Acorn House - Amendment to Approved Energy and Sustainability Strategy

Project/Ref: 08580 – Acorn House

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Audit sheet

Revisions:	No.:	Date:	Approved:
	-	31/03/2023	JG
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	B	06/06/23	JG

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Executive Summary

This report describes proposed amendments to the approved Energy Strategy for a development of 33 new Dwellings, and mixed use – Office, Retail and Community – at Acorn House, 314-320 Gray's Inn Road, London, WC1X 8DP in the London Borough of Camden.

The proposed changes relate only to the dwellings; no changes are proposed to the Energy Strategy in relation to the Office, Retail, Community and Landlord areas.

The effect of the proposed changes will:

1. Improve on the approved scheme's Carbon Emissions Reduction (75% better than Building Regulations Part L instead of 68%)
2. Reduce the amount of electricity used for heating and hot water from £295 per apartment per year to £195
3. Reduce the standing losses from the heating and domestic hot water by around 50% compared to the approved scheme.
4. Reduce the size, weight and noise emission of the central plant, and make it significantly less expensive for the Landlord and Tenants to operate, maintain and eventually replace.

The proposed amendment seeks to retain the original over-arching strategy of using a communal heat network with central Air Source Heat Pumps (ASHP's) but change from instantaneous hydraulic heat interface units to separate centralised systems for Space Heating and Domestic hot water In this regard the proposal is very similar to the standard way of heating residential buildings from the first days of apartment block central heating right up to the arrival of combi boilers in the 1980's, but utilising Heat Pumps as the main heat source, instead of gas-fired boilers.

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1 Background – the approved scheme

Detailed planning approval was granted for the Energy Strategy described the report "Energy and sustainability statement, Revision 2B. August 2020" produced by Atelier Ten Ltd. A copy is appended for ease of reference.

This Energy Strategy employs central Air Source Heat Pumps ASHP's on the roof, producing Low Temperature Hot Water (LTHW) at 57°C which is distributed to the Apartments via risers in the central core serving corridor run-outs above ceilings.

The LTHW feeds a Hydraulic Heat Interface Unit (HIU) in each dwelling. Each HIU has 2 plate heat exchangers; one to transfer heat to an underfloor heating system and one to generate domestic hot water by instantaneously warming a cold feed.

Additionally, under the approved Energy Strategy, each dwelling has its own cooling system which consists of an air-to-air heat pump with a cooling coil in the MVHR Supply duct and a heat rejection coil in the MVHR Exhaust Air Discharge duct. The purpose of this cooling arrangement is to allow the windows to remain closed and maintain good air quality in hot weather.

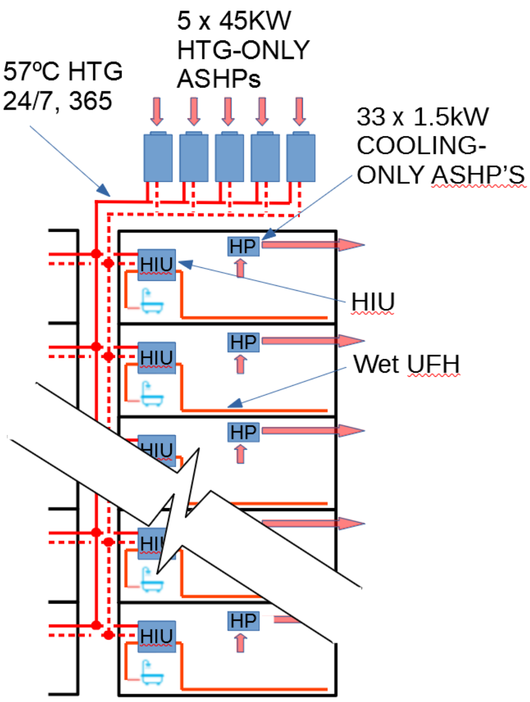
2. Proposed Material Amendment

The Atelier Ten report of August 2020 describes a communal heating system for the dwellings comprising:

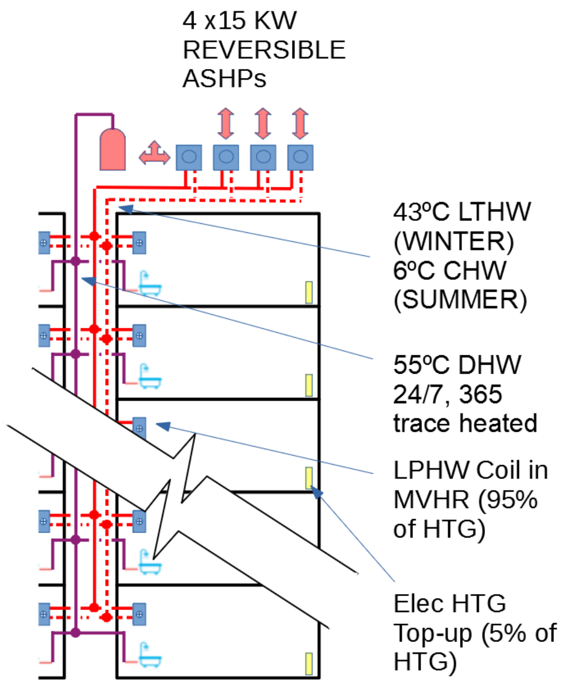
- 33 No. air-to-air heat pump-based cooling systems
- 33 No. wet underfloor heating systems
- 33 No. Hydraulic Interface Units to generate Domestic Hot Water and provide heat for Space Heating
- 1 No. 2-pipe communal heat network carrying LTHW at 57 ºC flow and 53 ºC return
- 1 No. Central, rooftop, mechanical plantroom, with pumps, pressure sets, buffer vessels, treatment & filtration
- 5 No. 45kW rooftop Air Source Heat Pumps (ASHP's) dedicated to the apartments heating and hot water.

Our proposed change to the Energy Strategy comprises the following:

- Omit 33 air-to-air heat pump-based cooling systems
- Omit 33 wet underfloor heating systems and add 33 No. Passivhaus-style LTHW air heating coils instead.
- Make the 33 Heating Coils capable of delivering cooling (add condensate tray, use 6-row coils instead of 2-row, use 2-stage controller instead of 1-stage)
- Omit 33 Hydraulic Interface units. Add 33 Heat meters and 33 Domestic Hot Water Meters in lieu.
- Provide a communal Domestic Hot Water Storage and Distribution System which is entirely separate to the Communal LTHW heating system. This allows the LTHW system to be reversed in summer to deliver chilled water and provide cooling in the dwellings via the "heater" coil.
- Omit 5 No. 45kW, heating-only, ASHP's and add 4 No. 15kW reversible ASHP's
- Rooftop plant generally as before (but around 75% smaller)



Current, HIU-based, Strategy



Proposed Strategy

3. Discussion

3.1 Changes to cooling strategy.

One reason for changing from the approved strategy of a standalone, cooling-only, heat pump in each apartment is because the proposed unit – the Zehnder "Comfocool" - is currently withdrawn from the UK market.

A second reason is that we believe maintenance will be greatly simplified if the rooftop ASHP's, which provide space heating in winter, can be used in reverse mode in summer to provide cooling. This removes 33 mini heat-pumps from the proposal entirely, leading to a reduction in maintenance and replacement costs. It also removes a potential noise source from inside each apartment.

A final reason is that we would like to make use of the waste heat from summertime cooling as a "free" resource for Domestic Hot Water generation. The current proposal has, on a summer day, 33 ASHP's dumping heat into the outside air, via the MVHR Exhaust Air Discharge Ducts, and 5 different ASHP's on the roof extracting heat from the outside air to generate Domestic Hot Water.

3.2 Changes to the Domestic Hot Water Strategy.

Changing to centralised Hot Water Storage Cylinders instead of a Hydraulic Interface Unit in each flat has a number of advantages:

1. It replaces 33 high maintenance HIU's, each of which require within-apartment access for servicing, with 3 low maintenance Hot Water Cylinders in the Landlord's rooftop plantroom.
2. The ASHP size needed to keep hot water cylinders topped-up with heat is ***much*** less than what is needed to provide 33 HIU's with enough heat for instantaneous Hot Water generation.
3. N+1 redundancy and full immersion heater backup is practical, whereas each HIU has multiple single points of failure.
4. The Domestic Hot Water system and Space Heating become independent of each other, meaning the Space Heating does not have to run throughout the summer and can even be reversed to become a space cooling system.
5. Using central Domestic Hot Water storage allows the DHW generation to be carried out in 2 stages:
    i. A low temperature stage which uses a buffer vessel containing LTHW and plate heat exchanger to instantaneously preheat the cold feed from 10oC to 35oC
    ii. Conventional Hot Water Cylinders that raise the preheated cold feed from 35oC to 55oC and store DHW in the normal manner.

This means half of the heat input for Domestic Hot Water generation takes place at a Heat Pump-friendly low temperature, and the amount of DHW heat that must be generated at the less efficient hight temperature is reduced by 50% compared to an HIU-based scheme.

MCS CERTIFIED

Grant Aerona3 HPID13 R32 (for space heating and hot water)

Certification Number: BBA 0009/18
Model Number: Grant Aerona3 HPID13 R32
Certification Period: 06/06/2019 - Present

Product Details

Manufacturer:	Grant Engineering (UK) Ltd	Product Name:	Grant Aerona3 HPID13 R32 (for space heating and hot water)
Model Number:	Grant Aerona3 HPID13 R32	Technology:	Air Source Heat Pump
Certification Body:	BBA	Manufacturer's Website:	Visit manufacturer's website
Certification Period:	06/06/2019 - Present	Current Certification Status:	Certified

SCOP Values

Flow Temperature	SCOP
50°C	4.11
51°C	4.03
52°C	3.95
53°C	3.88
54°C	3.8
55°C	3.72

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SCOP Values

Flow Temperature	SCOP
35°C	5.4
36°C	5.31
37°C	5.22
38°C	5.13
39°C	5.04
40°C	4.95

Domestic Hot Water cannot be stored at 35 deg C for the low temperature stage; so this stage has to be a buffer vessel and plate heat exchanger (commonly known as a heat bank). The buffer vessel contains chemically treated, sealed system, LTHW at 35 deg C and the Heat Exchanger is used to instantaneously warm the cold feed on its way to the hot cylinder from as low as 5 deg C in winter up to 30 deg C on entry to the cylinder. The net result is for every 100kWh of heat delivered to the Hot Water, 50kWh is generated at a SCOP of 3.72 (using 13.44kWh of electricity) and 50kWh is generated at a SCOP of 5.4, using 9.26kWh. The net result is 22.7 kWh of electricity has generated 100kWh of heat: a combined SCOP of 4.4.

4.4 is an ***extremely*** good SCOP for Domestic Hot Water Generation.

(The Approved scheme has a SCOP of 2.5. This is not unusual for HIU-based systems, because the LTHW on the Landlord's side *must* be hot enough to generate 50°C Domestic Hot Water on the resident's side for legionella prevention, this implies a landlord-side temperature of 65 or 70°C and, *at the very minimum,* 57°C.

3.3 Changes to the Space Heating Strategy

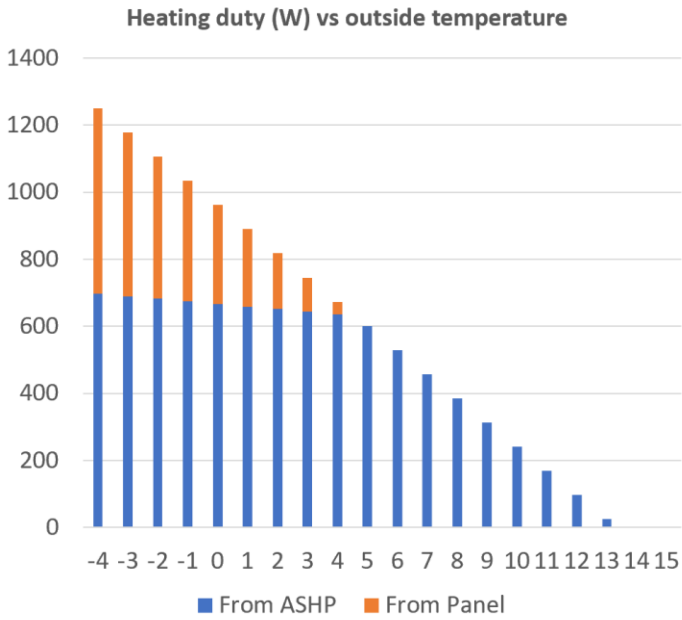
Our proposed amendment borrows from the Passivhaus approach to space heating. The Passivhaus philosophy is to make a dwelling so well-insulated and airtight it can be successfully heated simply by warming the air that is supplied to the living rooms and bedrooms from the Mechanical Ventilation (MVHR) system.

In practice many Passivhaus schemes use electric panel heaters in each room instead of the single duct-mounted electric heater battery. Our proposal is to use a single, duct-mounted heater battery in the MVHR supply air stream, but size it at 50% of the Apartment's peak heat loss and feed it with LTHW from central ASHP's instead of direct electric heating from the residents Electricity supply. We also propose to have panel heaters in each room sized to cover the full heat loss in the event of a heat pump failure but controlled to deliver only "top-up" heat in cold weather.

3.3.2 Secondary Heating Proportion

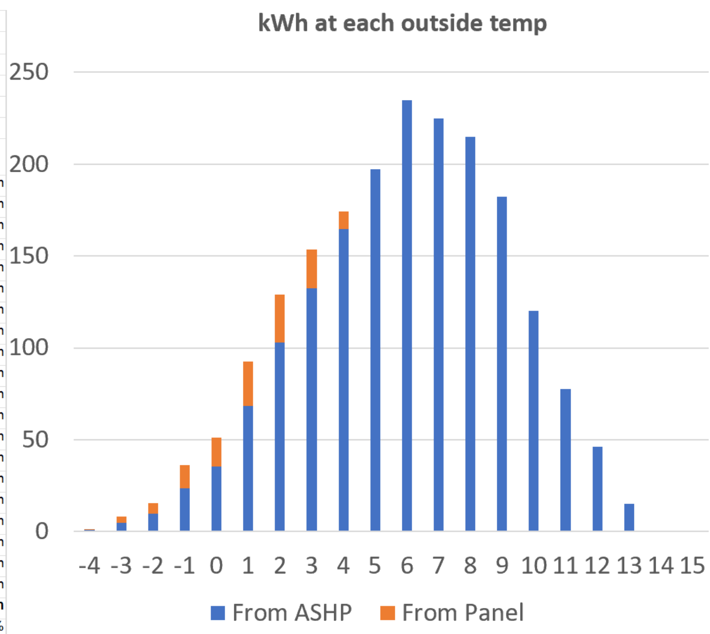
In the example below, the apartment starts to need space heating when the outside temperature drops below 14 deg C; passive gains from people, appliances, pumps & fans, solar gain and domestic hot water standing losses are sufficient to offset heat losses when it is warmer than this outside.

From the graph we can see the panel heaters are doing almost 50% of the heat load when it is -4 deg C outside.



But when we look at how many hours a year it is -4 deg C outside we see that the annual heating energy is dominated by the thousands of hours of 5 deg C and above, when the panel heaters are not required, not the few dozen hours below zero.

	AREA	87.6		
	MIT	20.0	(Row 93)	
	HLP	0.823	(Row 40)	
	Useful Gains	479.4	(Row 95)	
	Supply Air l/s	41.7	Part F / PH	
	MVHR Eff.	85%		
Outside Temperature	***hrs/yr**	**Net Heat loss rate**	**From ASHP**	**From Panel**
-4	1	1250 W	0.7 kWh	0.6 kWh
-3	7	1178 W	4.8 kWh	3.4 kWh
-2	14	1106 W	9.6 kWh	5.9 kWh
-1	35	1034 W	23.6 kWh	12.6 kWh
0	53	962 W	35.3 kWh	15.6 kWh
1	104	890 W	68.5 kWh	24.0 kWh
2	158	817 W	102.9 kWh	26.2 kWh
3	206	745 W	132.6 kWh	21.0 kWh
4	259	673 W	164.7 kWh	9.7 kWh
5	328	601 W	197.2 kWh	0.0 kWh
6	444	529 W	235.0 kWh	0.0 kWh
7	492	457 W	224.9 kWh	0.0 kWh
8	558	385 W	214.9 kWh	0.0 kWh
9	582	313 W	182.2 kWh	0.0 kWh
10	499	241 W	120.3 kWh	0.0 kWh
11	459	169 W	77.6 kWh	0.0 kWh
12	474	97 W	46.0 kWh	0.0 kWh
13	600	25 W	14.9 kWh	0.0 kWh
14	540	0 W	0.0 kWh	0.0 kWh
15	506	0 W	0.0 kWh	0.0 kWh
* weather file: LondonTRY05.fwt			**1856 kWh**	**119 kWh**
	3836		94.0%	6.0%



By sizing the Space Heating ASHP at 50% of heat loss at -4 deg C outside temperature, it can still deliver 94% of the annual heat energy but needs only half the heat pump size.

3.3.3 Standby and redundancy

Furthermore, the panel heaters can be sized to meet 100% of the peak heat loss in each room, in the event of central plant failure, meaning N+1 redundancy is not needed for the central Space Heating ASHPs.

The panel heaters can also carry the “design margin” for the heating design. “Design Margin” is built into heat loss calculations in the form of a number of standards, but not very realistic assumptions:

1. That there are no heat gains from Solar, Occupants, Lights, Appliances, Fans & Pumps, DHW etc. This effectively ignores about 600W of heat input for a typical apartment.

2. The apartments above, below, and on both sides of the apartment are unoccupied and unheated. This adds about 1200W of heat losses.

3. The apartment heating will operate on a timeclock, with OFF and ON periods, thus the heating system will need 20-40% extra capacity for “warm-up”.

4. Many designers then add 10% “for luck”.

The net result is an apartment, that in reality only needs 1200W of heat when it is -4 deg C outside, has a notional heat loss of 3,500W assigned to it. And even though the CP1 diversity factor (typically 0.62) rows back a bit from this oversizing, it still results in the central plant being based on around 2200W per apartment when in fact 1200W is more realistic.

In our proposal the panel heaters will be sized at 3500W per apartment, closing off the N+1 redundancy requirement and carrying all the “design margin”, but the Space heating ASHP will be sized on 95% of actual annual space heating energy, which equates to a heating coil sized at 350 to 600 W per dwelling and a total of 20kW for the 33 dwellings.

3.3.4 ASHP Sizing

Summing up, in terms of ASHP sizing we have the following:

Previous proposal: 4 x 45kW Heat Pumps on roof = 225kW Total

Amendment proposal: 3 x Grant Aerona HPID 17 Reversible ASHP’s Plus 1 x Vaillant Flexotherm 15kW Brine-to-water Heat Pump and Matched Vaillant Arocollect air-to-brine heat collector. (= 66kW Total, which is a 70% size reduction compared to the current scheme.

The Grant Aerona ASHP’s are each1418mm High x 874 mm wide x 403mm deep; weight 101kg; Sound power 60.8dB(A) / Sound Pressure 49.8dB(A).

The Vaillant ASHP’s is 1565mm high x 1,100mm wide x 449mm deep, weighing 194kg with a sound Power of 60dB(A).

Clearly, they will take less space and generate less noise than the ASHP’s for the previously approved scheme. See below for extract from previous energy strategy showing extent of plant area.

3.3.5 Heat Pump Performance

A key benefit of separating the Space Heating from the Domestic Hot Water is the Heating LTHW flow can be run at very low temperatures: 43 deg C. This gives a SCOP of 4.68 for the Grant AERONA R32 HPID ASHP.

As described in 3.3.2, we have calculated the panel heaters will contribute less than 10% of overall space heating.

90 kWh / 4.68 = 19.2kWh(e)

10kWh / 1.0 = 10kWh(e)

100kWh / 29.2 = a SCOP of 3.4

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SCOP Values

Flow Temperature	SCOP
38°C	5.13
39°C	5.04
40°C	4.95
41°C	4.86
42°C	4.77
43°C	4.68

3.3.6 Controls and controlability.

A key Probably the single most important job of the controls will be to ensure that a panel heater is NEVER used to do heating that could have been done by an ASHP.

Our proposed strategy is to control the MVHR on the basis of outside temperature; a simple weather compensator controller in the hallway will measure the outside temperature (using a sensor in the MVHR Fresh Air Intake duct) and also measure the supply air temperature. It will use these readings to control the heater battery's motorised valve and vary the supply air temperature based on how cold it is outside. The exact curve will be adjustable (hotter / colder) by a dial (or up/down) arrows on the hallway controller. The MVHR heater battery will operate 24/7.

The panel heaters will each have a 7-day programmer and room thermostat for individual set-up.

Because the MVHR supply air temperature is controlled on the basis of outside air temperature rather than room temperature it will avoid the scenario where a panel heater can become the lead heat source. (By contras, iIf the MVHR heater was controlled by a room thermostat which was set at lower temperature than the panel thermostat, then a situation could arise where the panel heater is on and "holding off" the MVHR heater. We must avoid this at all costs.)

Essentially the user will have:

- A dial in the hallway that makes the whole flat hotter or colder.
- A smart TRV on each panel heater that has setable on and off times as well as room temperature control.

When they go on holiday, they can turn the dial in the hall down to minimum and switch off all the panel heaters with a master switch in the hallway.

When they come back, they can turn the dial back-up and either switch the panel heaters back on immediately for a quick warm-up that will cost around 50p-£1 or wait while the MVHR heater slowly pulls the temperature up at a cost of around 10-20p.

4. Energy Calculations

A complete set of SAP Calculations, along with the GLA reporting template, are provided in the original Energy Strategy of June 9th, 2021. (Copy appended for ease of reference).

In order to give a like for like comparison we have used these figures in a revised GLA reporting Spreadsheet, changing the following:

1. "Efficiency of heat Source" (Box 367a on page 7 of the SAP Calculations) from 250% to 340% for heating, and 440% for Domestic Hot Water (to model SCOP's of 4.95 and 4.4)

2. Allocate 90% of heating to Heat Pump at SCOP of 4.68 and 10% to panel heaters at SCOP of 1.0

The following is a side-by side comparison of the Emissions reductions for the Approved Scheme (left) and proposed amendment (right).

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildings

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	35	19
After energy demand reduction	32	19
After heat network / CHP	32	19
After renewable energy	15	19

Table 2: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for domestic buildings

	Regulated domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Savings from energy demand reduction	3	8%
Savings from heat network / CHP	0	0%
Savings from renewable energy	17	49%
Cumulative on site savings	**20**	**58%**
Annual savings from off-set payment	15	-
	(Tonnes CO2)	
Cumulative savings for off-set payment	**446**	-
Cash in-lieu contribution (£)	**26,737**	

Table 1: Carbon Dioxide Emissions after each stage of the Energy Hierarchy for domestic buildi

	Carbon Dioxide Emissions for domestic buildings (Tonnes CO_2 per annum)	
	Regulated	Unregulated
Baseline: Part L 2013 of the Building Regulations Compliant Development	35.0	19.4
After energy demand reduction (be lean)	31.8	19.4
After heat network connection (be clean)	31.8	19.4
After renewable energy (be green)	11.3	19.4

Table 2: Regulated Carbon Dioxide savings from each stage of the Energy Hierarchy for dome

	Regulated domestic carbon dioxide savings	
	(Tonnes CO_2 per annum)	(%)
Be lean: Savings from energy demand reduction	3.1	9%
Be clean: Savings from heat network	0.0	0%
Be green: Savings from renewable energy	20.5	59%
Cumulative on site savings	**23.6**	**68%**
Annual savings from off-set payment	11.3	-
	(Tonnes CO_2)	
Cumulative savings for off-set payment	**340**	-
Cash in-lieu contribution (£)	**32,296**	

*carbon price is based on GLA recommended price of £95 per tonne of carbon dioxide unless

The thermal envelope specification (U-Values, Psi-Values and Airtightness) are unchanged from the original approved energy statement. These are reproduced below for ease of reference.

Table 4.1 Fabric performance targets for dwellings

Dwelling Fabric Efficiency Targets		
Parameter		Target value
Air Tightness $m^3/(h.m^2)$ @50Pa		≤ 3.00
Thermal Mass ($kJ/m^2.K$)		250 (medium)
Thermal Bridging (y-value) ($W/m^2.K$)		0.15*
U-Value ($W/m^2.K$)	External Wall	≤0.15
	Roof	≤ 0.10
	Floor /Ground	≤ 0.16
	Party wall	Fully filled cavity with effective sealing at all exposed edges
	Windows	≤ 1.20
Glass Properties	g-value	0.4
	$T_{visible}$	–

* Aspiration to pursue enhanced thermal bridging performance via Accredited details. These will be developed during the detailed design stage.

5.Sustainability

The sustainability measures set out in Atelier Ten original Energy and Sustainability report will be followed.

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Appendices:

A. GLA Reporting Templates (as .xls – separate document)
B. Copy of previous energy strategy (for ease of reference) as .pdf