RED PARTNERSHIP

Energy & Sustainability Assessment

Residential Development, 42-50 Thomas Street.

20 June 2016

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1. Executive Summary

The following report relates to the proposed residential development at 42-50 Thomas Street, Manchester.

It is written in response to the Manchester City Council's Development Framework Core Strategy July 2012 specifically addressing the following relevant planning policies:

- DM 1 Development management.
- EN 4 Reducing CO2 Emissions by Enabling Low and Zero Carbon Development.
- EN 6 Target Framework for CO2 reductions from low or zero carbon energy supplies.

The report details how the development will incorporate Sustainable Design and resource efficiency measures in accordance with the Energy Hierarchy, so to meet the policy requirements and reduce its overall environmental impact. The methodology and calculations are consistent with the MCC Appendix A EN6 Energy Target Explanation.

In relation to policy EN 6, the development is required to achieve a 15% Carbon Reduction over Part L 2010 Compliancy of the Building Regulations. This equates to a 6% Carbon Reduction over Part L 2014 Compliancy.

In order to demonstrate this 6% reduction in carbon emissions, resource efficiency measures and the application of Low / Zero Carbon technologies have been considered and implemented.

The figures used within this report have been based on sample units and modelled using SAP 2014 to accurately predict Energy Usage and CO_2 reductions.

The dwellings utilise electric heating and hot water and the U Values and design targets specified exceed Part L 2014 compliance.

Following the LZC feasibility assessment, it is proposed that the development will also benefit from a 3kWp PV array.

As a result of the above, the predicted site wide reduction in CO_2 over Part L 2014 of the Building Regulations is 7.7%.

Therefore, the development is in compliance with the CO_2 reduction target outlined in EN 6.

2. Planning Statement

The following report relates to the proposed mixed use development at Ellesmere House, Ellesmere Street, Manchester.

2.1 The Development

The development includes 3No change of use of apartments with a listed section of the site and 19No new build apartments within the Northern Quarter of Manchester.



Proposed Site Plan

2.2 Relevant Policies

This report is written in response to the Manchester City Council's Development Framework Core Strategy July 2012 specifically addressing the following relevant planning policies:

DM 1 Development management.

Subject to scheme viability, developers are required to demonstrate that new development incorporates sustainable construction techniques as follows:

- BREEAM New Construction (Commercial Development& Domestic Refurbishment)

EN 4 Reducing CO2 Emissions by Enabling Low and Zero Carbon Development.

All developments must follow the principle of the Energy Hierarchy, being designed:

- to reduce the need for energy through design features that provide passive heating, natural lighting and cooling
- to reduce the need for energy through energy efficient features such as improved insulation and glazing
- to meet residual energy requirements through the use of low or zero carbon energy generating technologies

EN 6 Target Framework for CO2 reductions from low or zero carbon energy supplies.

All Applications for residential development of 10 or more units and all other development over 1,000 sq.m will be expected as a minimum to meet the targets shown below unless this can be shown not to be viable.

Domestic CO_2 emissions reduction targets

Table 12.1

Target	% Minimum requirement
Target 1: Network development area	CHP/district heating anchor or connection or where not feasible a 15% increase on Part L 2010
Target 2: Electricity intense buildings	+15% increase on Part L 2010
Target 3: Micro generation area	+15%increase on Part L 2010

Table 12.1 - Manchester Core Strategy 2012 to 2027.

Non-domestic CO_2 emissions reduction targets

Table 12.2

Target	% Minimum requirement
Target 1: Network development area	CHP/district heating anchor or connection or where not feasible, a 15% increase on Part L 2010
Target 2: Electricity intense buildings (Applies to commercial uses with a high proportion of emissions from electricity use (>45 kg CO2/m2))	+10%increase on Part L 2010
Target 3: Micro generation area	+15% increase on Part L 2010

Table 12.2 - Manchester Core Strategy 2012 to 2027.

In relation to policy EN 6, the development is required to achieve a 15% Carbon Reduction over Part L 2010 Compliancy of the Building Regulations. This equates to a 6% Carbon Reduction over Part L 2014 Compliancy.

2.3 Sustainable Design Strategy

In response to the policy requirements set out in section 2.2, the development aims to achieve the following design targets:

1. All residential units will be formally assessed against the Code for Sustainable Homes and achieve Level 4 Compliancy.
2. All commercial units will be formally assessed against BREEAM 2014 and achieve a 'Very Good' rating.
3. The Site as a whole will achieve a minimum of 15% CO2 reduction over the Part L 2010 Target Emission Rate (TER).

To achieve the most accurate calculations and estimates, sample units have been modelled using *SAP 2012* the governments Standard Assessment Procedure for residential dwellings and *SBEM* the Simplified Building Energy Model for commercial buildings.

A Part L compliant baseline has been established and then further improvements have been made to the building fabric and specification prior to the addition of LZC technologies. This is in compliance with the Energy Hierarchy:



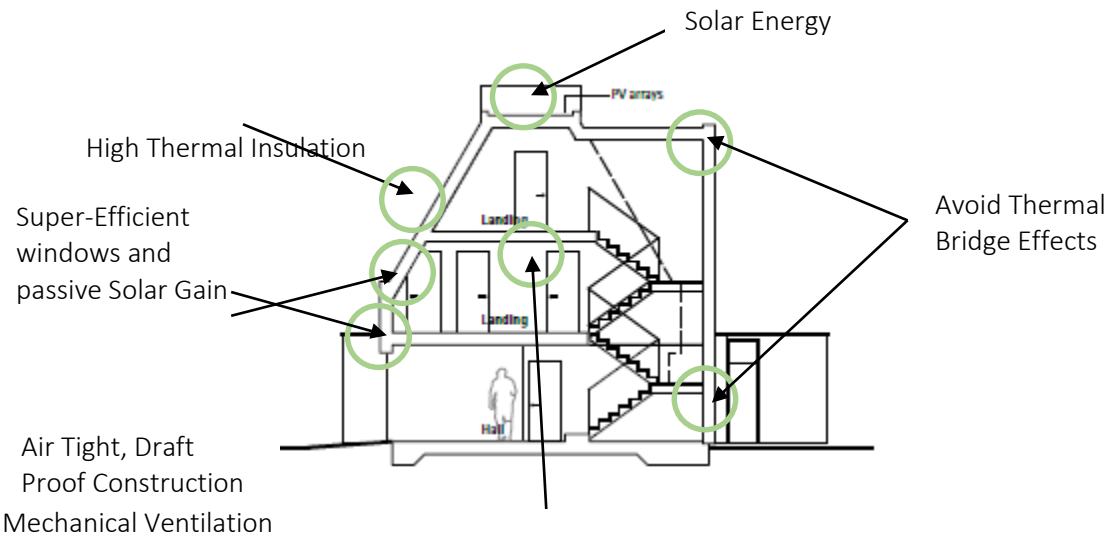
In accordance with the above methodology, the design will utilise Passivhaus principles and will be designed with a fabric first approach, all fabric U Values, air permeability and ventilation targets are above and beyond Building regulations Compliancy for both the domestic and commercial elements.

Further efficiency measures to both the building fabric and building services will be incorporated to reduce the energy demand further and associated carbon emissions. This approach demonstrates a holistic low energy design concept, involving very low limiting values and thus leads to high energy performance targets.

2.4 Energy Efficient Design and Specification

In line with the above Sustainable Design Strategy, the following Energy Efficient design measures are specified.

- High levels of insulation throughout with minimal thermal bridges.
- Passive solar gains and internal heat sources.
- Excellent level of airtightness.
- Good indoor air quality by openable windows



The Proposed specifications and key energy efficient design measures are as follows:

Residential Units:

- Ground Floor U-value of 0.10 W/m²K
- External Wall U-value of 0.20 W/m²K
- Roof U-value of 0.15 W/m²K
- Use of ACD's to minimize Thermal Bridging and y Value
- Low Door & Window U-values of 1.0 W/m²K
- 100% low energy lighting throughout
- Mechanical Ventilation with Heat Recovery
- 100% efficient Electric Heating and Hot Water
- Air Permeability Rate of 3 m³/hm² in new dwellings

Operational usage will be improved further by ensuring better occupant management through the following:

- Energy Display devices showing electricity and primary fuel consumption.
- Efficient White Goods where supplied (A+ or A rated).
- Low Water Use fittings on Sanitary Ware
- A Home User Guide to explain how to use the dwelling, fittings and appliances efficiently.

2.5 Sustainable Development

In addition to the primary building design and fabric there are many other issues that will impact on creating a Sustainable Development. Sustainability should be taken into consideration from the start of the development and promoted throughout the building construction on site. Features which enable more efficient usage should also be specified to encourage the building users to maintain efficient use throughout occupation.

Examples of how the above will be implemented are as follows:

The site itself is in an excellent location which supports the Use Class, a good local infrastructure is already established with good public transport links and many amenities within walking distance. A variety of new open and green space is planned within the development, this will reduce travel but also promote social integration and enhance community values. Cycle storage is also provided.

Materials

- Any new materials will have an A+ or A rating under BRE's Green Guide.
- Where possible, materials will be chosen that are responsibly sourced (such as FSC timber), recycled or reclaimed.
- All insulation materials will have a GWP (Global Warming Potential) of 5 or less.

Water Use

- Indoor water use will be restricted by use of fittings with lower flow rates, baths with smaller capacity, dual-flush toilets, and (where applicable) washing machines and dishwashers with low water usage.

Waste

- The contractor will be obligated to register with and achieve certification under Considerate Constructors.
- The contractor will be obligated to produce a Site Waste Management Plan (SWMP) to set targets and monitor to reduce waste and divert from landfill.
- The development will incorporate dedicated internal and external general waste and recyclable storage in accordance with the LA collection.

Health, Wellbeing & pollution

- Key rooms have good levels of day lighting and so the need for artificial lighting is reduced.
- Materials with low VOC emissions will be used.
- Boilers with very Low NOx emissions will be specified.
- Improved acoustic performance between dwellings and units.

Ecology

- Any existing features of ecological value will be protected during construction.
- A qualified Ecologist will be employed to provide advice on the support and enhancement of Ecology on site.

2.6 Choice and Impact of Renewable Technology

All technologies were investigated for their suitability to the site and development, please refer to section 3 for details.

In addition to energy efficiency measures it is proposed that the development will feature the following Low/Zero carbon Technologies:

- 3kWp Site Wide PV Array (Approx. 12no. 250W Panels)

The above LZC contribution has provided a **7.7%** reduction in CO2 following Energy Efficiency Measures.

2.7 Energy & CO2 Reduction Summary

A summary of all stages of the energy demand assessment from baseline figures to final carbon reduction are shown in Figures 1 & 2 below:

Summary of CO2 Emission Reductions	Total CO2 emissions (kgCO2/year)
Baseline emissions	27942.5
Improved emissions (after application of energy efficiency measures)	27927.5
Improved emissions (after incorporation of efficient energy supply)	27927.5
Improved emissions (after incorporation of renewable energy technology) % CO2 displaced in total	25787.1
% CO2 displaced in total	**7.71%**
% CO2 displaced by energy efficiency measures	0.1%
% CO2 displaced by efficient supply of energy	0.00%
% CO2 displaced by LZC Technologies	**7.66%**

Fig 1. Summary of CO2 Reductions

	Energy demand (kWh pa)	Energy saving achieved (%)	Regulated CO_2 emissions (kg pa)		Saving achieved on residual CO_2 emissions (%)
Building Regulations Part L compliance ("Baseline" energy demand & emissions)	54047.4		27942.5		
Proposed scheme after energy efficiency measures and CHP ("Residual" energy demand & emissions)	54018.3	0.1%	27927.5		0.1%
Proposed scheme after on-site renewables	49878.3	7.7%	25787.1		7.7%
Proposed scheme offset for financial contribution or other "allowable solution"			0		0
Total CO2 Saving					**7.7%**

Fig 2. Savings on residual emissions

For a full Breakdown of the figures and calculations please see Appendix A – Energy Demand Assessment Spreadsheet.

Baseline energy demand

'Standard Assessment Procedure - SAP 2012' and SBEM was used to produce example SAP & BRUKL reports to generate the figures used within the calculations.

Baseline energy demand (kWh pa)	1402357.5
Regulated emissions (kg pa)	688364.5

Heating

The heating and cooling hierarchy has been applied to the design process of the development. It has resulted in large focus on energy efficiency measures and as can be seen in Figure 1.

Energy savings from the use of CHP systems (kWh pa)	-
Emission savings from the use of CHP systems (kg pa)	-
Total regulated emissions after CHP savings (kg pa)	685209.1

Energy efficiency

The following table demonstrates how the development achieves the reduction in carbon dioxide emissions from energy efficiency measures.

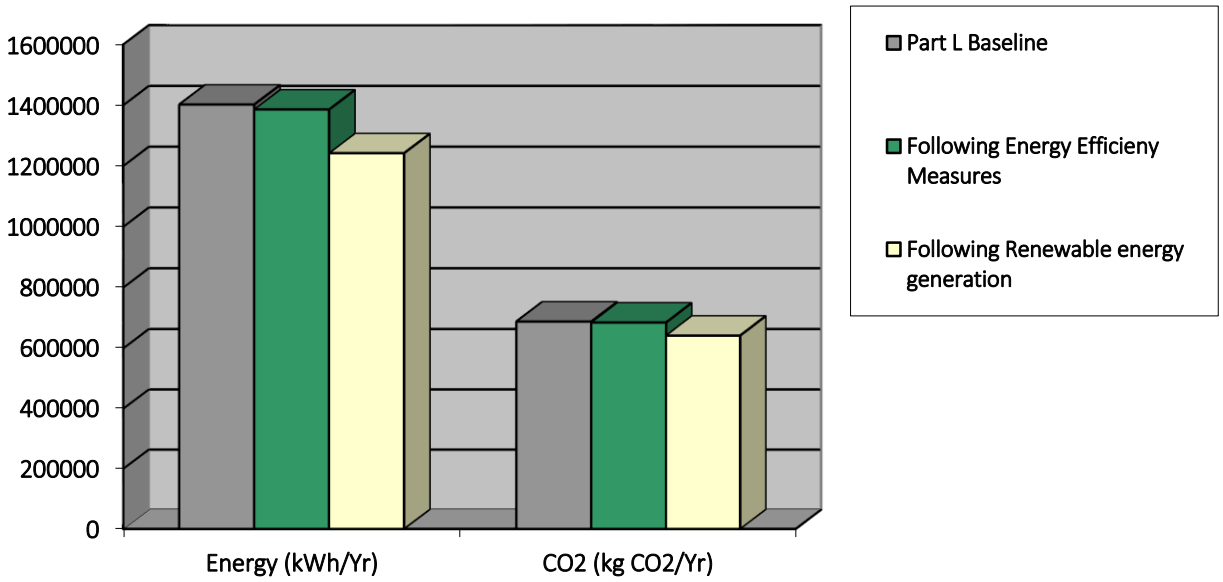
Energy savings from energy efficiency measures (kWh pa)	16187.6
Emission savings from energy efficiency measures (kg pa)	3155.4
Total regulated emissions after CHP savings and energy effi ciency measures (kg pa) ("residual emissions")	685209.1

On-site renewables

The following table demonstrates how the development achieves the reduction in carbon dioxide emissions from LZC technologies.

Energy saving from the use of renewables (kWh)	143931.7
Saving on residual emissions from the use of renewables (kg)	42971.9
Saving on residual emissions from the use of renewables (%)	6.27%

The chart below illustrates the improvements over the Part L Compliant Baseline:



3. Feasibility assessment of renewable energy technologies

Solar Hot Water (Thermal)

Solar water heating systems are one of the more familiar renewable technologies used at the moment. They use the energy from the sun to heat water, most commonly for hot water needs. Solar heating systems use a heat collector that is usually mounted on a roof in which a fluid is heated by the sun. This fluid is used to heat water that is stored in either a separate hot water cylinder or in a twin-coil hot water cylinder (the second coil is used to provide additional heating from a boiler or other heat source).

Solar hot water panels could be used however compared with PV, PV will provide slightly better savings and avoid the need for water storage cylinders.

Renewable Technology Chosen.

Wind

Wind turbines convert the kinetic energy in wind into mechanical energy that is then converted to electricity. Turbines are available in a range of sizes and designs and can either be free-standing, mounted on a building or integrated into a building structure.

The windspeed in the area is under the advised minimum and the built up area means that a wind turbine wouldn't be feasible.

Renewable Technology Not Viable

Photovoltaic Panels (PV)

Photovoltaic modules convert sunlight directly to DC electricity. The solar cells consist of a thin piece of semiconductor material, in most cases of silicon. Through a process called doping, a very small amount of impurities are added to the semiconductor, which creates two different layers called n-type and p-type layers.

Certain wavelengths of light are able to ionize the silicon atoms, which separates some of the positive charges (holes) from the negative charges (electrons). The holes move into the positive or p-layer and the electrons into the negative or n-layer. These opposite charges are attracted to each other, but most of them can only re-combine by the electrons passing through an external circuit, due to an internal potential energy barrier. This flow of electrons produces a DC current.

A PV array can be mounted on the suitable roof space. The amount proposed at this stage is **3kWp Site Wide PV Array (Approx. 12no. 250W Panels)**

Chosen Renewable Technology

Biomass Heating

Biomass is any plant-derived organic material that renews itself over a short period.

Biomass energy systems are based on either the direct or indirect combustion of fuels derived from those plant sources. The most common form of biomass is the direct combustion of wood in treated or untreated forms. The use of biomass is becoming increasingly common in some European countries (some countries such as Austria are heavily dependent on biomass).

The environmental benefits relate to the significantly lower amounts of energy used in biomass production and processing compared to the energy released when they are burnt. This can range from a four-fold return for biodiesel to an approximate 20-fold energy return for woody biomass. Biomass-fuels can be used to produce energy on a continuous basis (unlike renewables such as wind or solar energy) and it can be an economic alternative to fossil fuels as it is a potential source of both heat and electricity.

However Biomass systems have particular design management and maintenance requirements associated with sourcing, transportation and storage and are therefore more commonly used in commercial developments rather than domestic installations. It can be less convenient to operate than mains-supplied fuels such as natural gas and are more management intensive and require expertise in facilities management. Sources of biomass can also fluctuate, so boilers should be specified to operate on a variety of fuels without risk of overheating or tripping out.

A communal biomass system would not be feasible for this development due to use, space and maintenance issues. The system would be extremely large and there is very little space around the properties to locate the boilers, hoppers and fuel stores that is suitable for deliveries, but also appropriate for feeding the boiler.

Renewable Technology Not Viable

Ground Source Heat pumps

A heat pump is a device that takes up heat at a certain temperature and releases it at a higher temperature. The essential components of a heat pump are heat exchangers (through which energy is extracted and emitted) and a means of pumping heat between the exchangers. The effectiveness of the heat pump is measured by the ratio of the heating capacity to the effective power input, usually known as the coefficient of performance (COP). Ground-source heat pumps (GSHP) extract heat from the ground. They are classified as either water-to-air or water-to-water units depending on whether the heat distribution system in the building uses air or water. Ground source heat pumps either use long shallow trenches or deep vertical boreholes to take low grade heat from the ground and then compress it to create higher temperatures.

Ground source heat pumps would not be suitable due to the lack of land space around the properties and the associates costs.

Renewable Technology Not Viable

Air Source Heat pumps

Air source heat pumps absorb heat from the outside air. This is usually used to heat radiators, underfloor heating systems, or warm air convectors and hot water in your home. An air source heat pump extracts heat from the outside air in the same way that a fridge extracts heat from its inside.

The system performs down to air temperatures of -20°c which means that they are more than suitable for installations within the UK. Hot water and Heating can be provided 365 days a year. The hot water is produced without the aid of electrical immersions and at 55°c is more than hot enough for baths and showers.

There are two main types of air source heat pump system:

- An air-to-water system distributes heat via your wet central heating system. Heat pumps work much more efficiently at a lower temperature than a standard boiler system would. So they are more suitable for under-floor heating systems or larger radiators, which give out heat at lower temperatures over longer periods of time.
- An air-to-air system produces warm air which is circulated by fans to heat your home. They are unlikely to provide you with hot water as well.

Air Source heat pumps would require significant external condenser space and omit external noise which would be detrimental to the development and surrounding areas.

Renewable Technology Not Viable

Unit Type	Apartments	Apartments	Apartments			SITE TOTAL	SITE TOTAL
Floor area m2	1200						
Summary of BASELINE Energy Demand	Total Energy Demand (kWh/yr)	Carbon Emission Factor	Associated Total CO2 (kgCO2/yr)			Total Energy Demand (kWh/yr)	Associated Total CO2 (kgCO2/yr)
Hot Water	41310.0	0.517	21357.3			41310.0	21357.3
Space Heating	31.5	0.517	16.3			31.5	16.3
Secondary Heating	0.0	0.517	0.0			0.0	0.0
Pumps & Fans	5610.0	0.517	2900.4			5610.0	2900.4
Lighting	7095.9	0.517	3668.6			7095.9	3668.6
TOTAL PER DEVELOPMENT	**54047.4**		**27942.5**			**54047.4**	**27942.5**
Summary of Energy Demand After Energy Efficiency Measures	Total Energy Demand (kWh/yr)	Carbon Emission Factor	Associated Total CO2 (kgCO2/yr)			Total Energy Demand (kWh/yr)	Associated Total CO2 (kgCO2/yr)
Hot Water	41310.0	0.517	21357.3			41310.0	21357.3
Space Heating	2.4	0.517	1.2			2.4	1.2
Secondary Heating	0.0	0.517	0.0			0.0	0.0
Pumps & Fans	5610.0	0.517	2900.4			5610.0	2900.4
Lighting	7095.9	0.517	3668.6			7095.9	3668.6
TOTAL PER DEVELOPMENT	**54018.3**		**27927.5**			**54018.3**	**27927.5**
Summary of Energy Demand After Renewables	Total Energy Demand (kWh/yr)	Carbon Emission Factor (kgCO2/kWh)	Associated Total CO2 (kgCO2/yr)			Total Energy Demand (kWh/yr)	Associated Total CO2 (kgCO2/yr)
Hot Water	41310.0	0.517	21357.3			41310.0	21357.3
Space Heating	2.4	0.517	1.2			2.4	1.2
Secondary Heating	0.0	0.517	0.0			0.0	0.0
Pumps & Fans	5610.0	0.517	2900.4			5610.0	2900.4
Lighting	7095.9	0.517	3668.6			7095.9	3668.6
PV Elec Generated	-4140.0	0.517	-2140.4			-4140.0	-2140.4
TOTAL PER DEVELOPMENT	**49878.3**		**25787.1**			**49878.3**	**25787.1**

SAP Input

Property Details: Example Thomas Street FINAL

Address:	Thomas Street , Manchester
Located in:	England
Region:	North West England
UPRN:	
Date of assessment:	06 May 2016
Date of certificate:	13 June 2016
Assessment type:	New dwelling design stage
Transaction type:	New dwelling
Tenure type:	Unknown
Related party disclosure:	Employed by the professional dealing with the property transaction
Thermal Mass Parameter:	Indicative Value Medium
Water use <= 125 litres/person/day:	True
PCDF Version:	394

Property description:

Dwelling type:	Flat
Detachment:	
Year Completed:	2016

Floor Location:	Floor area:	Storey height:
Floor 0	40 m²	2.5 m

Living area:	35 m² (fraction 0.875)
Front of dwelling faces:	North

Opening types:

Name:	Source:	Type:	Glazing:	Argon:	Frame:
windows	Manufacturer	Windows	low-E, En = 0.05, soft coat	Yes	PVC-U

Name:	**Gap:**	**Frame Factor:**	**g-value:**	**U-value:**	**Area:**	**No. of Openings:**
windows	16mm or more	0.7	0.7	1	2.8	1

Name:	Type-Name:	Location:	Orient:	Width:	Height:
windows		External Walls	South	0	0

Overshading:	Average or unknown

Opaque Elements:

Type:	Gross area:	Openings:	Net area:	U-value:	Ru value:	Curtain wall:	Kappa:
External Elements							
External Walls	13.5	2.8	10.7	0.2	0	False	N/A
Internal Elements							
Party Elements							
Party Walls	17						N/A
Party Floor	61						N/A

Thermal bridges:

Thermal bridges: User-defined (individual PSI-values) Y-Value = 0.0601

	Length	**Psi-value**		
[Approved]	6.5	0.04	E3	Sill
[Approved]	6	0.02	E9	Balcony between dwellings, wall insulation continuous
[Approved]	2.4	0.09	E16	Corner (normal)
[Approved]	2.4	-0.09	E17	Corner (inverted internal area greater than external area)
[Approved]	7.2	0.06	E18	Party wall between dwellings
	2.4	0	E25	Staggered party wall between dwellings

SAP Input

Ventilation:

Pressure test:	Yes (As designed)
Ventilation:	Balanced with heat recovery Number of wet rooms: Kitchen + 2 Ductwork: Insulation, rigid Approved Installation Scheme: True
Number of chimneys:	0
Number of open flues:	0
Number of fans:	0
Number of passive stacks:	0
Number of sides sheltered:	3
Pressure test:	3

Main heating system:

Main heating system:	Boiler systems with radiators or underfloor heating Electric boilers Fuel: Electricity Info Source: SAP Tables SAP Table: 191 Direct acting electric boiler Underfloor heating, pipes in screed above insulation

Main heating Control:

Main heating Control:	Time and temperature zone control by device in database Control code: 2112

Secondary heating system:

Secondary heating system:	None

Water heating:

Water heating:	Electric immersion (on-peak or off-peak) Water code: 903 Fuel :Electricity Hot water cylinder Cylinder volume: 150 litres Cylinder insulation: Factory 100 mm Primary pipework insulation: False Cylinderstat: True Cylinder in heated space: True Immersion: Single Solar panel: False

Others:

Electricity tariff:	Standard Tariff
In Smoke Control Area:	Unknown
Conservatory:	No conservatory
Low energy lights:	100%
Terrain type:	Dense urban
EPC language:	English
Wind turbine:	No
Photovoltaics:	Photovoltaic 1 Installed Peak power: 0.16 Tilt of collector: 30° Overshading: None or very little Collector Orientation: South
Assess Zero Carbon Home:	No

SAP WorkSheet: New dwelling design stage

User Details:

Assessor Name:	Daniel Watt	**Stroma Number:**	STRO026464
Software Name:	Stroma FSAP 2012	**Software Version:**	Version: 1.0.3.4

Property Address: Example Thomas Street FINAL

Address : Thomas Street , Manchester

1. Overall dwelling dimensions:

	Area(m²)		Av. Height(m)		Volume(m³)	
Ground floor	40	(1a) x	2.5	(2a) =	100	(3a)
Total floor area TFA = (1a)+(1b)+(1c)+(1d)+(1e)+.....(1n)	40	(4)				
Dwelling volume			(3a)+(3b)+(3c)+(3d)+(3e)+.....(3n) =		100	(5)

2. Ventilation rate:

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

			Air changes per hour	
Infiltration due to chimneys, flues and fans =	(6a)+(6b)+(7a)+(7b)+(7c) =	0	÷ (5) =	0 (8)
If a pressurisation test has been carried out or is intended, proceed to (17), otherwise continue from (9) to (16)				
Number of storeys in the dwelling (ns)				0 (9)
Additional infiltration			[(9)-1]x0.1 =	0 (10)
Structural infiltration: 0.25 for steel or timber frame or 0.35 for masonry construction				0 (11)
if both types of wall are present, use the value corresponding to the greater wall area (after deducting areas of openings); if equal user 0.35				
If suspended wooden floor, enter 0.2 (unsealed) or 0.1 (sealed), else enter 0				0 (12)
If no draught lobby, enter 0.05, else enter 0				0 (13)
Percentage of windows and doors draught stripped				0 (14)
Window infiltration	0.25 - [0.2 x (14) ÷ 100] =			0 (15)
Infiltration rate	(8) + (10) + (11) + (12) + (13) + (15) =			0 (16)
Air permeability value, q50, expressed in cubic metres per hour per square metre of envelope area				3 (17)
If based on air permeability value, then	(18) = [(17) ÷ 20]+(8), otherwise (18) = (16)			0.15 (18)
Air permeability value applies if a pressurisation test has been done or a degree air permeability is being used				
Number of sides sheltered				3 (19)
Shelter factor	(20) = 1 - [0.075 x (19)] =			0.78 (20)
Infiltration rate incorporating shelter factor	(21) = (18) x (20) =			0.12 (21)

Infiltration rate modified for monthly wind speed

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Monthly average wind speed from Table 7												
(22)m=	5.1	5	4.9	4.4	4.3	3.8	3.8	3.7	4	4.3	4.5	4.7
Wind Factor (22a)m = (22)m ÷ 4												
(22a)m=	1.27	1.25	1.23	1.1	1.08	0.95	0.95	0.92	1	1.08	1.12	1.18

SAP WorkSheet: New dwelling design stage

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

0.15	0.15	0.14	0.13	0.12	0.11	0.11	0.11	0.12	0.12	0.13	0.14

Calculate effective air change rate for the applicable case

If mechanical ventilation: 0.5 (23a)

If exhaust air heat pump using Appendix N, (23b) = (23a) × Fmv (equation (N5)) , otherwise (23b) = (23a) 0.5 (23b)

If balanced with heat recovery: efficiency in % allowing for in-use factor (from Table 4h) = 77.35 (23c)

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

(24a)m=	0.26	0.26	0.26	0.24	0.24	0.22	0.22	0.22	0.23	0.24	0.24	0.25	(24a)

b) If balanced mechanical ventilation without heat recovery (MV) (24b)m = (22b)m + (23b)

(24b)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24b)

c) If whole house extract ventilation or positive input ventilation from outside
if (22b)m < 0.5 × (23b), then (24c) = (23b); otherwise (24c) = (22b) m + 0.5 × (23b)

(24c)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24c)

d) If natural ventilation or whole house positive input ventilation from loft
if (22b)m = 1, then (24d)m = (22b)m otherwise (24d)m = 0.5 + [(22b)m² x 0.5]

(24d)m=	0	0	0	0	0	0	0	0	0	0	0	0	(24d)

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

(25)m=	0.26	0.26	0.26	0.24	0.24	0.22	0.22	0.22	0.23	0.24	0.24	0.25	(25)

3. Heat losses and heat loss parameter:

ELEMENT	Gross area (m²)	Openings m²	Net Area A ,m²		U-value W/m2K		A X U (W/K)	k-value kJ/m²·K	A X k kJ/K	
Windows			2.8	x	1/[1/(1)+ 0.04]	=	2.69			(27)
Walls	13.5	2.8	10.7	x	0.2	=	2.14			(29)
Total area of elements, m²			13.5							(31)
Party wall			17	x	0	=	0			(32)
Party floor			61							(32a)

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

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

Fabric heat loss, W/K = S (A x U) (26)…(30) + (32) = 4.83 (33)

Heat capacity Cm = S(A x k) ((28)…(30) + (32) + (32a)…(32e) = 5369.8 (34)

Thermal mass parameter (TMP = Cm ÷ TFA) in kJ/m²K Indicative Value: Medium 250 (35)

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

Thermal bridges : S (L x Y) calculated using Appendix K 0.81 (36)

if details of thermal bridging are not known (36) = 0.15 x (31)

Total fabric heat loss (33) + (36) = 5.64 (37)

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(38)m=	8.63	8.53	8.44	7.96	7.86	7.38	7.38	7.29	7.57	7.86	8.05	8.24	(38)

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

(39)m=	14.27	14.18	14.08	13.6	13.51	13.03	13.03	12.93	13.22	13.51	13.7	13.89	

Average = Sum(39)$_{1...12}$ /12= 13.58 (39)

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

(40)m=	0.36	0.35	0.35	0.34	0.34	0.33	0.33	0.32	0.33	0.34	0.34	0.35	

Average = Sum(40)$_{1...12}$ /12= 0.34 (40)

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Number of days in month (Table 1a)

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

4. Water heating energy requirement: kWh/year:

Assumed occupancy, N 1.41 (42)

if TFA > 13.9, N = 1 + 1.76 x [1 - exp(-0.000349 x (TFA -13.9)2)] + 0.0013 x (TFA -13.9)

if TFA £ 13.9, N = 1

Annual average hot water usage in litres per day Vd,average = (25 x N) + 36 67.6 (43)

Reduce the annual average hot water usage by 5% if the dwelling is designed to achieve a water use target of not more that 125 litres per person per day (all water use, hot and cold)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Hot water usage in litres per day for each month Vd,m = factor from Table 1c x (43)													
(44)m=	74.36	71.66	68.95	66.25	63.54	60.84	60.84	63.54	66.25	68.95	71.66	74.36	

Total = Sum(44)$_{1...12}$ = 811.21 (44)

Energy content of hot water used - calculated monthly = 4.190 x Vd,m x nm x DTm / 3600 kWh/month (see Tables 1b, 1c, 1d)

(45)m=	110.27	96.45	99.52	86.77	83.26	71.84	66.57	76.39	77.31	90.09	98.34	106.79	

Total = Sum(45)$_{1...12}$ = 1063.62 (45)

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

(46)m=	16.54	14.47	14.93	13.02	12.49	10.78	9.99	11.46	11.6	13.51	14.75	16.02	(46)

Water storage loss:

Storage volume (litres) including any solar or WWHRS storage within same vessel 150 (47)

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

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

Water storage loss:

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

Temperature factor from Table 2b 0 (49)

Energy lost from water storage, kWh/year (48) x (49) = 150 (50)

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

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

If community heating see section 4.3

Volume factor from Table 2a 0.93 (52)

Temperature factor from Table 2b 0.6 (53)

Energy lost from water storage, kWh/year (47) x (51) x (52) x (53) = 0.86 (54)

Enter (50) or (54) in (55) 0.86 (55)

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

(56)m=	26.65	24.07	26.65	25.79	26.65	25.79	26.65	26.65	25.79	26.65	25.79	26.65	(56)

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

(57)m=	26.65	24.07	26.65	25.79	26.65	25.79	26.65	26.65	25.79	26.65	25.79	26.65	(57)

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

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

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

(59)m=	0	0	0	0	0	0	0	0	0	0	0	0	(59)

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

(61)m=	0	0	0	0	0	0	0	0	0	0	0	0	(61)

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

(62)m=	136.92	120.52	126.17	112.56	109.9	97.63	93.22	103.04	103.09	116.74	124.13	133.44	(62)

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

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

(63)m=	0	0	0	0	0	0	0	0	0	0	0	0	(63)

Output from water heater

(64)m=	136.92	120.52	126.17	112.56	109.9	97.63	93.22	103.04	103.09	116.74	124.13	133.44	

Output from water heater (annual)$_{1...12}$ 1377.37 (64)

Heat gains from water heating, kWh/month 0.25 ´ [0.85 × (45)m + (61)m] + 0.8 x [(46)m + (57)m + (59)m]

(65)m=	57.98	51.32	54.41	49.48	49	44.52	43.45	46.72	46.33	51.27	53.33	56.83	(65)

include (57)m in calculation of (65)m only if cylinder is in the dwelling or hot water is from community heating

5. Internal gains (see Table 5 and 5a):

Metabolic gains (Table 5), Watts

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(66)m=	84.38	84.38	84.38	84.38	84.38	84.38	84.38	84.38	84.38	84.38	84.38	84.38	(66)

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

(67)m=	33.48	29.74	24.19	18.31	13.69	11.56	12.49	16.23	21.78	27.66	32.28	34.41	(67)

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

(68)m=	181.39	183.28	178.53	168.43	155.69	143.71	135.7	133.82	138.56	148.66	161.41	173.39	(68)

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

(69)m=	44.84	44.84	44.84	44.84	44.84	44.84	44.84	44.84	44.84	44.84	44.84	44.84	(69)

Pumps and fans gains (Table 5a)

(70)m=	0	0	0	0	0	0	0	0	0	0	0	0	(70)

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

(71)m=	-56.25	-56.25	-56.25	-56.25	-56.25	-56.25	-56.25	-56.25	-56.25	-56.25	-56.25	-56.25	(71)

Water heating gains (Table 5)

(72)m=	77.94	76.37	73.13	68.72	65.86	61.83	58.41	62.79	64.35	68.92	74.07	76.38	(72)

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

(73)m=	365.78	362.36	348.82	328.44	308.21	290.06	279.57	285.82	297.67	318.21	340.73	357.15	(73)

6. Solar gains:

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

Orientation:	Access Factor Table 6d		Area m²		Flux Table 6a		g_ Table 6b		FF Table 6c		Gains (W)	
South	0.9x 0.77	x	2.8	x	46.75	x	0.7	x	0.7	=	44.45	(78)
South	0.9x 0.77	x	2.8	x	76.57	x	0.7	x	0.7	=	72.8	(78)
South	0.9x 0.77	x	2.8	x	97.53	x	0.7	x	0.7	=	92.73	(78)
South	0.9x 0.77	x	2.8	x	110.23	x	0.7	x	0.7	=	104.81	(78)
South	0.9x 0.77	x	2.8	x	114.87	x	0.7	x	0.7	=	109.22	(78)
South	0.9x 0.77	x	2.8	x	110.55	x	0.7	x	0.7	=	105.11	(78)
South	0.9x 0.77	x	2.8	x	108.01	x	0.7	x	0.7	=	102.7	(78)
South	0.9x 0.77	x	2.8	x	104.89	x	0.7	x	0.7	=	99.73	(78)

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South	0.9x	0.77	x	2.8	x	101.89	x	0.7	x	0.7	=	96.87	(78)
South	0.9x	0.77	x	2.8	x	82.59	x	0.7	x	0.7	=	78.52	(78)
South	0.9x	0.77	x	2.8	x	55.42	x	0.7	x	0.7	=	52.69	(78)
South	0.9x	0.77	x	2.8	x	40.4	x	0.7	x	0.7	=	38.41	(78)

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

(83)m=	44.45	72.8	92.73	104.81	109.22	105.11	102.7	99.73	96.87	78.52	52.69	38.41	(83)

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

(84)m=	410.23	435.16	441.56	433.25	417.43	395.17	382.26	385.55	394.54	396.73	393.42	395.57	(84)

7. Mean internal temperature (heating season)

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

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

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
(86)m=	0.58	0.52	0.46	0.38	0.3	0.21	0.15	0.15	0.23	0.35	0.48	0.59	(86)

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

(87)m=	20.98	20.98	20.98	20.98	20.98	20.98	20.98	20.98	20.98	20.98	20.98	20.98	(87)

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

(88)m=	20.65	20.66	20.66	20.67	20.67	20.68	20.68	20.69	20.68	20.67	20.67	20.66	(88)

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

(89)m=	0.57	0.51	0.45	0.37	0.29	0.2	0.14	0.14	0.22	0.34	0.47	0.58	(89)

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

(90)m=	20.62	20.63	20.63	20.64	20.64	20.66	20.66	20.66	20.65	20.64	20.64	20.63	(90)

fLA = Living area ÷ (4) = 0.88 (91)

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

(92)m=	20.94	20.94	20.94	20.94	20.94	20.94	20.94	20.94	20.94	20.94	20.94	20.94	(92)

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

(93)m=	20.94	20.94	20.94	20.94	20.94	20.94	20.94	20.94	20.94	20.94	20.94	20.94	(93)

8. Space heating requirement

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

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

Utilisation factor for gains, hm:

(94)m=	0.58	0.52	0.46	0.38	0.3	0.21	0.15	0.15	0.23	0.35	0.48	0.59	(94)

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

(95)m=	237.39	227.33	203.28	163.75	124.78	82.6	56.55	58.73	90.42	139.64	189.55	232.42	(95)

Monthly average external temperature from Table 8

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

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

(97)m=	237.44	227.35	203.28	163.75	124.78	82.6	56.55	58.73	90.42	139.64	189.55	232.47	(97)

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

(98)m=	0.04	0.01	0	0	0	0	0	0	0	0	0	0.04	

Total per year (kWh/year) = Sum(98)$_{1...5,9...12}$ = 0.08 (98)

Space heating requirement in kWh/m²/year 0 (99)

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

Space heating:

Fraction of space heat from secondary/supplementary system		0 (201)
Fraction of space heat from main system(s)	(202) = 1 – (201) =	1 (202)
Fraction of total heating from main system 1	(204) = (202) × [1 – (203)] =	1 (204)
Efficiency of main space heating system 1		100 (206)
Efficiency of secondary/supplementary heating system, %		0 (208)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	kWh/year
Space heating requirement (calculated above)													
	0.04	0.01	0	0	0	0	0	0	0	0	0	0.04	
(211)m = {[(98)m x (204)] } x 100 ÷ (206)													(211)
	0.04	0.01	0	0	0	0	0	0	0	0	0	0.04	

Total (kWh/year) =Sum(211)$_{1...5,10...12}$= 0.08 (211)

Space heating fuel (secondary), kWh/month

= {[(98)m x (201)] } x 100 ÷ (208)

(215)m=	0	0	0	0	0	0	0	0	0	0	0	0	

Total (kWh/year) =Sum(215)$_{1...5,10...12}$= 0 (215)

Water heating

Output from water heater (calculated above)

	136.92	120.52	126.17	112.56	109.9	97.63	93.22	103.04	103.09	116.74	124.13	133.44

Efficiency of water heater 100 (216)

(217)m=	100	100	100	100	100	100	100	100	100	100	100	100	(217)

Fuel for water heating, kWh/month

(219)m = (64)m x 100 ÷ (217)m

(219)m=	136.92	120.52	126.17	112.56	109.9	97.63	93.22	103.04	103.09	116.74	124.13	133.44	

Total = Sum(219a)$_{1...12}$ = 1377.37 (219)

Annual totals	**kWh/year**	**kWh/year**
Space heating fuel used, main system 1		0.08
Water heating fuel used		1377.37
Electricity for pumps, fans and electric keep-hot		
mechanical ventilation - balanced, extract or positive input from outside	67.1	(230a)
central heating pump:	120	(230c)
Total electricity for the above, kWh/year	sum of (230a)…(230g) =	187.1 (231)
Electricity for lighting		236.53 (232)
Electricity generated by PVs		-138.18 (233)

10a. Fuel costs - individual heating systems:

	Fuel kWh/year	**Fuel Price** (Table 12)	**Fuel Cost** £/year
Space heating - main system 1	(211) x	13.19 x 0.01 =	0.01 (240)
Space heating - main system 2	(213) x	0 x 0.01 =	0 (241)
Space heating - secondary	(215) x	13.19 x 0.01 =	0 (242)

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Water heating (electric off-peak tariff)					
High-rate fraction (Table 13, or Appendix F for electric CPSU)				1	(243)
Low-rate fraction	1.0 – (243) =			0	(244)
High-rate cost	(219) x (243) x	13.19	x 0.01 =	181.67	(245)
Low-rate cost	(219) x (244) x	13.19	x 0.01 =	0	(246)
Pumps, fans and electric keep-hot	(231)	13.19	x 0.01 =	24.68	(249)
(if off-peak tariff, list each of (230a) to (230g) separately as applicable and apply fuel price according to Table 12a					
Energy for lighting	(232)	13.19	x 0.01 =	31.2	(250)
Additional standing charges (Table 12)				0	(251)
	one of (233) to (235) x)	13.19	x 0.01 =	0	(252)
Appendix Q items: repeat lines (253) and (254) as needed					
Total energy cost	(245)...(247) + (250)…(254) =			237.56	(255)

11a. SAP rating - individual heating systems

Energy cost deflator (Table 12)		0.42	(256)
Energy cost factor (ECF)	[(255) x (256)] ÷ [(4) + 45.0] =	1.17	(257)
SAP rating (Section 12)		83.62	(258)

12a. CO2 emissions – Individual heating systems including micro-CHP

		Energy kWh/year	**Emission factor** kg CO2/kWh		**Emissions** kg CO2/year	
Space heating (main system 1)	(211) x		0.519	=	0.04	(261)
Space heating (secondary)	(215) x		0.519	=	0	(263)
Water heating	(219) x		0.519	=	714.85	(264)
Space and water heating	(261) + (262) + (263) + (264) =				714.9	(265)
Electricity for pumps, fans and electric keep-hot	(231) x		0.519	=	97.1	(267)
Electricity for lighting	(232) x		0.519	=	122.76	(268)
Energy saving/generation technologies						
Item 1			0.519	=	-71.71	(269)
Total CO2, kg/year	sum of (265)…(271) =				863.05	(272)
CO2 emissions per m²	(272) ÷ (4) =				21.58	(273)
EI rating (section 14)					86	(274)

13a. Primary Energy

		Energy kWh/year	**Primary** factor		**P. Energy** kWh/year	
Space heating (main system 1)	(211) x		3.07	=	0.25	(261)
Space heating (secondary)	(215) x		3.07	=	0	(263)
Energy for water heating	(219) x		3.07	=	4228.52	(264)
Space and water heating	(261) + (262) + (263) + (264) =				4228.77	(265)

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Electricity for pumps, fans and electric keep-hot	(231)	x		3.07	=	574.4	(267)
Electricity for lighting	(232)	x		0	=	726.15	(268)
Energy saving/generation technologies Item 1				3.07	=	-424.21	(269)
‘Total Primary Energy			sum of (265)…(271) =			5105.1	(272)
Primary energy kWh/m²/year			(272) ÷ (4) =			127.63	(273)