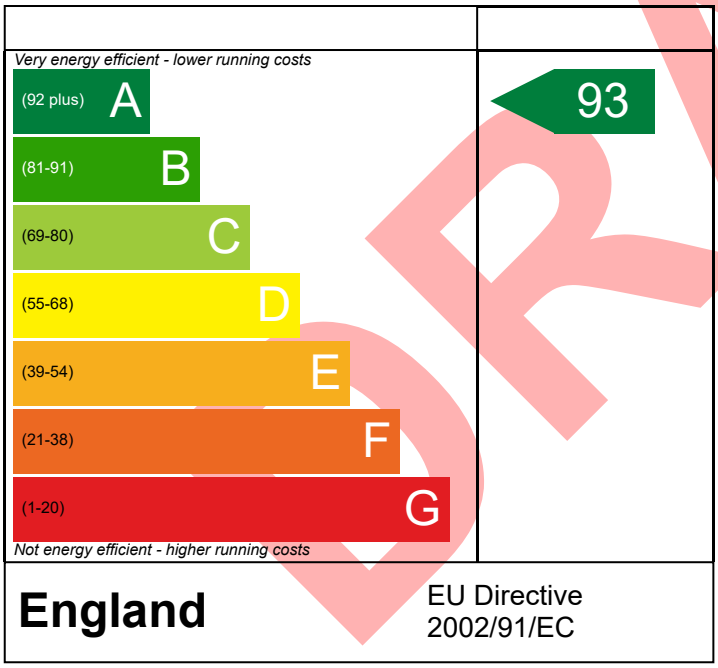
Predicted Energy Assessment

Dwelling type:	House, Mid-Terrace
Date of assessment:	21/02/2024
Produced by:	Vanessa Vienna
Total floor area:	138.47 m²
DRRN:	

This document is a Predicted Energy Assessment for properties marketed when they are incomplete. It includes a predicted energy rating which might not represent the final energy rating of the property on completion. Once the property is completed, this rating will be updated and an official Energy Performance Certificate will be created for the property. This will include more detailed information about the energy performance of the completed property.

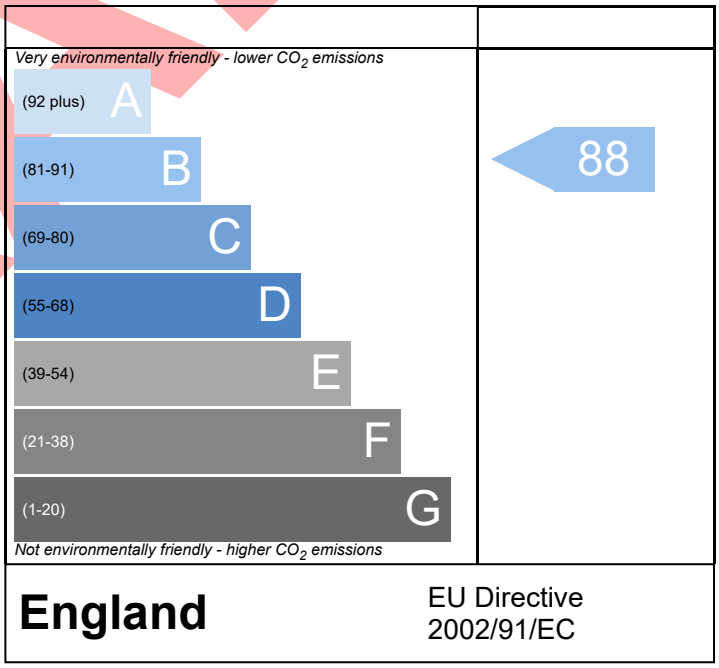
The energy performance has been assessed using the Government approved SAP 10 methodology and is rated in terms of the energy use per square meter of floor area; the energy efficiency is based on fuel costs and the environmental impact is based on carbon dioxide (CO2) emissions.

Energy Efficiency Rating



The energy efficiency rating is a measure of the overall efficiency of a home. The higher the rating the more energy efficient the home is and the lower the fuel bills are likely to be.

Environmental Impact (CO_2) Rating



The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions. The higher the rating the less impact it has on the environment.

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Appendix B

SAP files

The emission figures and details of the calculations and methodology used to determine the figures provided within the report can be found in the following pages:

- Baseline Residential – DER from the DER SAP worksheet of the baseline (Notional GLA's Appendix 3)
- Be Lean Residential – DER from the Be Lean scenario DER SAP worksheet
- Be Green Residential – DER from the Be Green scenario DER SAP worksheet

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Baseline Residential – DER from the DER SAP worksheet of the baseline (Notional GLA's Appendix 3)

Full SAP Calculation Printout

Property Reference	GLA Appendix 3	**Issued on Date**	21/02/2024
Assessment Reference	Gas boiler, Nat Vent,PV export	**Prop Type Ref**	
Property			

SAP Rating	82 B	**DER**	17.81	**TER**	8.95
Environmental	82 B	**% DER < TER**			-98.99
CO₂ Emissions (t/year)	2.11	**DFEE**	59.48	**TFEE**	33.84
Compliance Check	See BREL	**% DFEE < TFEE**			-75.76
% DPER < TPER	-110.50	**DPER**	98.05	**TPER**	46.58

Assessor Details	Ms. Vanessa Vienna	**Assessor ID**	T798-0001
Client			

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	59.3700 (1b)	x	2.6600 (2b)	=	157.9242	(1b) - (3b)
First floor	43.4700 (1c)	x	2.6600 (2c)	=	113.0220	(1c) - (3c)
Second floor	35.6300 (1d)	x	2.6600 (2d)	=	94.7758	(1d) - (3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n)	138.4700					(4)
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	365.7220	(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) =	0.1094	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		10.0000	(17)
Infiltration rate		0.6094	(18)
Number of sides sheltered		2	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.8500	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.5180	(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	0.6604	0.6475	0.6345	0.5698	0.5568	0.4921	0.4921	0.4791	0.5180	0.5568	0.5827	0.6086	(22b)
Effective ac	0.7181	0.7096	0.7013	0.6623	0.6550	0.6211	0.6211	0.6148	0.6341	0.6550	0.6698	0.6852	(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	
Opening Type 1			2.4600	1.0000	2.4600			(26)
Opening Type 2 (Uw = 1.60)			18.6900	1.5038	28.1053			(27)
Opening			1.3400	1.5038	2.0150			(27a)
Opening			2.8700	1.5038	4.3158			(27a)
Heatloss Floor 1			59.3700	0.2500	14.8425			(28a)
External Wall 1	71.3900	21.1500	50.2400	0.3000	15.0720			(29a)
Wall to unheated	22.2800		22.2800	0.3000	6.6840			(29a)
External Roof 1	54.9400	4.2100	50.7300	0.1600	8.1168			(30)
Total net area of external elements Aum(A, m2)			207.9800					(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		81.6114			(33)
Party Wall 1			142.0300	0.0000	0.0000			(32)

Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K	250.0000	(35)
Thermal bridges (Default value 0.200 * total exposed area)	41.5960	(36)
Point Thermal bridges (36a) =	0.0000	
Total fabric heat loss (33) + (36) + (36a) =	123.2074	(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	86.6625	85.6405	84.6388	79.9337	79.0534	74.9553	74.9553	74.1964	76.5338	79.0534	80.8342	82.6960	(38)
Heat transfer coeff	209.8699	208.8479	207.8462	203.1411	202.2607	198.1627	198.1627	197.4038	199.7412	202.2607	204.0416	205.9034	(39)
Average = Sum(39)m / 12 =												203.1368	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.5156	1.5083	1.5010	1.4670	1.4607	1.4311	1.4311	1.4256	1.4425	1.4607	1.4735	1.4870	(40)
HLP (average)												1.4670	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

4. Water heating energy requirements (kWh/year)

Assumed occupancy												2.9141	(42)
Hot water usage for mixer showers	73.0800	71.9817	70.3814	67.3193	65.0597	62.5397	61.1073	62.6956	64.4366	67.1423	70.2701	72.8000	(42a)
Hot water usage for baths	31.5500	31.0814	30.4216	29.2050	28.2940	27.2839	26.7382	27.3935	28.1069	29.1878	30.4294	31.4433	(42b)
Hot water usage for other uses	44.4735	42.8562	41.2390	39.6218	38.0046	36.3874	36.3874	38.0046	39.6218	41.2390	42.8562	44.4735	(42c)
Average daily hot water use (litres/day)												137.0595	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	149.1034	145.9194	142.0420	136.1461	131.3583	126.2109	124.2329	128.0936	132.1653	137.5691	143.5557	148.7168	(44)
Energy conte	236.1434	207.7873	218.3132	186.3773	176.8335	155.1910	150.2490	158.6067	162.9730	186.6799	204.5215	232.8545	(45)
Energy content (annual)											Total = Sum(45)m =	2276.5302	
Distribution loss (46)m = 0.15 x (45)m	35.4215	31.1681	32.7470	27.9566	26.5250	23.2787	22.5373	23.7910	24.4459	28.0020	30.6782	34.9282	(46)
Water storage loss:													
Total storage 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	(56)
If cylinder contains dedicated solar storage	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(57)
Primary 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	(59)
Combi loss	50.9589	46.0274	50.9589	49.3151	50.9589	49.3151	50.9589	50.9589	49.3151	50.9589	49.3151	50.9589	(61)
Total heat required for water heating calculated for each month	287.1023	253.8147	269.2721	235.6923	227.7924	204.5061	201.2079	209.5656	212.2881	237.6388	253.8365	283.8134	(62)
WWHRS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(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	287.1023	253.8147	269.2721	235.6923	227.7924	204.5061	201.2079	209.5656	212.2881	237.6388	253.8365	283.8134	(64)
										Total per year (kWh/year) = Sum(64)m =		2876.5302	(64)
12Total per year (kWh/year)												2877	(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	91.2574	80.5961	85.3289	74.2992	71.5369	63.9298	62.6975	65.4764	66.5173	74.8108	80.3322	90.1639	(65)

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	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	156.6135	173.3935	156.6135	161.8340	156.6135	161.8340	156.6135	156.6135	161.8340	156.6135	161.8340	156.6135	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	307.6657	310.8583	302.8130	285.6856	264.0653	243.7453	230.1702	226.9776	235.0229	252.1503	273.7706	294.0906	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	(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)	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	(71)
Water heating gains (Table 5)	122.6578	119.9347	114.6894	103.1933	96.1517	88.7914	84.2708	88.0060	92.3851	100.5522	111.5724	121.1880	(72)
Total internal gains	656.6487	673.8982	643.8276	620.4246	586.5422	561.0823	537.7663	538.3088	555.9537	579.0277	616.8887	641.6039	(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	
Northeast	6.6100	11.2829	0.6300	0.8000	0.7700	26.0488	(75)
Southwest	12.0800	36.7938	0.6300	0.8000	0.7700	155.2408	(79)
Northeast	2.8700	26.0000	0.6300	0.8000	1.0000	33.8476	(82)
Southwest	1.3400	26.0000	0.6300	0.8000	1.0000	15.8034	(82)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains	230.9406	420.5769	640.6657	891.6349	1079.6741	1105.2612	1051.8560	907.9338	727.7776	483.0899	281.7374	194.2293	(83)
Total gains	887.5893	1094.4752	1284.4933	1512.0595	1666.2163	1666.3435	1589.6223	1446.2427	1283.7313	1062.1176	898.6261	835.8331	(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, ni1,m (see Table 9a)													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
tau	45.8187	46.0429	46.2648	47.3364	47.5425	48.5256	48.5256	48.7122	48.1422	47.5425	47.1275	46.7014	
alpha	4.0546	4.0695	4.0843	4.1558	4.1695	4.2350	4.2350	4.2475	4.2095	4.1695	4.1418	4.1134	
util living area	0.9971	0.9930	0.9821	0.9444	0.8521	0.6859	0.5282	0.5924	0.8356	0.9705	0.9941	0.9978	(86)
MIT	19.4977	19.6838	19.9682	20.3602	20.6724	20.8578	20.9092	20.8989	20.7582	20.3364	19.8602	19.4888	(87)
Th 2	19.6758	19.6813	19.6867	19.7123	19.7171	19.7396	19.7396	19.7438	19.7309	19.7171	19.7074	19.6973	(88)

util rest of house													
	0.9961	0.9905	0.9754	0.9227	0.7954	0.5792	0.3869	0.4474	0.7512	0.9549	0.9916	0.9970	(89)
MIT 2	17.9416	18.1830	18.5478	19.0525	19.4132	19.6082	19.6409	19.6411	19.5233	19.0369	18.4287	17.9460	(90)
Living area fraction										fLA = Living area / (4) =		0.3639	(91)
MIT	18.5079	18.7292	19.0647	19.5284	19.8714	20.0629	20.1024	20.0989	19.9727	19.5098	18.9496	18.5074	(92)
Temperature adjustment												-0.1500	
adjusted MIT	18.3579	18.5792	18.9147	19.3784	19.7214	19.9129	19.9524	19.9489	19.8227	19.3598	18.7996	18.3574	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9946	0.9875	0.9701	0.9156	0.7957	0.5952	0.4118	0.4726	0.7585	0.9489	0.9890	0.9958	(94)
Useful gains	882.8175	1080.7639	1246.0356	1384.4436	1325.7553	991.8622	654.6127	683.5567	973.6866	1007.8943	888.7657	832.3300	(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													
	2950.3268	2856.8631	2580.3426	2128.5977	1622.4239	1052.8238	664.3217	700.5567	1143.0512	1771.7629	2387.2141	2915.0651	(97)
Space heating kWh													
	1538.2269	1193.5387	992.7244	535.7910	220.7214	0.0000	0.0000	0.0000	0.0000	568.3182	1078.8829	1549.5549	(98a)
Space heating requirement - total per year (kWh/year)												7677.7584	
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													
	1538.2269	1193.5387	992.7244	535.7910	220.7214	0.0000	0.0000	0.0000	0.0000	568.3182	1078.8829	1549.5549	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												7677.7584	
Space heating per m2											(98c) / (4) =	55.4471	(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 %)												92.0000	(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													
	1538.2269	1193.5387	992.7244	535.7910	220.7214	0.0000	0.0000	0.0000	0.0000	568.3182	1078.8829	1549.5549	(98)
Space heating efficiency (main heating system 1)													
	92.0000	92.0000	92.0000	92.0000	92.0000	0.0000	0.0000	0.0000	0.0000	92.0000	92.0000	92.0000	(210)
Space heating fuel (main heating system)													
	1671.9858	1297.3246	1079.0483	582.3815	239.9146	0.0000	0.0000	0.0000	0.0000	617.7372	1172.6988	1684.2988	(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													
	287.1023	253.8147	269.2721	235.6923	227.7924	204.5061	201.2079	209.5656	212.2881	237.6388	253.8365	283.8134	(64)
Efficiency of water heater												92.0000	(216)
(217)m	92.0000	92.0000	92.0000	92.0000	92.0000	92.0000	92.0000	92.0000	92.0000	92.0000	92.0000	92.0000	(217)
Fuel for water heating, kWh/month													
	312.0677	275.8855	292.6871	256.1873	247.6004	222.2893	218.7042	227.7887	230.7479	258.3031	275.9093	308.4929	(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	39.0866	31.3567	28.2333	20.6849	15.9776	13.0538	14.5753	18.9455	24.6084	32.2875	36.4687	40.1730	(232)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233a)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	(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	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(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	8345.3895	(211)
Space heating fuel - main system 2	0.0000	(213)
Space heating fuel - secondary	0.0000	(215)
Efficiency of water heater	92.0000	
Water heating fuel used	3126.6633	(219)
Space cooling fuel	0.0000	(221)
Electricity for pumps and fans:		
central heating pump	41.0000	(230c)
main heating flue fan	45.0000	(230e)
Total electricity for the above, kWh/year	86.0000	(231)
Electricity for lighting (calculated in Appendix L)	315.4514	(232)
Energy saving/generation technologies (Appendices M ,N and Q)		
PV generation	0.0000	(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	11873.5042	(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	8345.3895	0.2100	1752.5318	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	3126.6633	0.2100	656.5993	(264)
Space and water heating			2409.1311	(265)
Pumps, fans and electric keep-hot	86.0000	0.1387	11.9293	(267)
Energy for lighting	315.4514	0.1443	45.5294	(268)
Total CO2, kg/year			2466.5897	(272)
EPC Dwelling Carbon Dioxide Emission Rate (DER)			17.8100	(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	8345.3895	1.1300	9430.2902	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	3126.6633	1.1300	3533.1295	(278)
Space and water heating			12963.4197	(279)
Pumps, fans and electric keep-hot	86.0000	1.5128	130.1008	(281)
Energy for lighting	315.4514	1.5338	483.8499	(282)
Total Primary energy kWh/year			13577.3704	(286)
Dwelling Primary energy Rate (DPER)			98.0500	(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	59.3700 (1b)	x	2.6600 (2b)	=	157.9242	(1b) - (3b)
First floor	43.4700 (1c)	x	2.6000 (2c)	=	113.0220	(1c) - (3c)
Second floor	35.6300 (1d)	x	2.6600 (2d)	=	94.7758	(1d) - (3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n)	138.4700					(4)
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	365.7220	(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) =	0.1094	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		5.0000	(17)
Infiltration rate		0.3594	(18)
Number of sides sheltered		2	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.8500	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.3055	(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	0.3895	0.3818	0.3742	0.3360	0.3284	0.2902	0.2902	0.2826	0.3055	0.3284	0.3437	0.3589	(22b)
Effective ac	0.5758	0.5729	0.5700	0.5565	0.5539	0.5421	0.5421	0.5399	0.5467	0.5539	0.5590	0.5644	(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	
TER Opaque door			2.4600	1.0000	2.4600			(26)
TER Opening Type (Uw = 1.20)			18.6900	1.1450	21.4008			(27)
Opening			1.3400	2.0221	2.7096			(27a)
Opening			2.8700	2.0221	5.8033			(27a)
Heatloss Floor 1			59.3700	0.1300	7.7181			(28a)
External Wall 1	71.3900	21.1500	50.2400	0.1800	9.0432			(29a)
Wall to unheated	22.2800		22.2800	0.1800	4.0104			(29a)
External Roof 1	54.9400	4.2100	50.7300	0.1100	5.5803			(30)
Total net area of external elements Aum(A, m2)			207.9800					(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		58.7256			(33)
Party Wall 1			142.0300	0.0000	0.0000			(32)
Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K							250.0000	(35)
Thermal bridges (User defined value 0.050 * total exposed area)							10.3990	(36)
Point Thermal bridges						(36a) =	0.0000	

Total fabric heat loss (33) + (36) + (36a) = 69.1246 (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	69.4976	69.1421	68.7937	67.1573	66.8511	65.4258	65.4258	65.1619	65.9748	66.8511	67.4705	68.1180	(38)
Heat transfer coeff	138.6222	138.2667	137.9183	136.2819	135.9757	134.5505	134.5505	134.2865	135.0995	135.9757	136.5951	137.2427	(39)
Average = Sum(39)m / 12 =												136.2805	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.0011	0.9985	0.9960	0.9842	0.9820	0.9717	0.9717	0.9698	0.9757	0.9820	0.9865	0.9911	(40)
HLP (average)												0.9842	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

4. Water heating energy requirements (kWh/year)

Assumed occupancy 2.9141 (42)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage for mixer showers	73.0800	71.9817	70.3814	67.3193	65.0597	62.5397	61.1073	62.6956	64.4366	67.1423	70.2701	72.8000	(42a)
Hot water usage for baths	31.5500	31.0814	30.4216	29.2050	28.2940	27.2839	26.7382	27.3935	28.1069	29.1878	30.4294	31.4433	(42b)
Hot water usage for other uses	44.4735	42.8562	41.2390	39.6218	38.0046	36.3874	36.3874	38.0046	39.6218	41.2390	42.8562	44.4735	(42c)
Average daily hot water use (litres/day)												137.0595	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	149.1034	145.9194	142.0420	136.1461	131.3583	126.2109	124.2329	128.0936	132.1653	137.5691	143.5557	148.7168	(44)
Energy conte	236.1434	207.7873	218.3132	186.3773	176.8335	155.1910	150.2490	158.6067	162.9730	186.6799	204.5215	232.8545	(45)
Energy content (annual)										Total = Sum(45)m =		2276.5302	
Distribution loss (46)m = 0.15 x (45)m	35.4215	31.1681	32.7470	27.9566	26.5250	23.2787	22.5373	23.7910	24.4459	28.0020	30.6782	34.9282	(46)
Water storage loss:													
Total storage 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	(56)
If cylinder contains dedicated solar storage	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(57)
Primary 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	(59)
Combi loss	50.9589	46.0274	50.9589	49.3151	50.9589	49.3151	50.9589	50.9589	49.3151	50.9589	49.3151	50.9589	(61)
Total heat required for water heating calculated for each month	287.1023	253.8147	269.2721	235.6923	227.7924	204.5061	201.2079	209.5656	212.2881	237.6388	253.8365	283.8134	(62)
WWHRS	-33.4091	-29.5473	-30.9402	-25.6197	-23.8767	-20.4314	-19.1512	-20.3654	-21.1391	-24.9207	-28.2322	-32.7904	(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	253.6932	224.2674	238.3319	210.0726	203.9157	184.0747	182.0567	189.2002	191.1489	212.7181	225.6044	251.0230	(64)
									Total per year (kWh/year) = Sum(64)m =			2566.1067	(64)
12Total per year (kWh/year)												2566	(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	91.2574	80.5961	85.3289	74.2992	71.5369	63.9298	62.6975	65.4764	66.5173	74.8108	80.3322	90.1639	(65)

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	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	159.7801	176.8994	159.7801	165.1061	159.7801	165.1061	159.7801	159.7801	165.1061	159.7801	165.1061	159.7801	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	307.6657	310.8583	302.8130	285.6856	264.0653	243.7453	230.1702	226.9776	235.0229	252.1503	273.7706	294.0906	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	(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)	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	(71)
Water heating gains (Table 5)	122.6578	119.9347	114.6894	103.1933	96.1517	88.7914	84.2708	88.0060	92.3851	100.5522	111.5724	121.1880	(72)
Total internal gains	659.8153	677.4041	646.9942	623.6968	589.7088	564.3545	540.9329	541.4754	559.2259	582.1943	620.1609	644.7704	(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	
Northeast	6.6100	11.2829	0.6300	0.7000	0.7700	22.7927	(75)
Southwest	12.0800	36.7938	0.6300	0.7000	0.7700	135.8357	(79)
Northeast	2.8700	26.0000	0.6300	0.7000	1.0000	29.6167	(82)
Southwest	1.3400	26.0000	0.6300	0.7000	1.0000	13.8280	(82)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains	202.0730	368.0048	560.5825	780.1805	944.7148	967.1035	920.3740	794.4421	636.8054	422.7036	246.5202	169.9506	(83)
Total gains	861.8883	1045.4089	1207.5766	1403.8773	1534.4236	1531.4580	1461.3069	1335.9175	1196.0313	1004.8979	866.6811	814.7210	(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	69.3682	69.5465	69.7222	70.5594	70.7183	71.4674	71.4674	71.6079	71.1770	70.7183	70.3976	70.0655	
alpha	5.6245	5.6364	5.6481	5.7040	5.7146	5.7645	5.7645	5.7739	5.7451	5.7146	5.6932	5.6710	
util living area	0.9976	0.9925	0.9762	0.9101	0.7581	0.5532	0.4038	0.4595	0.7289	0.9543	0.9937	0.9982	(86)

MIT	19.8421	20.0538	20.3461	20.7035	20.9191	20.9889	20.9985	20.9969	20.9517	20.6365	20.1722	19.8102	(87)
Th 2	20.0824	20.0846	20.0867	20.0965	20.0984	20.1070	20.1070	20.1086	20.1037	20.0984	20.0946	20.0907	(88)
util rest of house													
	0.9968	0.9900	0.9686	0.8839	0.7034	0.4800	0.3226	0.3720	0.6529	0.9351	0.9913	0.9976	(89)
MIT 2	18.7257	18.9971	19.3669	19.8046	20.0342	20.1010	20.1065	20.1075	20.0726	19.7378	19.1569	18.6912	(90)
Living area fraction										fLA = Living area / (4) =		0.3639	(91)
MIT	19.1320	19.3816	19.7233	20.1317	20.3562	20.4241	20.4311	20.4312	20.3926	20.0648	19.5264	19.0984	(92)
Temperature adjustment												0.0000	
adjusted MIT	19.1320	19.3816	19.7233	20.1317	20.3562	20.4241	20.4311	20.4312	20.3926	20.0648	19.5264	19.0984	(93)

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8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9956	0.9876	0.9648	0.8850	0.7199	0.5064	0.3522	0.4039	0.6787	0.9342	0.9892	0.9967	(94)
Useful gains	858.1114	1032.4190	1165.0824	1242.4548	1104.5777	775.5024	514.6526	539.5782	811.6908	938.7752	857.3393	812.0606	(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													
	2056.0398	2002.3253	1823.7296	1530.6772	1177.0380	783.6321	515.4749	541.3304	850.1208	1286.9860	1697.3810	2044.6985	(97)
Space heating kWh													
	891.2587	651.7770	490.0335	207.5201	53.9104	0.0000	0.0000	0.0000	0.0000	259.0689	604.8300	917.0826	(98a)
Space heating requirement - total per year (kWh/year)												4075.4814	
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													
	891.2587	651.7770	490.0335	207.5201	53.9104	0.0000	0.0000	0.0000	0.0000	259.0689	604.8300	917.0826	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												4075.4814	
Space heating per m2											(98c) / (4) =	29.4322	(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 %)												92.4000	(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													
	891.2587	651.7770	490.0335	207.5201	53.9104	0.0000	0.0000	0.0000	0.0000	259.0689	604.8300	917.0826	(98)
Space heating efficiency (main heating system 1)													
	92.4000	92.4000	92.4000	92.4000	92.4000	0.0000	0.0000	0.0000	0.0000	92.4000	92.4000	92.4000	(210)
Space heating fuel (main heating system)													
	964.5657	705.3864	530.3393	224.5889	58.3446	0.0000	0.0000	0.0000	0.0000	280.3776	654.5780	992.5136	(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													
	253.6932	224.2674	238.3319	210.0726	203.9157	184.0747	182.0567	189.2002	191.1489	212.7181	225.6044	251.0230	(64)
Efficiency of water heater												80.3000	(216)
(217)m	86.8393	86.5277	85.8901	84.3552	81.9578	80.3000	80.3000	80.3000	80.3000	84.8049	86.3865	86.9000	(217)
Fuel for water heating, kWh/month													
	292.1411	259.1858	277.4849	249.0333	248.8057	229.2337	226.7206	235.6167	238.0435	250.8323	261.1568	288.8643	(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	33.1991	26.6336	23.9806	17.5692	13.5710	11.0876	12.3799	16.0918	20.9017	27.4242	30.9756	34.1219	(232)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233a)m	-54.3094	-75.9380	-108.2369	-120.5860	-129.0170	-119.9586	-118.3668	-112.1752	-101.1928	-86.2018	-59.4399	-47.0184	(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	-32.6200	-68.3931	-135.5595	-203.1010	-268.1294	-269.3502	-266.2848	-225.7458	-165.7695	-97.7666	-43.5288	-25.8214	(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												4410.6941	(211)
Space heating fuel - main system 2												0.0000	(213)
Space heating fuel - secondary												0.0000	(215)
Efficiency of water heater												80.3000	
Water heating fuel used												3057.1186	(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)												267.9361	(232)
Energy saving/generation technologies (Appendices M ,N and Q)													
PV generation												-2934.5110	(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												4887.2379	(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	4410.6941	0.2100	926.2458	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	3057.1186	0.2100	641.9949	(264)
Space and water heating			1568.2407	(265)
Pumps, fans and electric keep-hot	86.0000	0.1387	11.9293	(267)
Energy for lighting	267.9361	0.1443	38.6715	(268)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1132.4408	0.1348	-152.6426	
PV Unit electricity exported	-1802.0702	0.1260	-226.9876	
Total			-379.6301	(269)
Total CO2, kg/year			1239.2113	(272)
EPC Target Carbon Dioxide Emission Rate (TER)			8.9500	(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	4410.6941	1.1300	4984.0844	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	3057.1186	1.1300	3454.5441	(278)
Space and water heating			8438.6284	(279)
Pumps, fans and electric keep-hot	86.0000	1.5128	130.1008	(281)
Energy for lighting	267.9361	1.5338	410.9694	(282)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1132.4408	1.4982	-1696.5951	
PV Unit electricity exported	-1802.0702	0.4624	-833.2043	
Total			-2529.7994	(283)
Total Primary energy kWh/year			6449.8992	(286)
Target Primary Energy Rate (TPER)			46.5800	(287)

Energy Assessment
13-15 John's Mews

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Be Lean Residential – DER from the Be Lean scenario DER SAP worksheet

Full SAP Calculation Printout

Property Reference	GLA Appendix 3_Improved	**Issued on Date**	21/02/2024
Assessment Reference	Be Lean	**Prop Type Ref**	
Property			

SAP Rating	85 B	**DER**	14.40	**TER**	8.95
Environmental	86 B	**% DER < TER**			-60.89
CO_2 Emissions (t/year)	1.71	**DFEE**	48.96	**TFEE**	33.84
Compliance Check	See BREL	**% DFEE < TFEE**			-44.66
% DPER < TPER	-70.50	**DPER**	79.42	**TPER**	46.58

Assessor Details	Ms. Vanessa Vienna	**Assessor ID**	T798-0001
Client			

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

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1. Overall dwelling characteristics

	Area (m2)		Storey height (m)		Volume (m3)	
Ground floor	59.3700 (1b)	x	2.6600 (2b)	=	157.9242	(1b) - (3b)
First floor	43.4700 (1c)	x	2.6600 (2c)	=	113.0220	(1c) - (3c)
Second floor	35.6300 (1d)	x	2.6600 (2d)	=	94.7758	(1d) - (3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n)	138.4700					(4)
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	365.7220	(5)

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2. Ventilation rate

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		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) =	0.1094	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		5.0000	(17)
Infiltration rate		0.3594	(18)
Number of sides sheltered		2	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.8500	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.3055	(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	0.3895	0.3818	0.3742	0.3360	0.3284	0.2902	0.2902	0.2826	0.3055	0.3284	0.3437	0.3589	(22b)
Effective ac	0.5758	0.5729	0.5700	0.5565	0.5539	0.5421	0.5421	0.5399	0.5467	0.5539	0.5590	0.5644	(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	
Opening Type 1			2.4600	1.4000	3.4440			(26)
Opening Type 2 (Uw = 1.10)			18.6900	1.0536	19.6925			(27)
Opening			1.3400	2.0221	2.7096			(27a)
Opening			2.8700	2.0221	5.8033			(27a)
Heatloss Floor 1			59.3700	0.1800	10.6866			(28a)
External Wall 1	71.3900	21.1500	50.2400	0.3000	15.0720			(29a)
Wall to unheated	22.2800		22.2800	0.1800	4.0104			(29a)
External Roof 1	54.9400	4.2100	50.7300	0.1500	7.6095			(30)
Total net area of external elements Aum(A, m2)			207.9800					(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		69.0279			(33)
Party Wall 1			142.0300	0.0000	0.0000			(32)

Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K	250.0000	(35)
Thermal bridges (Default value 0.200 * total exposed area)	41.5960	(36)
Point Thermal bridges (36a) =	0.0000	
Total fabric heat loss (33) + (36) + (36a) =	110.6239	(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	69.4976	69.1421	68.7937	67.1573	66.8511	65.4258	65.4258	65.1619	65.9748	66.8511	67.4705	68.1180	(38)
Heat transfer coeff													
	180.1214	179.7660	179.4176	177.7812	177.4750	176.0497	176.0497	175.7858	176.5987	177.4750	178.0944	178.7419	(39)
Average = Sum(39)m / 12 =												177.7797	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.3008	1.2982	1.2957	1.2839	1.2817	1.2714	1.2714	1.2695	1.2754	1.2817	1.2862	1.2908	(40)
HLP (average)												1.2839	
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												2.9141	(42)
Hot water usage for mixer showers													
	73.0800	71.9817	70.3814	67.3193	65.0597	62.5397	61.1073	62.6956	64.4366	67.1423	70.2701	72.8000	(42a)
Hot water usage for baths													
	31.5500	31.0814	30.4216	29.2050	28.2940	27.2839	26.7382	27.3935	28.1069	29.1878	30.4294	31.4433	(42b)
Hot water usage for other uses													
	44.4735	42.8562	41.2390	39.6218	38.0046	36.3874	36.3874	38.0046	39.6218	41.2390	42.8562	44.4735	(42c)
Average daily hot water use (litres/day)												137.0595	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use													
	149.1034	145.9194	142.0420	136.1461	131.3583	126.2109	124.2329	128.0936	132.1653	137.5691	143.5557	148.7168	(44)
Energy conte	236.1434	207.7873	218.3132	186.3773	176.8335	155.1910	150.2490	158.6067	162.9730	186.6799	204.5215	232.8545	(45)
Energy content (annual)										Total = Sum(45)m =		2276.5302	
Distribution loss (46)m = 0.15 x (45)m													
	35.4215	31.1681	32.7470	27.9566	26.5250	23.2787	22.5373	23.7910	24.4459	28.0020	30.6782	34.9282	(46)
Water storage loss:													
Total storage 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	(56)
If cylinder contains dedicated solar storage													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(57)
Primary 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	(59)
Combi loss	14.3233	12.9240	14.2805	13.7601	14.1810	13.6853	14.1172	14.1372	13.7039	14.2046	13.8037	14.3154	(61)
Total heat required for water heating calculated for each month													
	250.4667	220.7113	232.5938	200.1374	191.0144	168.8763	164.3661	172.7439	176.6769	200.8845	218.3251	247.1699	(62)
WWHRS	-64.7181	-57.2372	-59.9355	-49.6290	-46.2524	-39.5785	-37.0985	-39.4506	-40.9495	-48.2749	-54.6896	-63.5196	(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													
	185.7486	163.4741	172.6583	150.5084	144.7620	129.2978	127.2676	133.2933	135.7275	152.6096	163.6355	183.6503	(64)
										Total per year (kWh/year) = Sum(64)m =		1842.6329	(64)
12Total per year (kWh/year)												1843	(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													
	82.0985	72.3203	76.1593	65.4105	62.3424	55.0223	53.4871	56.2710	57.6145	65.6222	71.4543	81.0030	(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	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
	156.6135	173.3935	156.6135	161.8340	156.6135	161.8340	156.6135	156.6135	161.8340	156.6135	161.8340	156.6135	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
	307.6657	310.8583	302.8130	285.6856	264.0653	243.7453	230.1702	226.9776	235.0229	252.1503	273.7706	294.0906	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	(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)													
	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	(71)
Water heating gains (Table 5)													
	110.3474	107.6194	102.3646	90.8479	83.7935	76.4199	71.8912	75.6331	80.0201	88.2019	99.2421	108.8750	(72)
Total internal gains													
	644.3384	661.5830	631.5029	608.0791	574.1840	548.7109	525.3867	525.9360	543.5887	566.6775	604.5584	629.2909	(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	
Northeast	6.6100	11.2829	0.6300	0.8000	0.7700	26.0488	(75)
Southwest	12.0800	36.7938	0.6300	0.8000	0.7700	155.2408	(79)
Northeast	2.8700	26.0000	0.6300	0.8000	1.0000	33.8476	(82)
Southwest	1.3400	26.0000	0.6300	0.8000	1.0000	15.8034	(82)

Solar gains	230.9406	420.5769	640.6657	891.6349	1079.6741	1105.2612	1051.8560	907.9338	727.7776	483.0899	281.7374	194.2293	(83)
Total gains	875.2789	1082.1599	1272.1685	1499.7140	1653.8581	1653.9721	1577.2427	1433.8698	1271.3664	1049.7673	886.2958	823.5201	(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	53.3860	53.4916	53.5955	54.0888	54.1821	54.6208	54.6208	54.7028	54.4510	54.1821	53.9937	53.7981	
alpha	4.5591	4.5661	4.5730	4.6059	4.6121	4.6414	4.6414	4.6469	4.6301	4.6121	4.5996	4.5865	
util living area													
	0.9974	0.9930	0.9802	0.9337	0.8210	0.6399	0.4817	0.5461	0.8045	0.9667	0.9943	0.9981	(86)
MIT	19.7257	19.9035	20.1662	20.5073	20.7669	20.8945	20.9249	20.9188	20.8221	20.4617	20.0295	19.6979	(87)
Th 2	19.8402	19.8422	19.8442	19.8535	19.8552	19.8633	19.8633	19.8648	19.8602	19.8552	19.8517	19.8480	(88)

util rest of house													
	0.9966	0.9905	0.9732	0.9102	0.7630	0.5428	0.3621	0.4202	0.7205	0.9502	0.9919	0.9974	(89)
MIT 2	18.3559	18.5843	18.9183	19.3438	19.6342	19.7568	19.7753	19.7745	19.7007	19.2998	18.7535	18.3264	(90)
Living area fraction										fLA = Living area / (4) =		0.3639	(91)
MIT	18.8544	19.0643	19.3724	19.7672	20.0464	20.1708	20.1937	20.1910	20.1088	19.7226	19.2178	18.8255	(92)
Temperature adjustment												0.0000	
adjusted MIT	18.8544	19.0643	19.3724	19.7672	20.0464	20.1708	20.1937	20.1910	20.1088	19.7226	19.2178	18.8255	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9955	0.9883	0.9695	0.9081	0.7738	0.5704	0.3976	0.4576	0.7410	0.9477	0.9901	0.9966	(94)
Useful gains	871.3464	1069.5456	1233.3926	1361.8901	1279.6967	943.4926	627.1705	656.1240	942.1394	994.9047	877.5218	820.6943	(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	2621.5579	2546.2663	2309.5413	1931.9803	1481.2825	980.7407	632.6617	666.3970	1061.1379	1619.0351	2158.1144	2614.1913	(97)
Space heating kWh	1302.1574	992.3563	800.6547	410.4650	149.9798	0.0000	0.0000	0.0000	0.0000	464.3530	922.0267	1334.3617	(98a)
Space heating requirement - total per year (kWh/year)												6376.3546	
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	1302.1574	992.3563	800.6547	410.4650	149.9798	0.0000	0.0000	0.0000	0.0000	464.3530	922.0267	1334.3617	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												6376.3546	
Space heating per m2											(98c) / (4) =	46.0486	(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 %)												89.0000	(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	1302.1574	992.3563	800.6547	410.4650	149.9798	0.0000	0.0000	0.0000	0.0000	464.3530	922.0267	1334.3617	(98)
Space heating efficiency (main heating system 1)	89.0000	89.0000	89.0000	89.0000	89.0000	0.0000	0.0000	0.0000	0.0000	89.0000	89.0000	89.0000	(210)
Space heating fuel (main heating system)	1463.0982	1115.0071	899.6120	461.1966	168.5166	0.0000	0.0000	0.0000	0.0000	521.7450	1035.9851	1499.2829	(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	185.7486	163.4741	172.6583	150.5084	144.7620	129.2978	127.2676	133.2933	135.7275	152.6096	163.6355	183.6503	(64)
Efficiency of water heater												87.3000	(216)
(217)m	88.7842	88.7556	88.6936	88.5374	88.1569	87.3000	87.3000	87.3000	87.3000	88.5734	88.7395	88.7908	(217)
Fuel for water heating, kWh/month	209.2137	184.1846	194.6682	169.9941	164.2096	148.1074	145.7819	152.6842	155.4725	172.2974	184.3998	206.8348	(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	33.2832	26.7011	24.0413	17.6137	13.6053	11.1157	12.4112	16.1326	20.9547	27.4937	31.0540	34.2083	(232)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233a)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	(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	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(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												7164.4433	(211)
Space heating fuel - main system 2												0.0000	(213)
Space heating fuel - secondary												0.0000	(215)
Efficiency of water heater												87.3000	
Water heating fuel used												2087.8481	(219)
Space cooling fuel												0.0000	(221)
Electricity for pumps and fans:													
central heating pump												41.0000	(230c)
main heating flue fan												45.0000	(230e)
Total electricity for the above, kWh/year												86.0000	(231)
Electricity for lighting (calculated in Appendix L)												268.6148	(232)
Energy saving/generation technologies (Appendices M ,N and Q)													
PV generation												0.0000	(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												9606.9063	(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	7164.4433	0.2100	1504.5331	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	2087.8481	0.2100	438.4481	(264)
Space and water heating			1942.9812	(265)
Pumps, fans and electric keep-hot	86.0000	0.1387	11.9293	(267)
Energy for lighting	268.6148	0.1443	38.7694	(268)
Total CO2, kg/year			1993.6799	(272)
EPC Dwelling Carbon Dioxide Emission Rate (DER)			14.4000	(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	7164.4433	1.1300	8095.8210	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	2087.8481	1.1300	2359.2684	(278)
Space and water heating			10455.0894	(279)
Pumps, fans and electric keep-hot	86.0000	1.5128	130.1008	(281)
Energy for lighting	268.6148	1.5338	412.0104	(282)
Total Primary energy kWh/year			10997.2006	(286)
Dwelling Primary energy Rate (DPER)			79.4200	(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	59.3700	(1b)	x 2.6600	(2b) =	157.9242	(1b) - (3b)
First floor	43.4700	(1c)	x 2.6000	(2c) =	113.0220	(1c) - (3c)
Second floor	35.6300	(1d)	x 2.6600	(2d) =	94.7758	(1d) - (3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n)	138.4700					(4)
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)...(3n) =		365.7220	(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) =	0.1094	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		5.0000	(17)
Infiltration rate		0.3594	(18)
Number of sides sheltered		2	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.8500	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.3055	(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	0.3895	0.3818	0.3742	0.3360	0.3284	0.2902	0.2902	0.2826	0.3055	0.3284	0.3437	0.3589	(22b)
Effective ac	0.5758	0.5729	0.5700	0.5565	0.5539	0.5421	0.5421	0.5399	0.5467	0.5539	0.5590	0.5644	(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	
TER Opaque door			2.4600	1.0000	2.4600			(26)
TER Opening Type (Uw = 1.20)			18.6900	1.1450	21.4008			(27)
Opening			1.3400	2.0221	2.7096			(27a)
Opening			2.8700	2.0221	5.8033			(27a)
Heatloss Floor 1			59.3700	0.1300	7.7181			(28a)
External Wall 1	71.3900	21.1500	50.2400	0.1800	9.0432			(29a)
Wall to unheated	22.2800		22.2800	0.1800	4.0104			(29a)
External Roof 1	54.9400	4.2100	50.7300	0.1100	5.5803			(30)
Total net area of external elements Aum(A, m2)			207.9800					(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		58.7256			(33)
Party Wall 1			142.0300	0.0000	0.0000			(32)
Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K							250.0000	(35)
Thermal bridges (User defined value 0.050 * total exposed area)							10.3990	(36)
Point Thermal bridges						(36a) =	0.0000	

Total fabric heat loss (33) + (36) + (36a) = 69.1246 (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	69.4976	69.1421	68.7937	67.1573	66.8511	65.4258	65.4258	65.1619	65.9748	66.8511	67.4705	68.1180	(38)
Heat transfer coeff	138.6222	138.2667	137.9183	136.2819	135.9757	134.5505	134.5505	134.2865	135.0995	135.9757	136.5951	137.2427	(39)
Average = Sum(39)m / 12 =												136.2805	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.0011	0.9985	0.9960	0.9842	0.9820	0.9717	0.9717	0.9698	0.9757	0.9820	0.9865	0.9911	(40)
HLP (average)												0.9842	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

4. Water heating energy requirements (kWh/year)

Assumed occupancy 2.9141 (42)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage for mixer showers	73.0800	71.9817	70.3814	67.3193	65.0597	62.5397	61.1073	62.6956	64.4366	67.1423	70.2701	72.8000	(42a)
Hot water usage for baths	31.5500	31.0814	30.4216	29.2050	28.2940	27.2839	26.7382	27.3935	28.1069	29.1878	30.4294	31.4433	(42b)
Hot water usage for other uses	44.4735	42.8562	41.2390	39.6218	38.0046	36.3874	36.3874	38.0046	39.6218	41.2390	42.8562	44.4735	(42c)
Average daily hot water use (litres/day)												137.0595	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	149.1034	145.9194	142.0420	136.1461	131.3583	126.2109	124.2329	128.0936	132.1653	137.5691	143.5557	148.7168	(44)
Energy conte	236.1434	207.7873	218.3132	186.3773	176.8335	155.1910	150.2490	158.6067	162.9730	186.6799	204.5215	232.8545	(45)
Energy content (annual)										Total = Sum(45)m =		2276.5302	
Distribution loss (46)m = 0.15 x (45)m	35.4215	31.1681	32.7470	27.9566	26.5250	23.2787	22.5373	23.7910	24.4459	28.0020	30.6782	34.9282	(46)
Water storage loss:													
Total storage 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	(56)
If cylinder contains dedicated solar storage	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(57)
Primary 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	(59)
Combi loss	50.9589	46.0274	50.9589	49.3151	50.9589	49.3151	50.9589	50.9589	49.3151	50.9589	49.3151	50.9589	(61)
Total heat required for water heating calculated for each month	287.1023	253.8147	269.2721	235.6923	227.7924	204.5061	201.2079	209.5656	212.2881	237.6388	253.8365	283.8134	(62)
WWHRS	-33.4091	-29.5473	-30.9402	-25.6197	-23.8767	-20.4314	-19.1512	-20.3654	-21.1391	-24.9207	-28.2322	-32.7904	(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	253.6932	224.2674	238.3319	210.0726	203.9157	184.0747	182.0567	189.2002	191.1489	212.7181	225.6044	251.0230	(64)
									Total per year (kWh/year) = Sum(64)m =			2566.1067	(64)
12Total per year (kWh/year)												2566	(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	91.2574	80.5961	85.3289	74.2992	71.5369	63.9298	62.6975	65.4764	66.5173	74.8108	80.3322	90.1639	(65)

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	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	159.7801	176.8994	159.7801	165.1061	159.7801	165.1061	159.7801	159.7801	165.1061	159.7801	165.1061	159.7801	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	307.6657	310.8583	302.8130	285.6856	264.0653	243.7453	230.1702	226.9776	235.0229	252.1503	273.7706	294.0906	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	(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)	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	(71)
Water heating gains (Table 5)	122.6578	119.9347	114.6894	103.1933	96.1517	88.7914	84.2708	88.0060	92.3851	100.5522	111.5724	121.1880	(72)
Total internal gains	659.8153	677.4041	646.9942	623.6968	589.7088	564.3545	540.9329	541.4754	559.2259	582.1943	620.1609	644.7704	(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	
Northeast	6.6100	11.2829	0.6300	0.7000	0.7700	22.7927	(75)
Southwest	12.0800	36.7938	0.6300	0.7000	0.7700	135.8357	(79)
Northeast	2.8700	26.0000	0.6300	0.7000	1.0000	29.6167	(82)
Southwest	1.3400	26.0000	0.6300	0.7000	1.0000	13.8280	(82)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains	202.0730	368.0048	560.5825	780.1805	944.7148	967.1035	920.3740	794.4421	636.8054	422.7036	246.5202	169.9506	(83)
Total gains	861.8883	1045.4089	1207.5766	1403.8773	1534.4236	1531.4580	1461.3069	1335.9175	1196.0313	1004.8979	866.6811	814.7210	(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	69.3682	69.5465	69.7222	70.5594	70.7183	71.4674	71.4674	71.6079	71.1770	70.7183	70.3976	70.0655	
alpha	5.6245	5.6364	5.6481	5.7040	5.7146	5.7645	5.7645	5.7739	5.7451	5.7146	5.6932	5.6710	
util living area	0.9976	0.9925	0.9762	0.9101	0.7581	0.5532	0.4038	0.4595	0.7289	0.9543	0.9937	0.9982	(86)

MIT	19.8421	20.0538	20.3461	20.7035	20.9191	20.9889	20.9985	20.9969	20.9517	20.6365	20.1722	19.8102	(87)
Th 2	20.0824	20.0846	20.0867	20.0965	20.0984	20.1070	20.1070	20.1086	20.1037	20.0984	20.0946	20.0907	(88)
util rest of house													
	0.9968	0.9900	0.9686	0.8839	0.7034	0.4800	0.3226	0.3720	0.6529	0.9351	0.9913	0.9976	(89)
MIT 2	18.7257	18.9971	19.3669	19.8046	20.0342	20.1010	20.1065	20.1075	20.0726	19.7378	19.1569	18.6912	(90)
Living area fraction										fLA = Living area / (4) =		0.3639	(91)
MIT	19.1320	19.3816	19.7233	20.1317	20.3562	20.4241	20.4311	20.4312	20.3926	20.0648	19.5264	19.0984	(92)
Temperature adjustment												0.0000	
adjusted MIT	19.1320	19.3816	19.7233	20.1317	20.3562	20.4241	20.4311	20.4312	20.3926	20.0648	19.5264	19.0984	(93)

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8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9956	0.9876	0.9648	0.8850	0.7199	0.5064	0.3522	0.4039	0.6787	0.9342	0.9892	0.9967	(94)
Useful gains	858.1114	1032.4190	1165.0824	1242.4548	1104.5777	775.5024	514.6526	539.5782	811.6908	938.7752	857.3393	812.0606	(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													
	2056.0398	2002.3253	1823.7296	1530.6772	1177.0380	783.6321	515.4749	541.3304	850.1208	1286.9860	1697.3810	2044.6985	(97)
Space heating kWh													
	891.2587	651.7770	490.0335	207.5201	53.9104	0.0000	0.0000	0.0000	0.0000	259.0689	604.8300	917.0826	(98a)
Space heating requirement - total per year (kWh/year)												4075.4814	
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													
	891.2587	651.7770	490.0335	207.5201	53.9104	0.0000	0.0000	0.0000	0.0000	259.0689	604.8300	917.0826	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												4075.4814	
Space heating per m2											(98c) / (4) =	29.4322	(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 %)												92.4000	(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													
	891.2587	651.7770	490.0335	207.5201	53.9104	0.0000	0.0000	0.0000	0.0000	259.0689	604.8300	917.0826	(98)
Space heating efficiency (main heating system 1)													
	92.4000	92.4000	92.4000	92.4000	92.4000	0.0000	0.0000	0.0000	0.0000	92.4000	92.4000	92.4000	(210)
Space heating fuel (main heating system)													
	964.5657	705.3864	530.3393	224.5889	58.3446	0.0000	0.0000	0.0000	0.0000	280.3776	654.5780	992.5136	(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													
	253.6932	224.2674	238.3319	210.0726	203.9157	184.0747	182.0567	189.2002	191.1489	212.7181	225.6044	251.0230	(64)
Efficiency of water heater												80.3000	(216)
(217)m	86.8393	86.5277	85.8901	84.3552	81.9578	80.3000	80.3000	80.3000	80.3000	84.8049	86.3865	86.9000	(217)
Fuel for water heating, kWh/month													
	292.1411	259.1858	277.4849	249.0333	248.8057	229.2337	226.7206	235.6167	238.0435	250.8323	261.1568	288.8643	(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	33.1991	26.6336	23.9806	17.5692	13.5710	11.0876	12.3799	16.0918	20.9017	27.4242	30.9756	34.1219	(232)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233a)m	-54.3094	-75.9380	-108.2369	-120.5860	-129.0170	-119.9586	-118.3668	-112.1752	-101.1928	-86.2018	-59.4399	-47.0184	(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	-32.6200	-68.3931	-135.5595	-203.1010	-268.1294	-269.3502	-266.2848	-225.7458	-165.7695	-97.7666	-43.5288	-25.8214	(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												4410.6941	(211)
Space heating fuel - main system 2												0.0000	(213)
Space heating fuel - secondary												0.0000	(215)
Efficiency of water heater												80.3000	
Water heating fuel used												3057.1186	(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)												267.9361	(232)
Energy saving/generation technologies (Appendices M ,N and Q)													
PV generation												-2934.5110	(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												4887.2379	(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	4410.6941	0.2100	926.2458	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	3057.1186	0.2100	641.9949	(264)
Space and water heating			1568.2407	(265)
Pumps, fans and electric keep-hot	86.0000	0.1387	11.9293	(267)
Energy for lighting	267.9361	0.1443	38.6715	(268)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1132.4408	0.1348	-152.6426	
PV Unit electricity exported	-1802.0702	0.1260	-226.9876	
Total			-379.6301	(269)
Total CO2, kg/year			1239.2113	(272)
EPC Target Carbon Dioxide Emission Rate (TER)			8.9500	(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	4410.6941	1.1300	4984.0844	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	3057.1186	1.1300	3454.5441	(278)
Space and water heating			8438.6284	(279)
Pumps, fans and electric keep-hot	86.0000	1.5128	130.1008	(281)
Energy for lighting	267.9361	1.5338	410.9694	(282)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1132.4408	1.4982	-1696.5951	
PV Unit electricity exported	-1802.0702	0.4624	-833.2043	
Total			-2529.7994	(283)
Total Primary energy kWh/year			6449.8992	(286)
Target Primary Energy Rate (TPER)			46.5800	(287)

Energy Assessment
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Be Green Residential – DER from the Be Green scenario DER SAP worksheet

Full SAP Calculation Printout

Property Reference	GLA Appendix 3_Improved	**Issued on Date**	21/02/2024
Assessment Reference	Be Green	**Prop Type Ref**	
Property			

SAP Rating	93 A	**DER**	12.10	**TER**	8.95
Environmental	88 B	**% DER < TER**			-35.20
CO_2 Emissions (t/year)	1.38	**DFEE**	48.96	**TFEE**	33.84
Compliance Check	See BREL	**% DFEE < TFEE**			-44.66
% DPER < TPER	-36.50	**DPER**	63.58	**TPER**	46.58

Assessor Details	Ms. Vanessa Vienna	**Assessor ID**	T798-0001
Client			

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

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1. Overall dwelling characteristics

	Area (m2)		Storey height (m)		Volume (m3)	
Ground floor	59.3700 (1b)	x	2.6600 (2b)	=	157.9242	(1b) - (3b)
First floor	43.4700 (1c)	x	2.6600 (2c)	=	113.0220	(1c) - (3c)
Second floor	35.6300 (1d)	x	2.6600 (2d)	=	94.7758	(1d) - (3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n)	138.4700					(4)
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	365.7220	(5)

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2. Ventilation rate

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		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) =	0.1094	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		5.0000	(17)
Infiltration rate		0.3594	(18)
Number of sides sheltered		2	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.8500	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.3055	(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	0.3895	0.3818	0.3742	0.3360	0.3284	0.2902	0.2902	0.2826	0.3055	0.3284	0.3437	0.3589	(22b)
Effective ac	0.5758	0.5729	0.5700	0.5565	0.5539	0.5421	0.5421	0.5399	0.5467	0.5539	0.5590	0.5644	(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	
Opening Type 1			2.4600	1.4000	3.4440			(26)
Opening Type 2 (Uw = 1.10)			18.6900	1.0536	19.6925			(27)
Opening			1.3400	2.0221	2.7096			(27a)
Opening			2.8700	2.0221	5.8033			(27a)
Heatloss Floor 1			59.3700	0.1800	10.6866			(28a)
External Wall 1	71.3900	21.1500	50.2400	0.3000	15.0720			(29a)
Wall to unheated	22.2800		22.2800	0.1800	4.0104			(29a)
External Roof 1	54.9400	4.2100	50.7300	0.1500	7.6095			(30)
Total net area of external elements Aum(A, m2)			207.9800					(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		69.0279			(33)
Party Wall 1			142.0300	0.0000	0.0000			(32)

Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K	250.0000	(35)
Thermal bridges (Default value 0.200 * total exposed area)	41.5960	(36)
Point Thermal bridges (36a) =	0.0000	
Total fabric heat loss (33) + (36) + (36a) =	110.6239	(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	69.4976	69.1421	68.7937	67.1573	66.8511	65.4258	65.4258	65.1619	65.9748	66.8511	67.4705	68.1180	(38)
Heat transfer coeff													
	180.1214	179.7660	179.4176	177.7812	177.4750	176.0497	176.0497	175.7858	176.5987	177.4750	178.0944	178.7419	(39)
Average = Sum(39)m / 12 =												177.7797	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.3008	1.2982	1.2957	1.2839	1.2817	1.2714	1.2714	1.2695	1.2754	1.2817	1.2862	1.2908	(40)
HLP (average)												1.2839	
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												2.9141	(42)
Hot water usage for mixer showers													
	73.0800	71.9817	70.3814	67.3193	65.0597	62.5397	61.1073	62.6956	64.4366	67.1423	70.2701	72.8000	(42a)
Hot water usage for baths													
	31.5500	31.0814	30.4216	29.2050	28.2940	27.2839	26.7382	27.3935	28.1069	29.1878	30.4294	31.4433	(42b)
Hot water usage for other uses													
	44.4735	42.8562	41.2390	39.6218	38.0046	36.3874	36.3874	38.0046	39.6218	41.2390	42.8562	44.4735	(42c)
Average daily hot water use (litres/day)												137.0595	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use													
	149.1034	145.9194	142.0420	136.1461	131.3583	126.2109	124.2329	128.0936	132.1653	137.5691	143.5557	148.7168	(44)
Energy conte	236.1434	207.7873	218.3132	186.3773	176.8335	155.1910	150.2490	158.6067	162.9730	186.6799	204.5215	232.8545	(45)
Energy content (annual)										Total = Sum(45)m =		2276.5302	
Distribution loss (46)m = 0.15 x (45)m													
	35.4215	31.1681	32.7470	27.9566	26.5250	23.2787	22.5373	23.7910	24.4459	28.0020	30.6782	34.9282	(46)
Water storage loss:													
Total storage 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	(56)
If cylinder contains dedicated solar storage													
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(57)
Primary 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	(59)
Combi loss	14.3233	12.9240	14.2805	13.7601	14.1810	13.6853	14.1172	14.1372	13.7039	14.2046	13.8037	14.3154	(61)
Total heat required for water heating calculated for each month													
	250.4667	220.7113	232.5938	200.1374	191.0144	168.8763	164.3661	172.7439	176.6769	200.8845	218.3251	247.1699	(62)
WWHRS	-64.7181	-57.2372	-59.9355	-49.6290	-46.2524	-39.5785	-37.0985	-39.4506	-40.9495	-48.2749	-54.6896	-63.5196	(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													
	185.7486	163.4741	172.6583	150.5084	144.7620	129.2978	127.2676	133.2933	135.7275	152.6096	163.6355	183.6503	(64)
										Total per year (kWh/year) = Sum(64)m =		1842.6329	(64)
12Total per year (kWh/year)												1843	(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)
Heat gains from water heating, kWh/month													
	82.0985	72.3203	76.1593	65.4105	62.3424	55.0223	53.4871	56.2710	57.6145	65.6222	71.4543	81.0030	(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	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5													
	156.6135	173.3935	156.6135	161.8340	156.6135	161.8340	156.6135	156.6135	161.8340	156.6135	161.8340	156.6135	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5													
	307.6657	310.8583	302.8130	285.6856	264.0653	243.7453	230.1702	226.9776	235.0229	252.1503	273.7706	294.0906	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5													
	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	(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)													
	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	(71)
Water heating gains (Table 5)													
	110.3474	107.6194	102.3646	90.8479	83.7935	76.4199	71.8912	75.6331	80.0201	88.2019	99.2421	108.8750	(72)
Total internal gains													
	644.3384	661.5830	631.5029	608.0791	574.1840	548.7109	525.3867	525.9360	543.5887	566.6775	604.5584	629.2909	(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	
Northeast	6.6100	11.2829	0.6300	0.8000	0.7700	26.0488	(75)
Southwest	12.0800	36.7938	0.6300	0.8000	0.7700	155.2408	(79)
Northeast	2.8700	26.0000	0.6300	0.8000	1.0000	33.8476	(82)
Southwest	1.3400	26.0000	0.6300	0.8000	1.0000	15.8034	(82)

Solar gains	230.9406	420.5769	640.6657	891.6349	1079.6741	1105.2612	1051.8560	907.9338	727.7776	483.0899	281.7374	194.2293	(83)
Total gains	875.2789	1082.1599	1272.1685	1499.7140	1653.8581	1653.9721	1577.2427	1433.8698	1271.3664	1049.7673	886.2958	823.5201	(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	53.3860	53.4916	53.5955	54.0888	54.1821	54.6208	54.6208	54.7028	54.4510	54.1821	53.9937	53.7981	
alpha	4.5591	4.5661	4.5730	4.6059	4.6121	4.6414	4.6414	4.6469	4.6301	4.6121	4.5996	4.5865	
util living area													
	0.9974	0.9930	0.9802	0.9337	0.8210	0.6399	0.4817	0.5461	0.8045	0.9667	0.9943	0.9981	(86)
MIT	19.7257	19.9035	20.1662	20.5073	20.7669	20.8945	20.9249	20.9188	20.8221	20.4617	20.0295	19.6979	(87)
Th 2	19.8402	19.8422	19.8442	19.8535	19.8552	19.8633	19.8633	19.8648	19.8602	19.8552	19.8517	19.8480	(88)

util rest of house													
	0.9966	0.9905	0.9732	0.9102	0.7630	0.5428	0.3621	0.4202	0.7205	0.9502	0.9919	0.9974	(89)
MIT 2	18.3559	18.5843	18.9183	19.3438	19.6342	19.7568	19.7753	19.7745	19.7007	19.2998	18.7535	18.3264	(90)
Living area fraction										fLA = Living area / (4) =		0.3639	(91)
MIT	18.8544	19.0643	19.3724	19.7672	20.0464	20.1708	20.1937	20.1910	20.1088	19.7226	19.2178	18.8255	(92)
Temperature adjustment												0.0000	
adjusted MIT	18.8544	19.0643	19.3724	19.7672	20.0464	20.1708	20.1937	20.1910	20.1088	19.7226	19.2178	18.8255	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9955	0.9883	0.9695	0.9081	0.7738	0.5704	0.3976	0.4576	0.7410	0.9477	0.9901	0.9966	(94)
Useful gains	871.3464	1069.5456	1233.3926	1361.8901	1279.6967	943.4926	627.1705	656.1240	942.1394	994.9047	877.5218	820.6943	(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													
	2621.5579	2546.2663	2309.5413	1931.9803	1481.2825	980.7407	632.6617	666.3970	1061.1379	1619.0351	2158.1144	2614.1913	(97)
Space heating kWh													
	1302.1574	992.3563	800.6547	410.4650	149.9798	0.0000	0.0000	0.0000	0.0000	464.3530	922.0267	1334.3617	(98a)
Space heating requirement - total per year (kWh/year)												6376.3546	
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													
	1302.1574	992.3563	800.6547	410.4650	149.9798	0.0000	0.0000	0.0000	0.0000	464.3530	922.0267	1334.3617	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												6376.3546	
Space heating per m2											(98c) / (4) =	46.0486	(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 %)	89.0000 (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													
	1302.1574	992.3563	800.6547	410.4650	149.9798	0.0000	0.0000	0.0000	0.0000	464.3530	922.0267	1334.3617	(98)
Space heating efficiency (main heating system 1)													
	89.0000	89.0000	89.0000	89.0000	89.0000	0.0000	0.0000	0.0000	0.0000	89.0000	89.0000	89.0000	(210)
Space heating fuel (main heating system)													
	1463.0982	1115.0071	899.6120	461.1966	168.5166	0.0000	0.0000	0.0000	0.0000	521.7450	1035.9851	1499.2829	(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													
	185.7486	163.4741	172.6583	150.5084	144.7620	129.2978	127.2676	133.2933	135.7275	152.6096	163.6355	183.6503	(64)
Efficiency of water heater												87.3000	(216)
(217)m	88.7842	88.7556	88.6936	88.5374	88.1569	87.3000	87.3000	87.3000	87.3000	88.5734	88.7395	88.7908	(217)
Fuel for water heating, kWh/month													
	209.2137	184.1846	194.6682	169.9941	164.2096	148.1074	145.7819	152.6842	155.4725	172.2974	184.3998	206.8348	(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	33.2832	26.7011	24.0413	17.6137	13.6053	11.1157	12.4112	16.1326	20.9547	27.4937	31.0540	34.2083	(232)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233a)m	-44.0425	-64.4132	-96.1421	-111.1326	-121.3925	-113.6637	-112.0051	-104.8252	-92.0718	-74.8941	-49.0417	-37.6869	(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	-22.3001	-49.3181	-104.2802	-165.0990	-224.9137	-228.4857	-224.9438	-186.5089	-131.0010	-72.4520	-30.2779	-17.3899	(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	7164.4433 (211)
Space heating fuel - main system 2	0.0000 (213)
Space heating fuel - secondary	0.0000 (215)
Efficiency of water heater	87.3000
Water heating fuel used	2087.8481 (219)
Space cooling fuel	0.0000 (221)
Electricity for pumps and fans:	
central heating pump	41.0000 (230c)
main heating flue fan	45.0000 (230e)
Total electricity for the above, kWh/year	86.0000 (231)
Electricity for lighting (calculated in Appendix L)	268.6148 (232)
Energy saving/generation technologies (Appendices M ,N and Q)	
PV generation	-2478.2816 (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	7128.6247 (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	7164.4433	0.2100	1504.5331	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	2087.8481	0.2100	438.4481	(264)
Space and water heating			1942.9812	(265)
Pumps, fans and electric keep-hot	86.0000	0.1387	11.9293	(267)
Energy for lighting	268.6148	0.1443	38.7694	(268)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1021.3114	0.1340	-136.8898	
PV Unit electricity exported	-1456.9702	0.1246	-181.4752	
Total			-318.3650	(269)
Total CO2, kg/year			1675.3149	(272)
EPC Dwelling Carbon Dioxide Emission Rate (DER)			12.1000	(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	7164.4433	1.1300	8095.8210	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	2087.8481	1.1300	2359.2684	(278)
Space and water heating			10455.0894	(279)
Pumps, fans and electric keep-hot	86.0000	1.5128	130.1008	(281)
Energy for lighting	268.6148	1.5338	412.0104	(282)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1021.3114	1.4953	-1527.2048	
PV Unit electricity exported	-1456.9702	0.4571	-666.0516	
Total			-2193.2563	(283)
Total Primary energy kWh/year			8803.9443	(286)
Dwelling Primary energy Rate (DPER)			63.5800	(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	59.3700 (1b)	x	2.6600 (2b)	=	157.9242	(1b) - (3b)
First floor	43.4700 (1c)	x	2.6000 (2c)	=	113.0220	(1c) - (3c)
Second floor	35.6300 (1d)	x	2.6600 (2d)	=	94.7758	(1d) - (3d)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)...(1n)	138.4700					(4)
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)...(3n)	=	365.7220	(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) =	0.1094	(8)
Pressure test		Yes	
Pressure Test Method		Blower Door	
Measured/design AP50		5.0000	(17)
Infiltration rate		0.3594	(18)
Number of sides sheltered		2	(19)
Shelter factor	(20) = 1 - [0.075 x (19)] =	0.8500	(20)
Infiltration rate adjusted to include shelter factor	(21) = (18) x (20) =	0.3055	(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	0.3895	0.3818	0.3742	0.3360	0.3284	0.2902	0.2902	0.2826	0.3055	0.3284	0.3437	0.3589	(22b)
Effective ac	0.5758	0.5729	0.5700	0.5565	0.5539	0.5421	0.5421	0.5399	0.5467	0.5539	0.5590	0.5644	(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	
TER Opaque door			2.4600	1.0000	2.4600			(26)
TER Opening Type (Uw = 1.20)			18.6900	1.1450	21.4008			(27)
Opening			1.3400	2.0221	2.7096			(27a)
Opening			2.8700	2.0221	5.8033			(27a)
Heatloss Floor 1			59.3700	0.1300	7.7181			(28a)

External Wall 1	71.3900	21.1500	50.2400	0.1800	9.0432		(29a)
Wall to unheated	22.2800		22.2800	0.1800	4.0104		(29a)
External Roof 1	54.9400	4.2100	50.7300	0.1100	5.5803		(30)
Total net area of external elements Aum(A, m2)			207.9800				(31)
Fabric heat loss, W/K = Sum (A x U)			(26)...(30) + (32) =		58.7256		(33)
Party Wall 1			142.0300	0.0000	0.0000		(32)

Thermal mass parameter (TMP = Cm / TFA) in kJ/m2K	250.0000	(35)
Thermal bridges (User defined value 0.050 * total exposed area)	10.3990	(36)
Point Thermal bridges (36a) =	0.0000	
Total fabric heat loss (33) + (36) + (36a) =	69.1246	(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	69.4976	69.1421	68.7937	67.1573	66.8511	65.4258	65.4258	65.1619	65.9748	66.8511	67.4705	68.1180	(38)
Heat transfer coeff	138.6222	138.2667	137.9183	136.2819	135.9757	134.5505	134.5505	134.2865	135.0995	135.9757	136.5951	137.2427	(39)
Average = Sum(39)m / 12 =												136.2805	

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
HLP	1.0011	0.9985	0.9960	0.9842	0.9820	0.9717	0.9717	0.9698	0.9757	0.9820	0.9865	0.9911	(40)
HLP (average)												0.9842	
Days in mont	31	28	31	30	31	30	31	31	30	31	30	31	

4. Water heating energy requirements (kWh/year)

Assumed occupancy	2.9141	(42)

Hot water usage for mixer showers

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
73.0800	71.9817	70.3814	67.3193	65.0597	62.5397	61.1073	62.6956	64.4366	67.1423	70.2701	72.8000	(42a)

Hot water usage for baths

31.5500	31.0814	30.4216	29.2050	28.2940	27.2839	26.7382	27.3935	28.1069	29.1878	30.4294	31.4433	(42b)

Hot water usage for other uses

44.4735	42.8562	41.2390	39.6218	38.0046	36.3874	36.3874	38.0046	39.6218	41.2390	42.8562	44.4735	(42c)

Average daily hot water use (litres/day)	137.0595	(43)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Daily hot water use	149.1034	145.9194	142.0420	136.1461	131.3583	126.2109	124.2329	128.0936	132.1653	137.5691	143.5557	148.7168	(44)
Energy conte	236.1434	207.7873	218.3132	186.3773	176.8335	155.1910	150.2490	158.6067	162.9730	186.6799	204.5215	232.8545	(45)
Energy content (annual)										Total = Sum(45)m =		2276.5302	
Distribution loss (46)m = 0.15 x (45)m	35.4215	31.1681	32.7470	27.9566	26.5250	23.2787	22.5373	23.7910	24.4459	28.0020	30.6782	34.9282	(46)
Water storage loss:													
Total storage 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	(56)
If cylinder contains dedicated solar storage	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	(57)
Primary 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	(59)
Combi loss	50.9589	46.0274	50.9589	49.3151	50.9589	49.3151	50.9589	50.9589	49.3151	50.9589	49.3151	50.9589	(61)
Total heat required for water heating calculated for each month	287.1023	253.8147	269.2721	235.6923	227.7924	204.5061	201.2079	209.5656	212.2881	237.6388	253.8365	283.8134	(62)
WWHRS	-33.4091	-29.5473	-30.9402	-25.6197	-23.8767	-20.4314	-19.1512	-20.3654	-21.1391	-24.9207	-28.2322	-32.7904	(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	253.6932	224.2674	238.3319	210.0726	203.9157	184.0747	182.0567	189.2002	191.1489	212.7181	225.6044	251.0230	(64)
									Total per year (kWh/year) = Sum(64)m =			2566.1067	(64)
12Total per year (kWh/year)												2566	(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	91.2574	80.5961	85.3289	74.2992	71.5369	63.9298	62.6975	65.4764	66.5173	74.8108	80.3322	90.1639	(65)

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	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	145.7058	(66)
Lighting gains (calculated in Appendix L, equation L9 or L9a), also see Table 5	159.7801	176.8994	159.7801	165.1061	159.7801	165.1061	159.7801	159.7801	165.1061	159.7801	165.1061	159.7801	(67)
Appliances gains (calculated in Appendix L, equation L13 or L13a), also see Table 5	307.6657	310.8583	302.8130	285.6856	264.0653	243.7453	230.1702	226.9776	235.0229	252.1503	273.7706	294.0906	(68)
Cooking gains (calculated in Appendix L, equation L15 or L15a), also see Table 5	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	37.5706	(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)	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	-116.5646	(71)
Water heating gains (Table 5)	122.6578	119.9347	114.6894	103.1933	96.1517	88.7914	84.2708	88.0060	92.3851	100.5522	111.5724	121.1880	(72)
Total internal gains	659.8153	677.4041	646.9942	623.6968	589.7088	564.3545	540.9329	541.4754	559.2259	582.1943	620.1609	644.7704	(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	
Northeast	6.6100	11.2829	0.6300	0.7000	0.7700	22.7927	(75)
Southwest	12.0800	36.7938	0.6300	0.7000	0.7700	135.8357	(79)
Northeast	2.8700	26.0000	0.6300	0.7000	1.0000	29.6167	(82)
Southwest	1.3400	26.0000	0.6300	0.7000	1.0000	13.8280	(82)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Solar gains	202.0730	368.0048	560.5825	780.1805	944.7148	967.1035	920.3740	794.4421	636.8054	422.7036	246.5202	169.9506	(83)
Total gains	861.8883	1045.4089	1207.5766	1403.8773	1534.4236	1531.4580	1461.3069	1335.9175	1196.0313	1004.8979	866.6811	814.7210	(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, ni1,m (see Table 9a)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
tau	69.3682	69.5465	69.7222	70.5594	70.7183	71.4674	71.4674	71.6079	71.1770	70.7183	70.3976	70.0655	
alpha	5.6245	5.6364	5.6481	5.7040	5.7146	5.7645	5.7645	5.7739	5.7451	5.7146	5.6932	5.6710	
util living area	0.9976	0.9925	0.9762	0.9101	0.7581	0.5532	0.4038	0.4595	0.7289	0.9543	0.9937	0.9982	(86)
MIT	19.8421	20.0538	20.3461	20.7035	20.9191	20.9889	20.9985	20.9969	20.9517	20.6365	20.1722	19.8102	(87)
Th 2	20.0824	20.0846	20.0867	20.0965	20.0984	20.1070	20.1070	20.1086	20.1037	20.0984	20.0946	20.0907	(88)
util rest of house	0.9968	0.9900	0.9686	0.8839	0.7034	0.4800	0.3226	0.3720	0.6529	0.9351	0.9913	0.9976	(89)
MIT 2	18.7257	18.9971	19.3669	19.8046	20.0342	20.1010	20.1065	20.1075	20.0726	19.7378	19.1569	18.6912	(90)
Living area fraction										fLA = Living area / (4) =		0.3639	(91)
MIT	19.1320	19.3816	19.7233	20.1317	20.3562	20.4241	20.4311	20.4312	20.3926	20.0648	19.5264	19.0984	(92)
Temperature adjustment												0.0000	
adjusted MIT	19.1320	19.3816	19.7233	20.1317	20.3562	20.4241	20.4311	20.4312	20.3926	20.0648	19.5264	19.0984	(93)

8. Space heating requirement

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Utilisation	0.9956	0.9876	0.9648	0.8850	0.7199	0.5064	0.3522	0.4039	0.6787	0.9342	0.9892	0.9967	(94)
Useful gains	858.1114	1032.4190	1165.0824	1242.4548	1104.5777	775.5024	514.6526	539.5782	811.6908	938.7752	857.3393	812.0606	(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	2056.0398	2002.3253	1823.7296	1530.6772	1177.0380	783.6321	515.4749	541.3304	850.1208	1286.9860	1697.3810	2044.6985	(97)
Space heating kWh	891.2587	651.7770	490.0335	207.5201	53.9104	0.0000	0.0000	0.0000	0.0000	259.0689	604.8300	917.0826	(98a)
Space heating requirement - total per year (kWh/year)												4075.4814	
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	891.2587	651.7770	490.0335	207.5201	53.9104	0.0000	0.0000	0.0000	0.0000	259.0689	604.8300	917.0826	(98c)
Space heating requirement after solar contribution - total per year (kWh/year)												4075.4814	
Space heating per m2											(98c) / (4) =	29.4322	(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 %) 92.4000 (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	891.2587	651.7770	490.0335	207.5201	53.9104	0.0000	0.0000	0.0000	0.0000	259.0689	604.8300	917.0826	(98)
Space heating efficiency (main heating system 1)	92.4000	92.4000	92.4000	92.4000	92.4000	0.0000	0.0000	0.0000	0.0000	92.4000	92.4000	92.4000	(210)
Space heating fuel (main heating system)	964.5657	705.3864	530.3393	224.5889	58.3446	0.0000	0.0000	0.0000	0.0000	280.3776	654.5780	992.5136	(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	253.6932	224.2674	238.3319	210.0726	203.9157	184.0747	182.0567	189.2002	191.1489	212.7181	225.6044	251.0230	(64)
Efficiency of water heater												80.3000	(216)
(217)m	86.8393	86.5277	85.8901	84.3552	81.9578	80.3000	80.3000	80.3000	80.3000	84.8049	86.3865	86.9000	(217)
Fuel for water heating, kWh/month	292.1411	259.1858	277.4849	249.0333	248.8057	229.2337	226.7206	235.6167	238.0435	250.8323	261.1568	288.8643	(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	33.1991	26.6336	23.9806	17.5692	13.5710	11.0876	12.3799	16.0918	20.9017	27.4242	30.9756	34.1219	(232)
Electricity generated by PVs (Appendix M) (negative quantity)													
(233a)m	-54.3094	-75.9380	-108.2369	-120.5860	-129.0170	-119.9586	-118.3668	-112.1752	-101.1928	-86.2018	-59.4399	-47.0184	(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	-32.6200	-68.3931	-135.5595	-203.1010	-268.1294	-269.3502	-266.2848	-225.7458	-165.7695	-97.7666	-43.5288	-25.8214	(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 4410.6941 (211)
Space heating fuel - main system 2 0.0000 (213)
Space heating fuel - secondary 0.0000 (215)
Efficiency of water heater 80.3000
Water heating fuel used 3057.1186 (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) 267.9361 (232)

Energy saving/generation technologies (Appendices M ,N and Q)
PV generation -2934.5110 (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	4887.2379	(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	4410.6941	0.2100	926.2458	(261)
Total CO2 associated with community systems			0.0000	(373)
Water heating (other fuel)	3057.1186	0.2100	641.9949	(264)
Space and water heating			1568.2407	(265)
Pumps, fans and electric keep-hot	86.0000	0.1387	11.9293	(267)
Energy for lighting	267.9361	0.1443	38.6715	(268)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1132.4408	0.1348	-152.6426	
PV Unit electricity exported	-1802.0702	0.1260	-226.9876	
Total			-379.6301	(269)
Total CO2, kg/year			1239.2113	(272)
EPC Target Carbon Dioxide Emission Rate (TER)			8.9500	(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	4410.6941	1.1300	4984.0844	(275)
Total CO2 associated with community systems			0.0000	(473)
Water heating (other fuel)	3057.1186	1.1300	3454.5441	(278)
Space and water heating			8438.6284	(279)
Pumps, fans and electric keep-hot	86.0000	1.5128	130.1008	(281)
Energy for lighting	267.9361	1.5338	410.9694	(282)
Energy saving/generation technologies				
PV Unit electricity used in dwelling	-1132.4408	1.4982	-1696.5951	
PV Unit electricity exported	-1802.0702	0.4624	-833.2043	
Total			-2529.7994	(283)
Total Primary energy kWh/year			6449.8992	(286)
Target Primary Energy Rate (TPER)			46.5800	(287)