Ancion Court

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Innovate UK project number	450083
Project author	Connect Housing/Kiwa
Report date	2014
InnovateUK Evaluator	Fionn Stevenson (Contact via www.bpe-specialists.org.uk)

No of dwellings	**Location**	**Type**	**Constructed**
Two flats assessed	Marsden	2 bed apartments	2011
Area	**Construction form**	**Space heating target**	**Certification level**
63.7 m^2 and 55.5 m^2	Block construction	Flat A: 2633 kWh per annum Flat B: 1941 kWh per annum	CSH Level 4

Background to evaluation

Ancion Court was a new development in West Yorkshire consisting of 14 flats (13 occupied dwellings and a communal area). The properties were constructed to Level 4 of the *Code for Sustainable Homes* (a 25% reduction in dwelling emission rate) compared with the target emission rate. Flats A and B were modelled under SAP calculations) leading to a target emission rates of 31.7 and 31.1 respectively. The properties are heated two ground source heat pumps rated at 33.3 kW and 7.5 kW respectively. Monitoring was carried out to enable the performance of the heating and hot water systems to be analysed.

Design energy assessment	**In-use energy assessment**	**Sub-system breakdown**
Yes	Yes	Yes

The field trial results found a greater requirement for space heating energy than the calculated SAP assessments predicted, (15% higher for flat A and 41% for Flat B). However, they also show a higher internal temperature by approximately 3-4°C. The researchers suggested that the temperature difference alone could account for a 20 to 30% increase in energy required to maintain the internal temperature. Energy use by lighting was also higher than predicted in SAP assessments, with recorded values at least 50% higher than estimated.Artificial lighting was found to be required for the majority of the time for rear-facing ground floor flats, which was not predicted in the SAP assessments. The air tightness of the dwellings measured 4.72 m^3 (m^2.h) and 7.66 m^3 (m^2.h) for Flats A and B respectively.

Occupant survey type	**Survey sample**	**Structured interview**
BUS domestic	13 of 13 (100 % response rate)	Yes

A Building Use Study (BUS) was carried out approximately 12 months after the residents first moved into the development. All of the properties in the development were approached and all willingly completed the survey. Overall the air quality was considered satisfactory in both summer and winter. The air was thought to be odourless, but also dry and still. Several residents commented that the air was stuffy and they needed fans to create air movement during hot summer months. Control of heating, lighting (both natural and artificial) and cooling within the properties were by far the most criticised aspects of the development.

Contents

1 Introduction and overview

Technology Strategy Board guidance on section requirements:	This section of the report should be an introduction to the scope of the BPE project, the expected results and will include a summary of the key facts, figures and findings. Give an introduction to the project covering the project team and a broad overview of the energy strategy, design strategy rationale and soft and hard monitoring. Also summarise the building type, form, materials, surrounding environment and orientation, as well as related dwellings in the development (which may or may not be part of the BPE project). Other amenities, such as transport links, cycling facilities, etc. should also be outlined where relevant. Give information on any environmental requirements issues that are relevant to the site, but not to the research. Only the basic facts etc. should be included here - more detailed information should be given in the relevant sections in this document and added to the data storage system as appropriate.

1.1 Project Overview

Connect Housing in Partnership with Kiwa Ltd have monitored and evaluated one of Connect Housing's developments under the Technology Strategy Board Building Performance Evaluation (BPE) projects. The development was monitored under Phase Two of the BPE Programme to assess domestic dwellings *In-use and post occupancy*.

The main aim of the study was to evaluate the performance of the building over an extended period of time, once the building fabric had stabilised and the occupants were familiar with their dwellings. There were three main aims:

- To evaluate the performance of the building fabric 'as built'
- To evaluate the performance of key energy using and generating equipment and systems
- To evaluate the amenity, comfort, control and convenience experienced by occupants

In essence the main aim was to evaluate whether or not the building performed as expected when built and occupied compared to the design specifications. This was achieved using a variety of methods including quantitative data analysis and surveys, coupled with qualitative questionnaires and resident interaction.

The study was carried out by a project team consisting of Kiwa GASTEC at CRE (Kiwa) and Connect Housing (Connect). Kiwa is an experienced energy consultancy firm having carried out energy monitoring in over 450 domestic and commercial properties in national field trials for a range of clients. A particular focus for the company is to understand the operation and performance of new technologies, fuels and new building designs, and how these are likely to shape our energy use in the future.

Connect Housing are based in Leeds and are responsible for 3200 properties within the North of England. They are committed to reducing energy consumption in their housing stock and business through their Energy & Affordable Warmth Strategy 2010 – 2015. This has three strategic objectives:

- For Tenants – Aim to reduce the impact and incidence of fuel poverty amongst Connect tenants and increase awareness of environmental issues.
- For housing stock – Achieve an average SAP rating across Connect housing stock of 75, with no properties under a SAP rating of 55.
- For Connect Business – Reduce Carbon Dioxide emissions by 10% compared to a baseline level achieved in 2010.

1.2 Ancion Court

Ancion Court is a new development in Marsden, West Yorkshire completed in 2011. The development consists of 14 flats (13 occupied dwellings and a communal area), which are home to individuals over the age of 55.

Figure 1: Image of Ancion Court

The properties are constructed to Code for Sustainable Homes, code 4 meaning a 25% reduction in dwelling emission rate compared with the target emission rate. Using the SAP calculations for the monitored properties (discussed later) the target emission rate is 31.74 for Flat A and 31.15 for Flat B. Care has been taken in the design and development stages to ensure the nine categories within the Code for Sustainable Homes have been considered. These are:

- Energy & CO2 Emissions
- Water
- Materials
- Surface Water Run-off
- Waste
- Pollution
- Health and Well-being
- Management
- Ecology

The development is of block construction with stone cladding and considerable energy saving measures in place including:

- Low energy lighting,
- Underfloor heating
- Double glazing using Pilkington K glass
- High levels of thermal insulation:
    - 300mm Rockwool/mineral wool or fibreglass insulation on foiled back plasterboard ceiling ($0.16W/m^2/K$)
    - External walls – U-value not to exceed $0.2W/m^2/K$
    - Floors – U-value not to exceed $0.2W/m^2/K$
    - Windows – U-value not to exceed $1.8W/m^2/K$
- Draught sealing strip around doors, windows and loft hatches

The properties are heated via a district heat main fed from two ground source heat pumps, the ground loops of which are located under the car park of the development. The heat pumps are rated at 33.3kW and 7.5kW respectively and feed a 500l buffer tank which in turn is pumped to each flat before being distributed via an underfloor heating manifold. The domestic hot water (DHW) is also provided by the heat pumps, with 5x 400l cylinders feeding a constant pump around system allowing immediate hot water provision in the properties.

The following diagram outlines the layout of the system followed by a photograph of the installed heat pump appliances. The schematic diagram also formed part of the Energy Day carried out for the residents during the trial at Ancion Court; this is discussed in greater detail later in the report.

Figure 2: Diagram of heating and hot water system at Ancion Court

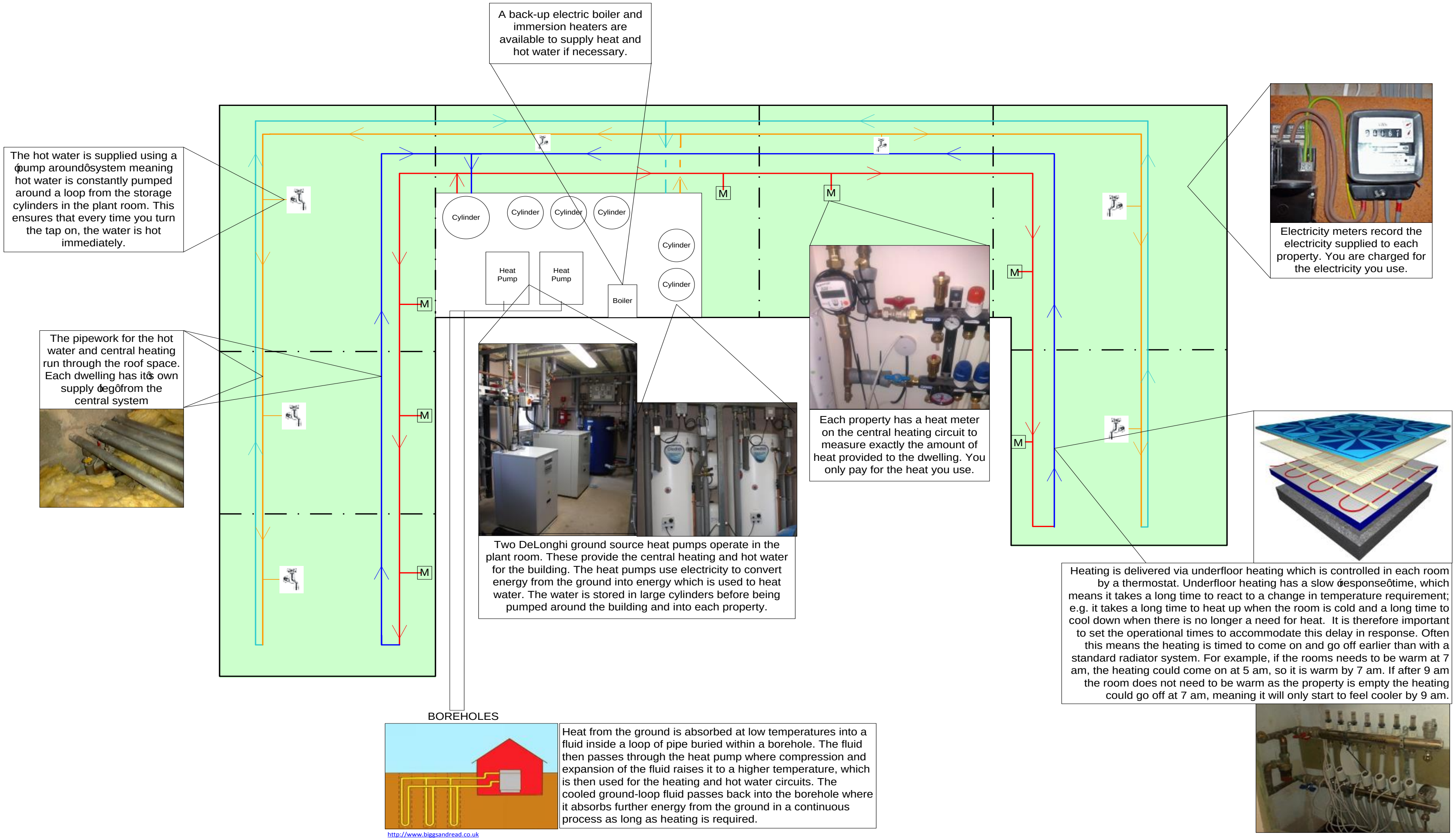


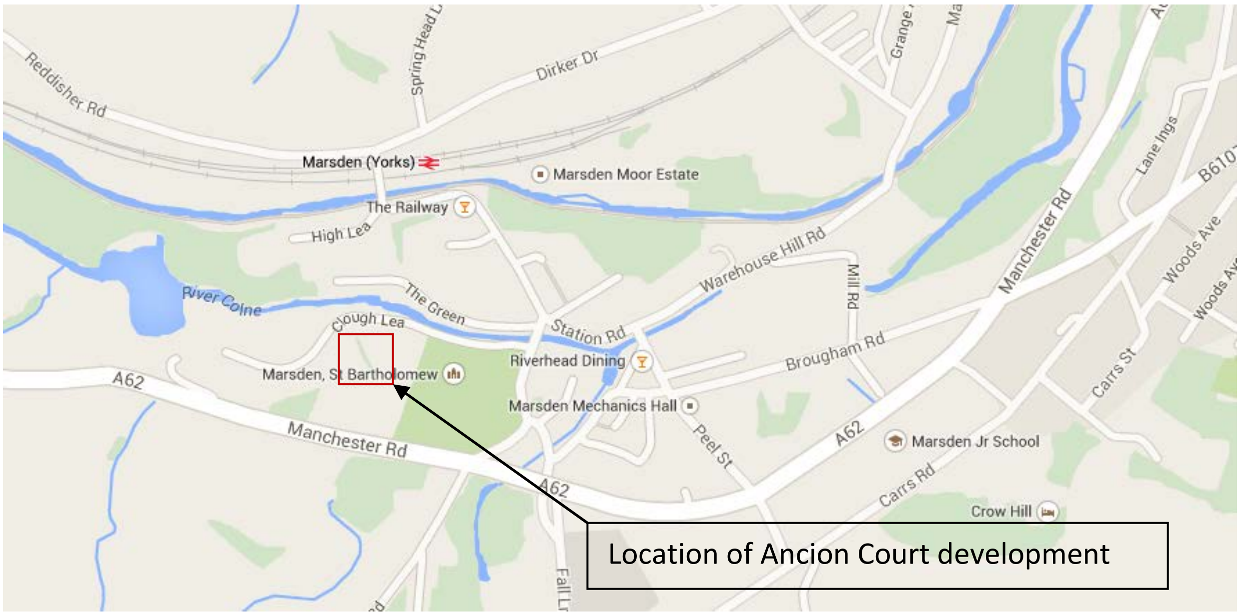
Figure 3: Photo of ground source heat pumps in the centralised plant room

The development also supports several environmental aspects such as rain water harvesting and is located in a protected area, with considerable tree coverage and wildlife conservation.

Figure 4: Tree coverage at rear of development

Marsden is a small town consisting of good local amenities and transport links. The town supports local businesses and consists of doctors, post office, church and convenience stores amongst others. There is also a train station providing links to local towns such as Huddersfield and Manchester, and regular bus services to the surrounding area.

Figure 5: Map of Marsden with Ancion Court Location (https://www.google.co.uk/maps)



Monitoring was carried out in two flats within the development as well as in the plant room to enable the performance of the heating and hot water system to be analysed. External conditions were also recorded to assess the success of the system in maintaining a suitable level of comfort within the development. Feedback was obtained from residents throughout the trial.

The flats were chosen as they represented the two extremes within the development. Flat A was a ground floor corner property, with the majority of the property facing the rear and almost fully over shadowed by the surrounding tress. The only aspect of the flat which faces the front of the property was the front door. In contrast, Flat B was a first floor, end property with aspects to both the front and the rear of the development. This property is accessed through a private front door in the central courtyard.

Key findings indicate that the residents are largely satisfied with the development and are comfortable within their homes. It is however apparent that successfully integrating the heat pump system has been difficult and options are available that may improve the operation and performance of these going forward.

2 About the building: design and construction audit, drawings and SAP calculation review

Technology Strategy Board guidance on section requirements:	This section should cover the project up until before commissioning. Give more details on the building type, form, materials, surrounding environment and orientation, as well as related dwellings in the development (which may or may not be part of the BPE project). Other amenities, such as transport links, cycling facilities, etc. should also be outlined where relevant to the design specification. Also provide comments on the design intent, construction process and the product delivered (including references to drawings, specifications, commissioning records, log book and building user guide). If the original specification is available, describe how closely the final design meets it, what the discrepancies are and why these occurred. Indicate whether the explanation comes from the design team or from evaluator judgement. Identify any discrepancies between the design and SAP and whether the design accurately reflected in the SAP calculations and describe where these discrepancies lie. Does the SAP performance match the specified performance and was this informed through measured or calculated data. As far as possible provide an explanation of the rationale behind the design and any changes that occurred. In particular, it will be helpful to understand the basis for making key decisions on the choice of measures and technologies. These may have been chosen to suit the particular property or a physical situation, or they may have been chosen to test an innovative material or a new product. List and describe any aspects of the design that are likely to introduce performance issues – e.g. cold bridges? Describe any aspects of the design that were a challenge to construct robustly - e.g. introduction of air leakage paths. Finally this section should also outline the construction and construction management processes adopted, construction phase influences i.e. builder went out of business, form of contract issues i.e. novation of design team, programme issues etc. Describe the overall construction process, highlighting any supply chain issues, delays in construction, contract(or) issues Important: please describe steps taken to overcome any stated challenges and issues. Report perceptions, concerns and positive nuggets raised by the client, designers, and construction team. Complete this section with conclusions and recommendations.

The monitored properties are part of the Ancion Court development in Marsden. This is a horseshoe shaped, two-storey building consisting of 13 occupied dwellings and a communal room. The development is for individuals over the age of 55, with the majority at retirement age or older. The flats are two bedroom properties, occupied on the whole by single adults or couples; one of the monitored flats is occupied by a mother and disabled son, the other a single adult. Each flat is a stand-alone dwelling consisting of two bedrooms, bathroom, kitchen, lounge and hallway. Each is accessed by private front doors. Site plans from Allcad Design and Drawing Services, and Colne Valley Design are shown below.

Figure 6: Ground Floor (Allcad Design & Drawing Services)

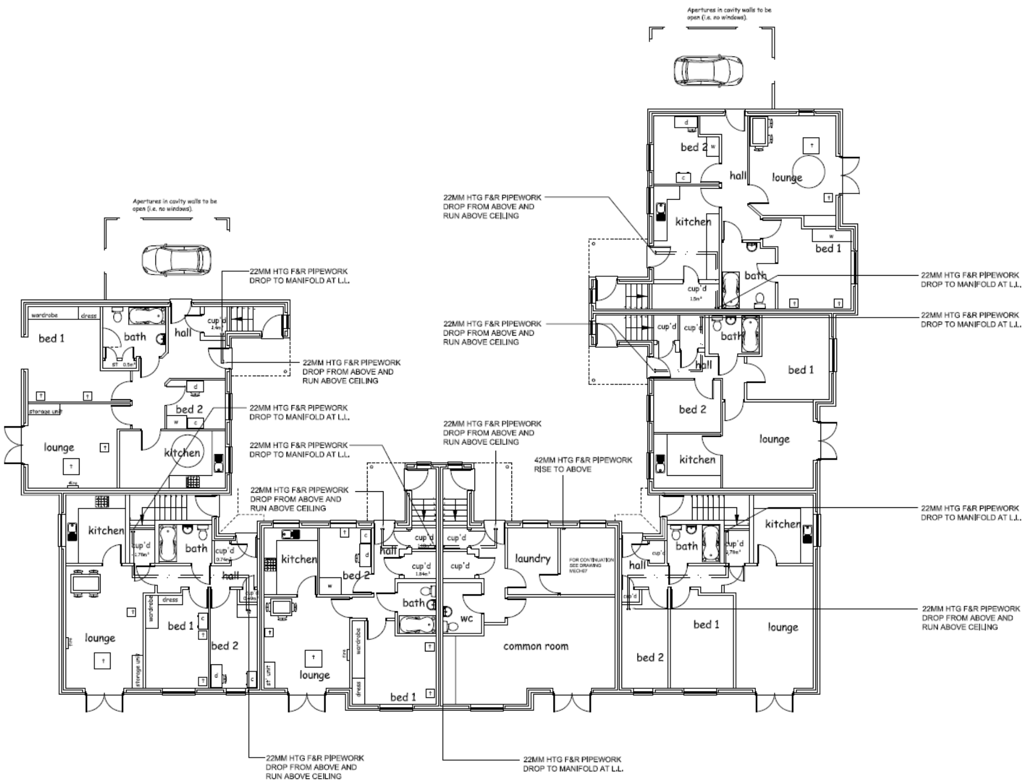
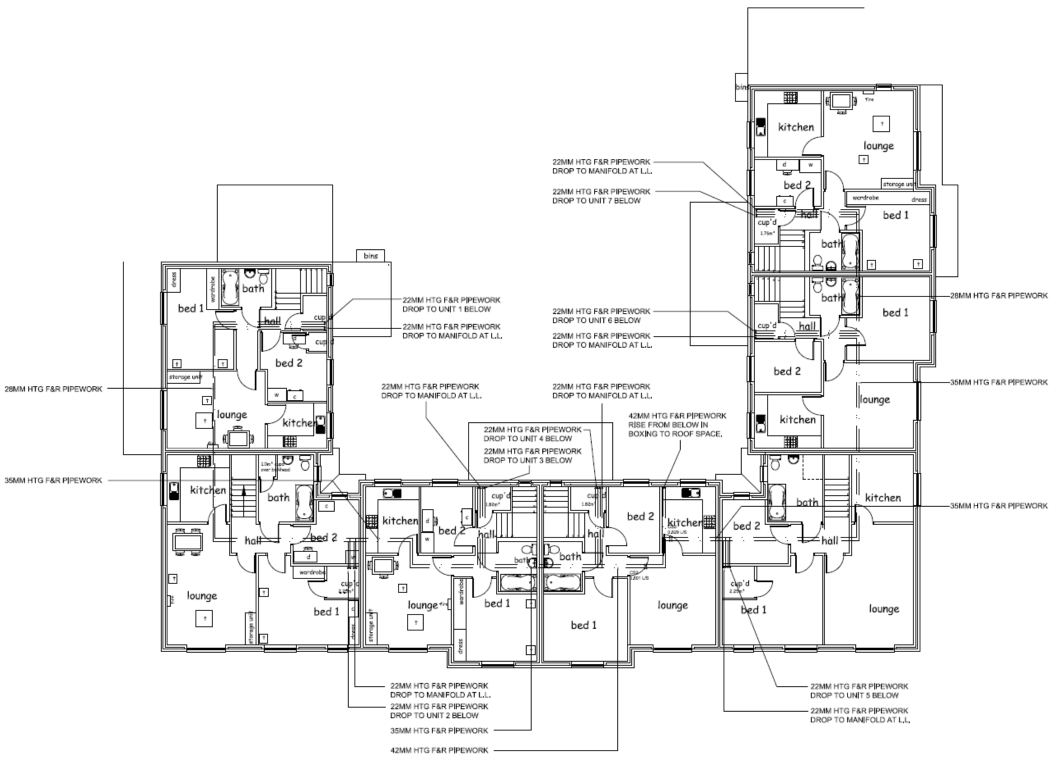


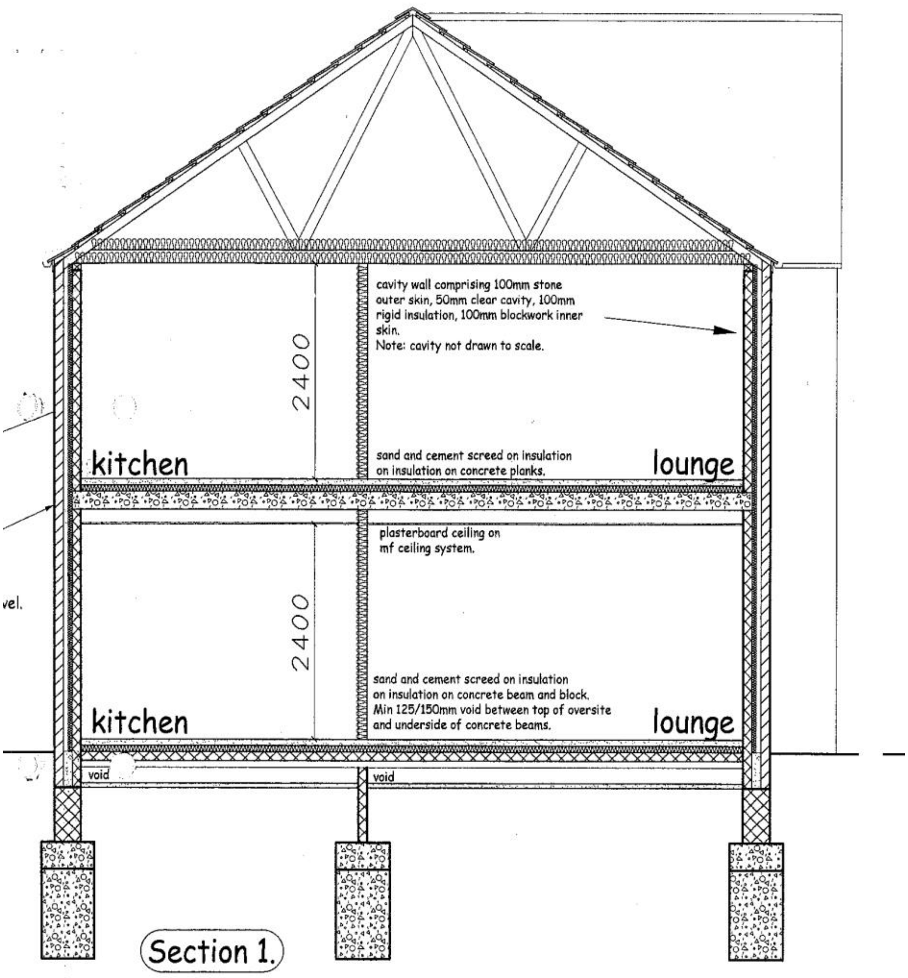
Figure 7: First Floor (Allcad Design & Drawing Services)



Ancion Court was designed as a sustainable homes code 4 development, constructed of block and brick with a Yorkshire stone outer leaf. The wall cavity is insulated with 80 to 100mm of rigid thermal board (Kingspan Thermawall TW50) giving a design U-value of 0.20W / m^2K. The building is damp proofed with Permabit bitumen polymer and sound proofing is fitted to internal surfaces.

Floors are constructed of sand and cement screed with 55mm Kingspan insulation on concrete slabs, with suspended floors also constructed of suspended concrete beam and block. Ground floors also consist of a radon barrier and void space.

Figure 8: Envelope construction (Colne Valley Design)



Ceilings are constructed of plasterboard suspended off a grid system and roof spaces are insulated with 300mm of mineral wool or fibreglass. The plasterboard ceiling is foil backed and designed to achieve a U-value of 0.16W/m2K. The domestic hot water distribution loop is also present in the roof space with individual DHW supplies teeing off the main pump around loop.

Figure 9: Floor and Ceiling construction (Colne Valley Design)

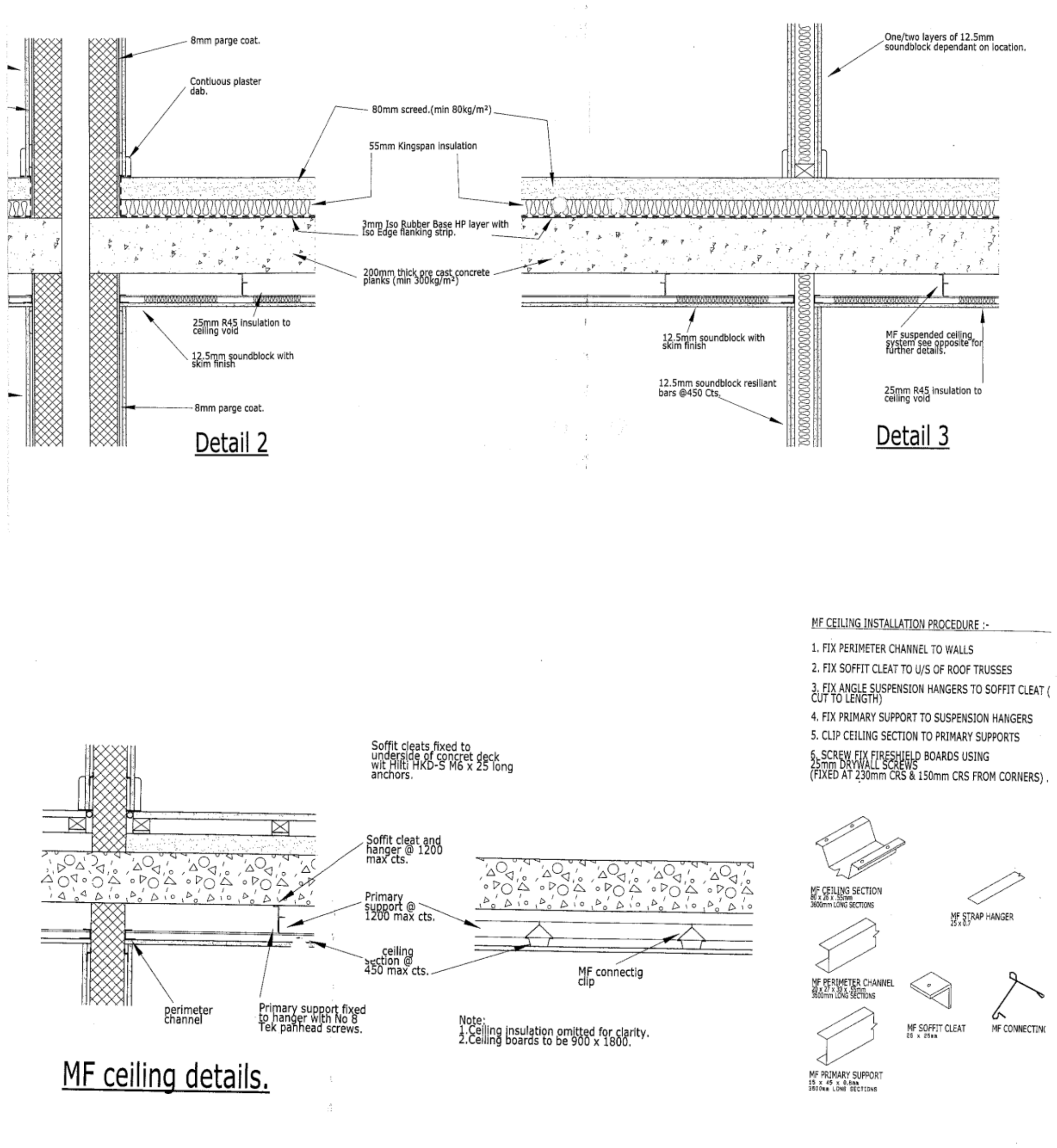


Figure 10: Loft insulation and heating & hot water pipes

Window and door frames are wooden and all are double glazed sealed units using Pilkington K glass. All doors also contain safety glass. Windows are rated at a U-value of 1.8W/m^{2}K.

Ventilation in the properties is largely provided by natural means however independent extract fans are also available in the bathrooms and kitchens. In the bathroom these extract vents are linked to lighting, thus when the light is on, so is the extract fan; the fan has an over-run of 15 minutes. On the design specifications, extraction vents in the bathroom are rated to achieve 3 air changes per hour. In kitchen areas, extract fans are rated at 60litres/second; both are fixed speed.

Overall, discussion with Connect Housing and the building contractors confirmed that the build was in line with the original specifications and no major problems were encountered during the completion of the project. Originally the communal room was designed to contain a laundry. However, the final heating system design was considerably larger than originally expected and following consultation with the residents association, it was considered likely that each resident would want the convenience of their own washing machine. As a result the laundry was removed from the plans and the plant room located in its place. This decision was made during the design stage and was a mutual decision between all interested parties; e.g. Connect Housing, the residents association and the designers, before any construction work took place. It therefore made minimal impact to the overall build process.

The design and building contractors used for this development were more familiar with working on code 3 properties and there was comment that the additional draught sealing and ventilation aspects that code 4 requires are not financially viable enhancements. The general consensus was that a disproportionate level of effort and man-hours were needed in order to result in any substantial improvements to the building fabric and air tightness, when meeting code 4 requirements. It was suggested that this effort could have been better utilised on alternative projects. A significant difference in this development was the use of individual extract fans instead of cooker hoods as many of the residents brought their own appliances and therefore cooker hoods were not suitable.

Connect Housing confirm there were no construction problems during the design or construction phases and the development was built as planned.

2.1 SAP Assessment

SAP assessments were carried out at each of the monitored properties by Stroma Technology at the design stage (see appendix) and again by Kiwa when the trial equipment was fitted. The monitored data was then compared to both the Stroma and Kiwa calculated SAP assessments. A summary of the results is shown below. Note; the field trial is an average of the two years of data collected.

Table 1: SAP Results

	Property Ref	Average Internal Temp	Space heating requirements kWh/yr.	Space heating fuel requirements kWh/yr.	Water heating requirements kWh/yr.	Water heating fuel requirements kWh/yr.	Elec for lighting kWh/yr.
Stroma	Flat A	18.3	2633	823	2942	1314	388
Stroma	Flat B	18.5	1941	607	2751	1228	306
Kiwa	Flat A	17.6	4437	1165	2988	784	698
Kiwa	Flat B	17.6	4486	1178	2691	706	475
Field	Flat A	21	5121	2328	2980	1355	1285
Field	Flat B	22	6327	2876	2980	1355	785

	Property Ref	CO2 heat kg	CO2 Water kg	CO2 Lighting kg	**Total CO2 kg** (including pumps & fans)	**Sap Band**	**SAP rating**
Stroma	Flat A	347	554	164	**1120**	**B**	**84**
Stroma	Flat B	256	518	129	**958**	**B**	**85**
Kiwa	Flat A	491	331	295	**1117**	**C**	**80**
Kiwa	Flat B	497	298	201	**996**	**C**	**79**
Field	Flat A	982	572	542	**2096**	**C**	**72**
Field	Flat B	1214	572	331	**2117**	**D**	**65**

It should be noted that to be comparable with the original SAP assessment carried out, these figures are based on SAP 2005 and although this is now outdated it was thought a useful evaluation. Overall, the field trial results (as shown in the table above) show a greater requirement for space heating energy than the calculated SAP assessments predict, (15% higher for flat A and 41% for Flat B). However, they also show a higher internal temperature by approximately 3 to 4C. This should automatically result in a greater energy consumption in the flats than SAP predicts, as more heat is required to maintain the 'lived in' temperature than the predicted temperature. It is suggested that the temperature difference alone could account for a 20 to 30% increase in energy required to maintain the internal temperature. This is further discussed in the air permeability sections later in the report.

Water heating requirements have been calculated based on the total output of the heat pumps to DHW divided by the number of flats within the development. The figures are shown to be comparable.

Energy requirements for lighting were also higher than predicted in both SAP assessments, with recorded values at least 50% higher than estimated. It was observed through the collected data and through interactions with the residents on site that artificial lighting is required for the majority of the time for rear facing ground floor flats which is not predicted in the SAP assessments.

Overall the as lived in energy requirements are notably higher than predicted from the original design detail. This is in part due to the higher as lived in temperatures experienced once occupied, however it also indicates that there may be aspects within the properties that are not performing as well as originally expected, an example of which is the significant increase in need for artificial lighting compared to expected. This is discussed in greater detail later.

2.2 Conclusions and key findings for this section

Ancion Court was designed and built as a Code for Sustainable Homes Code 4 development. It is evident from the design information made available, that every effort was made within the financial and structural restraints of the build and within the specific knowledge of the development team within Connect Housing, to utilise energy efficiency materials and technologies throughout the development.

Very few changes were identified during the review process with the construction team suggesting the property had been largely built as originally designed.

Total energy requirements of the properties measured during the field trial were shown to be 10 to 25% higher than those predicted in SAP. This is largely due to the higher internal temperature of the properties, as lived in, compared to that estimated in SAP. Energy for lighting was also much higher than predicted and this is supported by feedback from the residents who stated that natural lighting levels are poor and thus greater levels of artificial lighting are required.

3 Fabric testing (methodology approach)

Technology Strategy Board guidance on section requirements:	This section should provide a summary of the fabric testing undertaken as part of the mandatory elements of the BPE programme, *plus* any other discretionary elements that have been undertaken. Ensure that information on u-value measurements; thermography, air-tightness, any testing on party wall bypasses and any co-heating tests are covered. Give an overview of the testing process including conditions for the test any deviations in testing methodology and any measures taken to address deficiencies. Confirm whether any deviations highlighted have been rectified. As some tests (particularly the thermographic survey) are essentially qualitative it is important that the interpretation is informed by knowledge of the construction of the elements being looked at. Comment on the use of particular materials or approaches or their combination or installation methods lessons learned. Complete this section with conclusions and recommendations for future projects.

3.1 Air-tightness testing

Stroma was employed to carry out air tightness testing to ATTMA TS1 in the 2 properties taking part in trial. These tests consisted of a sealed (as per Part L1A of the Building Regulations) and unsealed depressurisation test in each property supported with an air leakage survey using a smoke gun. Stroma is an ATTMA certified company and carried out the original SAP surveys and tests on the dwellings when they were in the design and build phase.

The results of the tests are shown below:

Table 2: Air tightness test results 19/06/2012

Flat	**Sealed result @ 50 Pa** $m^3\ h^{-1}\ m^{-2}$	**Unsealed result @ 50 Pa** $m^3\ h^{-1}\ m^{-2}$
A	4.72	4.77
B	7.66	7.70

A second air tightness test was then carried out at the end of the trial period and the results of these are shown below (original test reports included in the appendix).

Table 3: Air tightness test results 11/09/2014

Flat	Sealed result @ 50Pa $m^3 h^{-1} m^{-2}$	Unsealed result @ 50 Pa $m^3 h^{-1} m^{-2}$
A	4.77	4.83
B	7.97	8.12

It is apparent that Flat A fulfils the design specification of 5 $m^3 h^{-1} m^{-2}$; however Flat B is above this target, but still below the lowest acceptable standard as per the current building regulations[1]. In support of this, smoke tests were carried out to identify areas of leakage in each of the dwellings.

Overall, both properties suffered from air leakage at points between the floor and skirting; although mastic sealant was present, it was not always consistent and thus gaps were present. Trickle vents were also identified as a significant area of air permeability which was also identified on the thermal imaging survey. Some of the air vents were ill fitting, also supported by comments from the householders that they are difficult to use as seem 'flimsy'. Finally the toilet and plumbing boxes within the bathrooms in each dwelling were not sealed, thus air could travel through the boxing to either the loft space or external wall cavity.

In Flat B several additional areas of air ingress were identified, which were not present in Flat A, these included:

- Unsealed cable penetrations into dry lining
- Unsealed pipe runs from the loft space into the heated envelope
- Unsealed boxing at base of stairs
- Breaks evident in dry lining at foot of stairs
- Ineffectively sealed loft hatch

These additional areas are likely to cause the higher air permeability seen in pressurisation tests and are also likely to result in an increased heat demand in Flat B than in Flat A (discussed in more detail in section 7.5); although personal preference with regard to internal temperature will also play a part. It is interesting to note that the resident in Flat B also complained of cold drafts from the stairs as part of the walkthrough and this may be

[1] The Building Regulations 2010, L1A Conservation of fuel and power in new dwellings, HM Government, 2013 edition.

explained by the aspects listed above. Photographs taken throughout the properties of the problem areas are shown below.

Figure 11: Photographs of air tightness test work (Stroma Technology)

Leakage at various points within both flats at the junction of skirting and floor. This had been sealed but mastic sealant was not consistent throughout.

Various trickle vents were ill fitting and/or broken causing the ingress of air. In both flats.

Toilet boxing in both flats was left unsealed allowing air ingress from ceiling void and loft space.

Toilet waste boxing unsealed again, in both flats allowing ingress.

Flat B

Cable penetrations into dry-lining unsealed. Flat B in head of stairs cupboard.

Cold water pipe from loft space penetration unsealed. Flat B in head of stairs cupboard.

Unsealed boxing at foot of stairs distribution cupboard.

Foot of dry-lining unsealed at foot of stairs distribution cupboard and breaks in the dry lining at foot of stairs cupboard.

Loft hatches not sealing effectively allow flow of air into property from the cold roof space. Flat B

It is suggested that Connect Housing review these aspects within the affected flat and potentially the other flats within the development if further complaints have been received. The aspects listed could be rectified by a building contractor and should provide an immediate improvement, both to energy consumption and occupant comfort.

3.2 In-situ U-Value Measurements

In support of the SAP assessments, heat flux measurements were carried out in the communal flat to determine in-situ U-Value measurements of the rear (south facing) wall. The test work was carried out by Stroma Technology using Hukseflux Heat Flux plate HFP01 and measurements of local internal and external temperatures. Although not ideal carrying out measurements on a south facing wall, it was confirmed by Stroma that the low-lying winter sun, in combination with shading by trees, the local topography and the fact the test element was on the ground floor, meant a rapid data convergence to allow successful measurement.

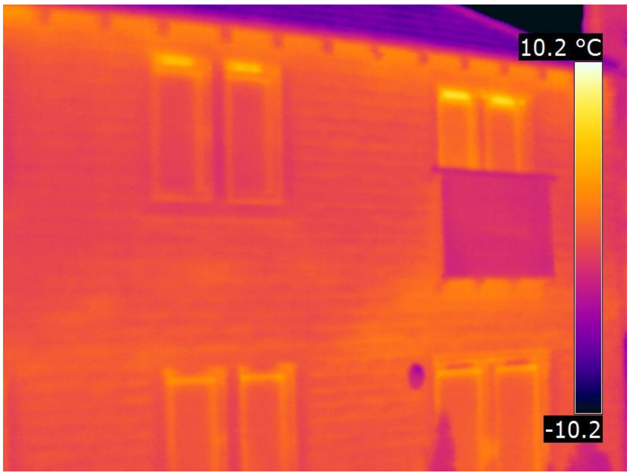
The test work was carried out during February and March 2013 and the results are shown below.

Table 4: U-Value Measurements

Period	U-Value [W/(m2.K)]	Variance %
19/02/2013 to 01/03/2013	0.61	0.8
01/03/2013 to 09/03/2013	0.56	3.7
09/03/2013 to 24/03/2013	0.58	4.5
Average	0.58	4.5

Interestingly the heat flux measurements offer a higher U/value than the SAP assessment and original building construction plans, with a measured average value of 0.58W/m^{2}K in comparison to 0.2W/m^{2}K used in the SAP assessments and building design. When comparing to the thermal imaging carried out on site (discussed later) there is no evidence of significant heat loss in this area or inconsistencies in construction, with the wall area showing very uniform (and low) temperatures (image shown below). This is further supported by the fact that the building is constructed using block with a stone outer leaf which should therefore mean a more uniform build than a timber frame.

Figure 12: Thermal image of tested wall



As a result of very tight budgetary constraints within this project it was not feasible to carry out U-value measurements as would have been considered representative of the development as a whole. Ideally measurements would need to be taken from multiple locations throughout the development, in each of the flats and at numerous locations across the wall area. It is therefore hypothesised that the section of wall tested may have been positioned over a joint in the thermal insulation panels and thus there was the potential for thermal bridging, or the materials used in this section are sub-standard compared to the building design. It is also possible that there are errors in the measurements taken, however with the limited budget available it was not possible to repeat the tests.

It is important to note that heat flux sensing focuses on only a very small area of the fabric, particularly within the confines of this project and therefore it is difficult to extrapolate this to the building as a whole without further investigations.

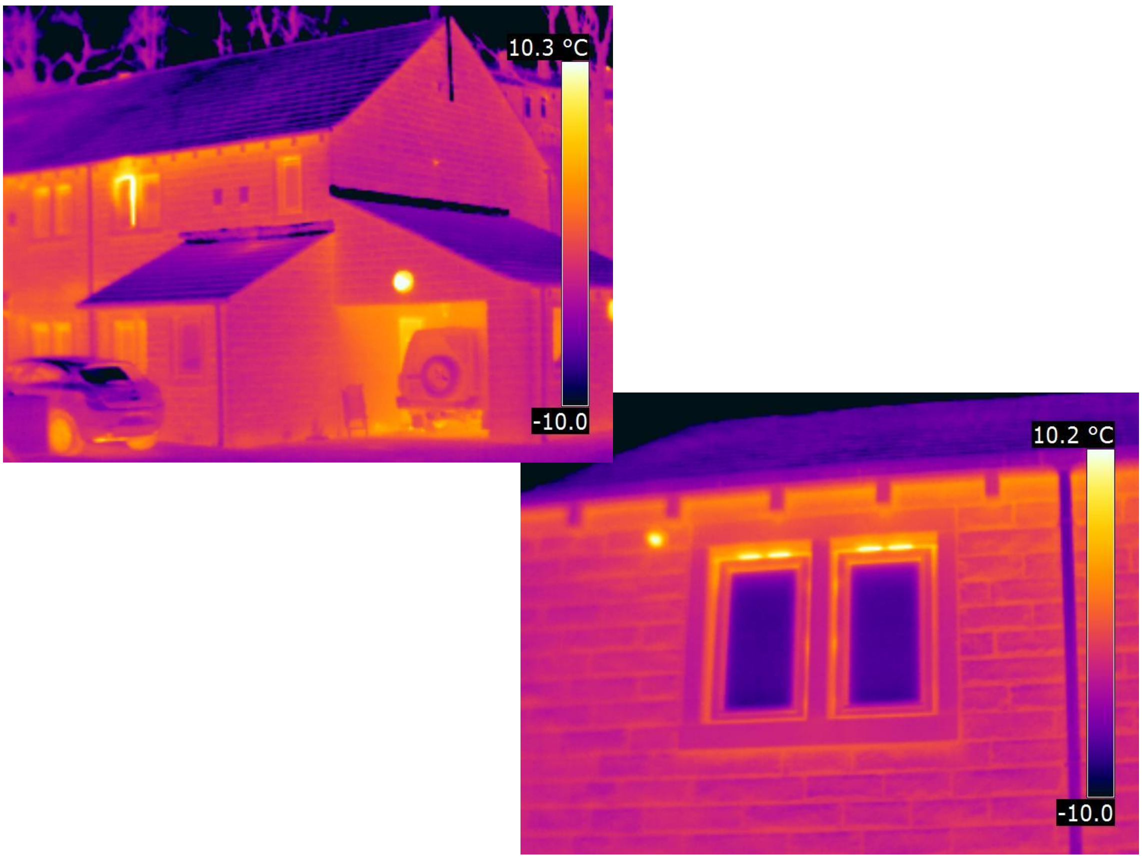
It is also important to stress the need to select good quality materials at design and specification stages within a development, and continue this focus on quality throughout the build process to achieve the design standards proposed by the building architects. This may require additional training within the building industry to ensure high levels of workmanship during the construction phase; as well as further education at design and specification stage, as to how materials perform, and how they can be most suitably applied to the building in development to achieve the best results.

3.3 Thermal Imaging

A thermal imaging survey was carried out as supporting evidence of the construction audit, SAP assessments and collected data. The development was photographed externally and internally in each of the monitored properties (Flat A and B). The whole development was photographed externally to identify areas of particular heat loss or interest. Some internal images were also taken in the communal flat to identify the impact of the plant room on this area. The full thermal imaging report is included in the appendix.

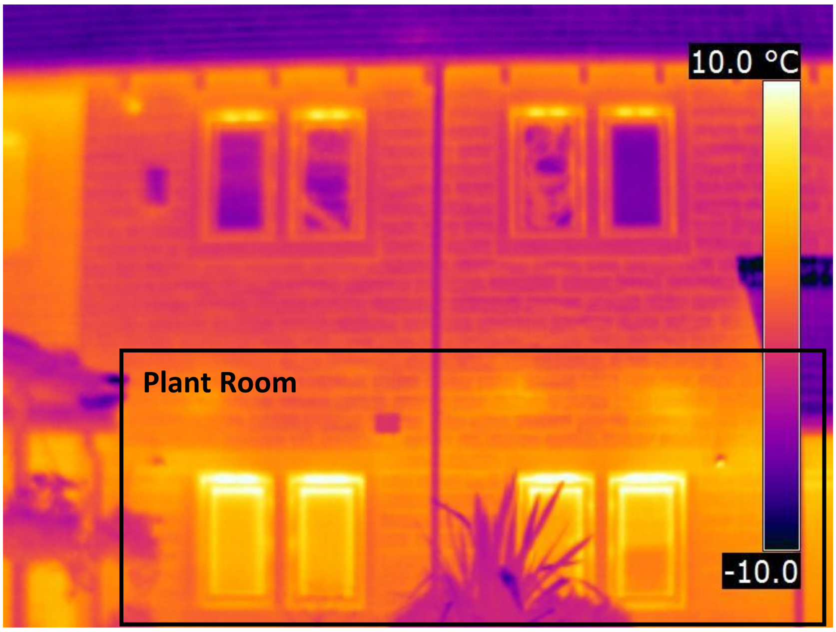
Overall the development showed minimal heat losses through the building fabric; the survey was carried out on a cold November evening with external temperature of 2C and maximum fabric temperatures were less than 10C. The most significant area of heat loss was through the window trickle vents which were easily identified in each property from the thermal images, also visible were the air bricks and roof vents. The structural building boundaries, between wall and roof, wall and ground and between porches, garages and extensions were also areas in which heat losses were evident, although again the level of heat lost was minimal. These structural joints are common areas of thermal bridging where there is a direct route for heat to travel from warmer internal spaces to external air; these are also visible in corners where two walls meet as insulation rarely meets exactly at these joints. In future developments, Connect should discuss with the design and construction contractors how to insulate corners of properties, perhaps looking at structural corner panels or wrapping insulation around corners or structural joints.

Figure 13: External images showing thermal bridging through structural joints and trickle vents



It was possible to identify the plant room from the external thermal images as the building fabric surrounding this was far warmer than the rest of the development. This is likely the result of the very high internal temperatures experienced in the plant room from the large volume of stored hot water and the number of exposed connections, valves and pumps. This high internal temperature was also evident in the communal flat whereby heat transfer from the plant room was clearly identified at the ceiling to wall boundary. It is suggested that the insulation within the plant room is surveyed and any exposed valves and connectors insulated where possible.

Figure 14: Thermal image clearly showing location of plant room



In Flat A, very little cold air ingress was seen, with the walls, ceiling and floor remarkably consistent. Even the joints between different structures e.g. the wall and ceiling, and wall and floor did not show significant alterations in temperature. There were however some areas where temperature gradients were observed, with the most significant around the front door and to a lesser extent around the bedroom window; this could potentially be improved by additional draught proofing around the door. There was also evidence of some thermal bridging on the rear external wall, similar to that seen on the external thermal images where structural joints occurred. This may not be rectifiable in this property without invasive works but as previously mentioned should be an area for discussion in future developments.

Similarly in Flat B temperature gradients were most evident at structural joints, particularly between the wall and ceiling and likely to be as a result of the roof space above the flat. Window frames, window vents and the front door were shown to suffer some cold air ingress; largely where the frame meets the wall. This is a key point in which thermal bridging is noticed and is often the result of the insulation boards not meeting fully at the structural join or an air gap being present between the wall and frame. Again to rectify this would involve invasive works but could be highlighted as an area of focus for future developments. The loft hatch was also identified as suffering cold air ingress and the sealing around the loft hatch was shown to be lacking in the smoke testing and should be investigated by Connect.

It should be noted that the pattern and location of the areas of heat loss are very much what would be predicted in a modern build constructed to Building Regulations of 2010 and are areas that could be improved on by further considering insulation practices suitable for corners and joints.

The thermal imaging in Flat B did enable a faulty thermostat in the spare bedroom to be identified following complaints from the householder, as the underfloor heating was shown to be operational even when the thermostat should have been satisfied. This was later rectified by Connect Housing.

3.4 Conclusions and key findings for this section

Overall the building fabric is shown to be uniform in construction with some heat loss shown through the thermal imaging surveys at particular key points.

The air tightness for Flat A successfully achieves the design air permeability rate. However, Flat B fails to reach the target rate, but still meets the rates required in the current building regulations.

Areas of air ingress and leakage in both flats consisted of:

- Join between floor and skirting; although mastic sealant was present, it was not always consistent and thus gaps were present.
- Trickle vents – also identified on the thermal imaging survey.
- Toilet and plumbing boxes within the bathrooms were not sealed; therefore air could travel through the boxing to either the loft space or external wall cavity.

Additional areas identified in Flat B included:

- Unsealed cable penetrations into dry lining
- Unsealed pipe runs from the loft space into the heated envelope
- Unsealed boxing at base of stairs
- Breaks evident in dry lining at foot of stairs

- Ineffectively sealed loft hatch

All of these aspects can be rectified by building contractors and it is suggested that a further review of the development as a whole is carried out and aspects rectified as found. These issues should also be identified when considering new developments and the building contractors made aware that care is needed to finish these aspects properly to meet the required building regulations and design values.

SAP assessments were carried out and compared to in trial data and this was supported by heat flux measurements within the communal room of the building. These measurements showed a worse U-valve for the wall fabric than predicted, however, because of the very limited nature of this work due to access and substantial budgetary constraints it is not possible to extrapolate this to the development as a whole. Further work would be required in this area to gain a significant enough number of results to provide satisfactory conclusions.

It is clear from the differences between the SAP predicted values and the as lived in figures, that the aspects identified above do have an impact on the energy required within a property. It is understood that SAP has limitations as the ‘human’ influence can be significant, however it provides a reasonable estimation of the energy demands of a dwelling and thus can be successfully compared. It is suggested that an area of focus for designers should be the smaller finishing touches within a property; possibly creating designs that do not require these aspects, or methods to achieve these more successfully without using short term sealing methods which become worn after several years of use.

4 Key findings from the design and delivery team walkthrough

Technology Strategy Board guidance on section requirements:	This section should highlight the BPE team's initial studies into possible causes and effects, which may require further study. The section should reveal the main findings learnt from the walkthrough with the design and delivery team covering the early stage BPE process and the design intentions. Comment on lessons learned, key findings, conclusions and recommendations on what would be done differently next time. A critical feature of this section is reviewing the original aspirations for the project as stated by the design team and comparing with the delivered building. This often goes beyond what is stated in supporting documentation and is a crucial initial discussion which then frames the discussion about what changed during the process and why. The purpose of the walkthrough is to compare design intent with reality and why there is a gap between the two. Explore the degree to which the design intent has been followed through in terms of delivery and subsequent adoption by the occupant(s). Focus on what constraints or problems they had to accept or address in delivering the project. Cover construction team issues and how these were cascaded through the project for example: training for design team on utilising specific technologies and new materials, sequencing of trades. Describe and evaluate the documentation generated to confirm and record the commissioning and hand-over from specialist contractor to house builder. Include in the appendix if necessary. How did this process influence the design and delivery team walkthrough? Can anything be improved? Capture and assess how decisions were made and captured when the team are together e.g. the materials being used and whether they are required or desired – is there the possibility of changing materials and if so it this known by the procurement and constructions teams. Are there any issues relating to the dwelling's operation? This would include: programmers; timing systems and controls; lights; ventilation systems; temperature settings; motorised or manual openings / vents. Do the developer / manufacturer produced user manuals help or hinder the correct use of the dwelling? Have there been any issues relating to maintenance, reliability and reporting of breakdowns of systems within the dwelling? Do breakdowns affect building use and operation? Have issues been logged in a record book or similar? Add further explanatory information if necessary. Explain any other items not covered above that may be relevant to a building performance study. This walkthrough should be compared and contrasted with the occupant walkthrough (see later section) with comments on whether the design intent was desired, delivered and valued by the occupant and where and how differences between intent and expectation have arisen. If action was taken to remedy misunderstandings, improve support or feed occupant preferences into future design cycles this should be explained. Graphs, images and test results could be included in this section where

	it supports a developing view of how well or otherwise the design intent has been delivered during the pre and post completion phases. This section should provide a summary of the initial aftercare process, post completion building operation, and initial maintenance and management – particularly in relation to energy efficiency, reliability, metering strategy, building operation and the approach to maintenance i.e. proactive or reactive. Guidance on walkthroughs is available in the document *TSB BPE Domestic - Guidance on handover and walkthroughs.doc*, which can be downloaded from the Building Performance Evaluation site on `_connect'.

4.1 Design and delivery team walkthrough ï topics covered

The aim of the design and delivery team interview was to review the 'as built' development in terms of the initial design and construction. Focusing on whether the aims and objectives for the development were met and any issues, including cost issues that have arisen in the process. The design and delivery team walkthrough was carried out at the onset of the trial and covered the following aspects:

Dwelling operation and usage patterns

- Issues relating to the operation of the building and dwellings e.g. programmers/timers/controls, ventilation, heating system, lights
- Do developer/manufacturer produced user manual help or hinder the correct use of the dwelling?

Maintenance

- Issues relating to maintenance, reliability and reporting of breakdowns of systems within the development
- Does the occupant have easy access to a help service?
- Do breakdowns affect building use and operation?
- Have issues been logged in a record book or similar?
- Does the occupant have any particular issues with lighting within the dwelling (both artificial and natural)?

Energy and water management

- Does the energy consumption meet the original expectations? If not, why not? What were the original expectations based on?
- Does the water consumption meet the original expectations? If not, why not? What were the original expectations based on?
- What was the SAP used for and did the team encounter any issues surrounding the use of SAP in flats?
- Are there any other issues which affect the energy and/or water consumption of the development?
- Was the whole heating system i.e. heat pumps, under-floor, boreholes all designed by the same person or a team or several people/teams?
- How were the heat pumps sized for the development and who carried out the heat loss calculations?
- Were there any changes to the design of the district heating system during the development phases and if so, why?

Other points

- It is understood there is an issue with a lack of natural light due to dense trees surrounding the south of the development – have there been any recent developments regarding this and the discussions with the council?
- Was the project delivered on time and on budget? If not, why not?

What would be done differently next time

- Comments on what would be done differently next time and why.

4.2 Design and delivery team responses

Three members of the design and delivery team were present at the site to discuss the topics listed in Section 4.1. They are:

- Architect
- Site Manager
- M&E contractor

The project at Ancion Court was a design and build contract so any variations to the project were discussed within the team as and when they arose. No major problems were encountered during the completion of the project and it was delivered on time. The most significant change was the alteration of the central laundry to a centralised plant room. This happened during the design stage and thus caused no issues with the construction of the building.

Dwelling operation and usage patterns

The total water consumption for each flat was estimated using the CIBSE design guides.

Maintenance

There were some comments from the residents regarding the trees at the back of the site and the amount of shading which has been experienced, especially in the ground floor flats. Connect Housing are in discussions with the local council about thinning the trees so as more natural light can enter the flats. No other maintenance issues have been raised so far.

Energy and water management

The original heat loss calculations were carried out by Allcad using the original SAP calculations. Allcad were given responsibility to oversee the installation and commissioning of the whole heating and hot water system.

The heating system was completed by various experts in their fields including Hepworth who supplied the under-floor heating. They used the heat loss calculations and a supply temperature of 40ºC to size the under-floor heating loops in each flat.

Although the team were familiar with the use of under-floor heating prior to this project, they had not worked with heat pumps before. This was not considered to be an issue during the development stage, although more space was required for the plant than was originally anticipated. This was resolved through conversations with Connect Housing who had originally proposed a laundry room in the communal flat. However, this was not deemed to be of any benefit to the residents considering they are mostly retired people who would want the convenience of a washing machine within their own flat. Therefore the space which had been allocated for the laundry was used for the plant room. This is within the main development and is accessed from inside the communal flat.

Some residents have commented that the flats farthest away from the plant room are experiencing lower DHW temperatures; this is part of an ongoing investigation and as yet has not been resolved.

The only issue with the heating system (now that the residents have become used to under-floor heating compared to radiators) is the controls. There is a separate time and temperature controller for each zone/room within each flat. The controllers are difficult to use due to a combination dial/button and the screen is very small. Connect Housing have since investigated replacement controls with input from the residents.

Other points

The choice of heating system was discussed with Connect Housing during the design phase. Various options were discussed including wind, solar and biomass.

Solar was discounted because there is a large amount of shading over the development due to trees around the South of the building. These trees cannot be removed because they are in a conservation area and some have Tree Preservation Orders (TPOs) on them.

Wind was discounted because the location of the site within a steep valley is not a suitable site for wind.

Biomass was also considered but would have required maintenance on a daily basis and Connect Housing did not have the resources to employ a member of maintenance staff on a full-time basis. The delivery and storage of fuel was also taken into consideration as the site is in a rural location, situated in a steep valley. This would made deliveries difficult and potentially unreliable, as fuel sources would have been remote to the site. The site is fairly constrained by the trees to the South and a Listed Building (church) so there was little additional space in which a fuel store could have been located.

The decision therefore was taken to use heat pumps as the method of providing heating and hot water to the development. Individual air source heat pumps were considered first but the view was taken by Connect Housing and the architect that it would be more difficult to obtain planning permission for air source heat pumps as they would have been visible on the outside of each individual flat. Therefore it was decided to use ground source heat pumps (with boreholes) combined with under-floor heating on a district heating scheme in order to provide heating and hot water to each flat. Comment from Connect that this decision was made by the heating engineers and was offered to Connect as a package. Very little interaction was had with Connect regarding the choice of equipment as at that point there was not the experience within Connect Housing to question the designs further. Following the experience at Ancion Court, there is a far better understanding of heat pump systems and if this process was repeated far more questions would be asked in the initial stages.

Ordinarily the construction team (used to building to code 3) would consider installing individual gas boilers with a solar thermal system. If they were to install a district heating heat pump system in another development they would investigate using solar PV to lower the carbon emissions from the electricity use of the heat pumps (discussed later). The ventilation mechanism (mechanical extract fans in the bathroom and kitchen) was also different to normal practices as the team would normally use cooker hoods in the kitchen as the means of ventilation. However, because the kitchens at Ancion Court do not have fitted cookers, Connect Housing requested that no cooker hoods be installed. This gave the residents the freedom to install their own appliances.

The design team stated that the assessor from Stroma who was working with them to ensure they met the Code for Sustainable Homes (CfSH) Level 4, was very helpful and guided them through various processes. This was the first time this particular design team had worked on a CfSH Level 4 development; ordinarily working on code 3, and expressed a view that they do not think the extra finance required to meet Level 4 is necessarily good value for money.

What would be done differently next time?

If the team were to repeat this project they would not make any major changes.

4.3 User Guide Review

A review was carried out on the Home User Guide to assess the effectiveness of the document in the hand-over process and the full review is included in the appendices of this document. In summary, the original user guide was large and repetitive in places, but contained very useful information in relation to local services and general housekeeping within the development e.g. rubbish collection. Some of the heating service descriptions were also informative. One of the main suggestions was to re-order the document and include one or two page quick start guides to various aspects, particularly the heating system. These could be supported by larger instruction manuals if there are specific problems.

For future schemes the Home User Guide will be simplified and reordered as far as resources allow. Connect would like to supplement the guide with clear pictorial operating instructions alongside equipment and controls, similar to the Ranulph Road Passivhaus scheme, designed by Alan Clarke and bere:architects[2]; however, as yet the resources have not been available to do this.

4.4 Evaluation of handover process

An evaluation of the handover process was carried out by members of the Connect Housing team including:

- Lettings & Leasehold Manager
- Senior Customer & Service Improvement Officer
- Chief Executive

A full review of the process is included in the appendix but in summary the following points were raised.

The home user guide was considered large and complex and clear concise operating instructions with annotated photos for specific pieces of equipment would be far more helpful to the residents.

Emphasis is needed in educating the residents about the heat pump and the heating controls within the properties; particularly the need to leave the controls as set (according to temperature preference) for the day and night settings.

From the experiences at Ancion Court, Connect are suggesting that the advice to householders should be to use additional heaters as required to 'top up' the heating in the property and leave the heating controls as set.

The heating is to be set at handover, with the residents provided with a phone number for contact if they experience problems with the heating controls or operation. This phone number must be for the correct member of staff as the system is complex and needs a specialist heating contractor.

Connect wish to use the handover as an opportunity to explain energy ratings within the development and the use of energy efficient lighting and appliances. Although equipment

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[2] **http://www.bere.co.uk/sites/default/files/blog_attachments/User%20guide%20for%20Ranulf%20road%20londons%20first%20passivhaus%20passive%20house.pdf**.

and lighting are the tenants responsibility it is thought important to provide information on the best options available.

Connect also wish to explain the importance of other aspects within the development such as window trickle vents, how to utilise natural light and how high levels of insulation coupled with the heat pump system installed will mean that the most energy and cost effective way to live in the flats is different to a standard boiler and radiator heating system.

The initial handover will be followed up with subsequent visits to reinforce the messages provided at initial handover and offer further assistance to problems such as difficulties with heating controls.

4.5 Conclusions and key findings for this section

The design and development team stated that no major changes to the construction and build process would be carried out if this process was to be repeated.

There were obviously requirements on the design and delivery team to integrate new low carbon technologies into the development of this property to meet the required standard; however, due to the location and space constraints the suitable options were limited.

However it is suggested that following feedback from the residents and the experiences had by Connect Housing that there would be changes made if the site were to be constructed again.

Certainly the thermostats and time controls specified for the heating within the flats will be replaced and different controls specified in future builds. The user guide will be replaced and the handover process simplified compared to the current procedures.

5 Occupant surveys using standardised housing questionnaire (BUS) and other occupant evaluation

Technology Strategy Board guidance on section requirements:	This section should reveal the main findings learnt from the early stage BPE process and in particular from the Building Use Survey. This section should be cross-referenced with findings from the occupant handover process and be informed by the design and delivery team walkthroughs. This section should draw on the BPE team's initial studies into possible causes and effects, which may require further study. BUS information will be stored in the data repository, but the link for BUS anonymised results should be included in this report. The BUS results come in 3 forms: • An anonymous web-link that will contain the result and benchmark graphic for each variable (question), a summary of the 12 main variables and some calculated summary variables. • Appendix A (.pdf) which contains largely the same set of results and graphics as the link above. • Appendix B (.pdf) which contains all the text comments from the questionnaires Reference the variable percentile scores, which show the percentile that the score is ranked at in the benchmark set, and comment on as appropriate. **Important:** The comments from Appendix B can be used in this section. However, great care must be taken when using comments to ensure that no personal information is divulged, no individual can be identified and no confidentiality is breached when publishing the comments. This is especially important if referring to a respondents' background. Graphs, images and test results could be included in this section where it supports a developing view of how well or otherwise the design intent has been delivered during the pre and post completion phases. Note where the dwelling is being used as intended and where it is not; what they like / dislike about the home; what is easy or awkward; what they worry about. It should cover which aspects provide occupant satisfaction and which do not meet their needs, result in frustration and / or compensating behaviour on the part of occupants. Any misunderstandings occupants have about the operation of their home should also be addressed. Are there any issues relating to the dwelling's operation? This would include: programmers; timing systems and controls; lights; ventilation systems; temperature settings; motorised or manual openings / vents. Do the developer / manufacturer produced user manuals help or hinder the correct use of the dwelling? Have there been any issues relating to maintenance, reliability and breakdowns of systems within the dwelling? Do breakdowns affect building use and operation? Does the occupant have easy access to a help service? Does the occupant log issues in a record book or similar? Does the occupant have any particular issues with lighting within the dwelling (both artificial lighting and natural day lighting)? Add further explanatory information if necessary From the occupiers point of view what improvements could be made to the dwelling to make it more user friendly and confortable to live in. Cover what the teams' would do differently in future (or wanted to do differently but could not) and why.

Occupant evaluation at Ancion Court was carried out using three main investigatory tools; these were:

- A Building Use Study (BUS)
- Occupant Interviews and walkthroughs
- Energy Day

These are discussed in detail below.

5.1 BUS Questionnaire

A Building Use Study (BUS) was carried out as part of this project during the first year of the trial, in July 2012 approximately 12 months after the residents first moved into the development. All of the properties in the development were approached and all willingly completed the Survey, meaning a 100% success rate and a very comprehensive overview of Ancion Court (Reports included in the appendix).

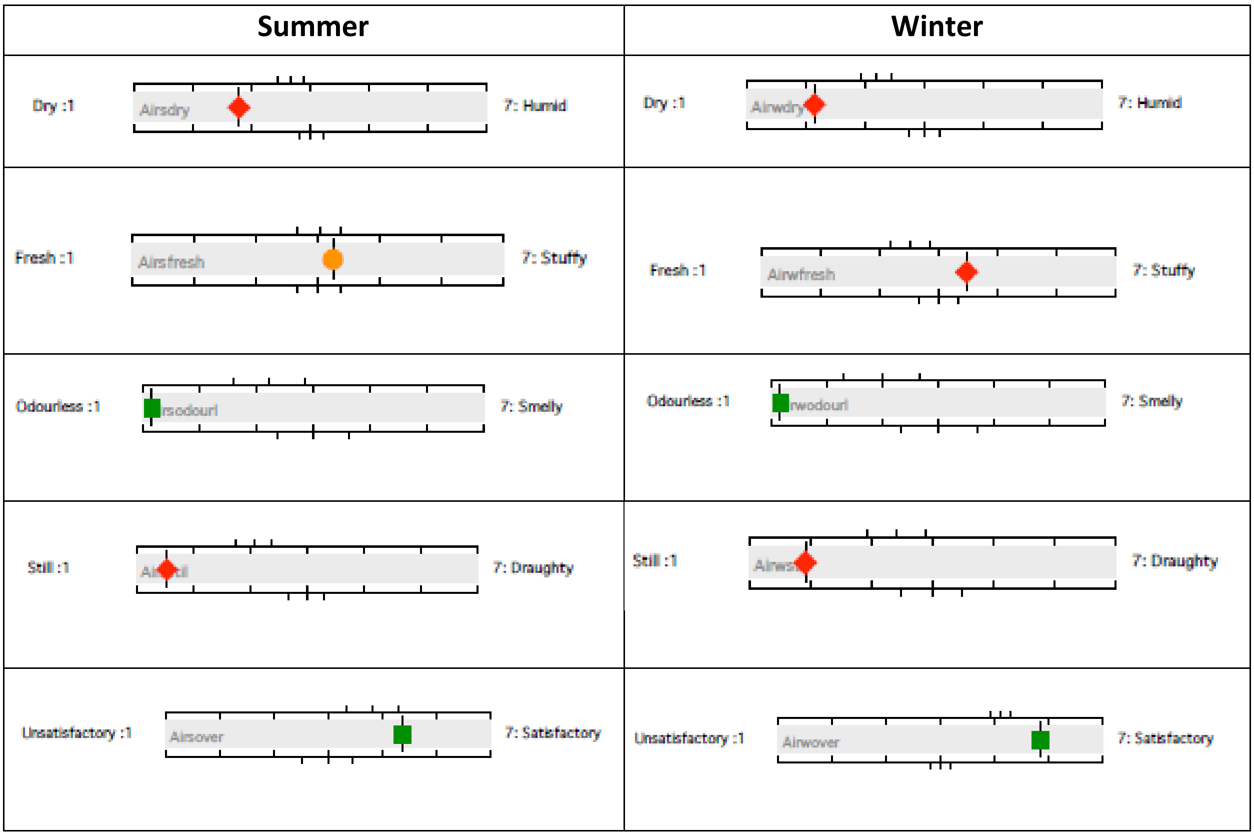
The BUS results are compared to UK 2011 BUS housing benchmarks and scale limits which show how this development compares to others. The colours relate to whether the aspect is good (green), bad (red) or average (yellow) and can apply if the results are above or below the upper or lower limits shown. As an example; if a better than average air quality is observed then the result may be shown above the upper limit but also coloured green as it has a positive impact on the residents.

The survey is split into five main sections, each of which was considered for the winter and summer months:

- Air Quality,
- Controllability,
- Design Aspects,
- User Needs,
- User Feedback

Overall the air quality was considered satisfactory in both summer and winter. The air was thought to be odourless, but also dry and still which has both positive and negative connotations to the comfort of the residents. Few of the residents complained of cold draughts; however several did comment that the air was stuffy and they needed fans to create air movement during hot summer months. There was also comment that the air was dry during both summer and winter months. The air tightness of the dwellings measured 4.72 and 7.66m^3/h/m^2 for Flats A and B respectively and suggests that air movement within the flats is limited and thus this supports the feedback from residents. This is commendable when considering energy use particularly the need for space heating and control of internal temperature. All of the flats have trickle vents in the windows and many of the residents left windows open to create a through flow of air. Overall, few of the residents had any significant complaints apart from the stuffy and dry air conditions.

Figure 15: Air Quality



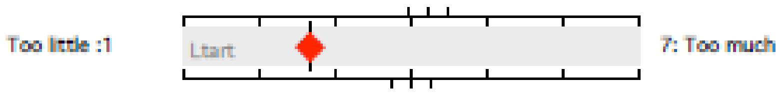
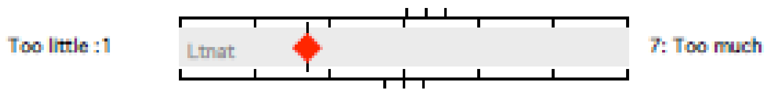
Control of heating, lighting (both natural and artificial) and cooling within the properties were by far the most criticised aspects of the development by all of the residents and this has been an area of focus for Connect Housing, particularly when considering heating controls and shading issues externally.

Approximately 60% of the residents thought they had full control when considering cooling of the properties, although some did complain that bedrooms were too warm. Some have added artificial fans to their homes to circulate air and enhance the cooling.

In contrast only 30% of the residents thought that they had full control of their heating system, with comments suggesting the controls are difficult to use and the system is unresponsive. In many cases this is likely to be the result of the resident moving from a radiator heating system to an underfloor system and this was confirmed by many of the residents through discussions at the Energy Day and general interaction with residents at the site. Radiator systems operate at far higher temperatures and are much quicker to respond than the low temperature slow response underfloor equivalents. It is suggested that educating new residents more with regards to the differences between radiator and underfloor systems would be very beneficial in combating this problem in future developments. Connect Housing have also addressed the control issue in a very proactive manner via an Energy Day (as discussed in section 5.2) allowing residents to input views about alteration of the controls currently installed. It does seem apparent that in properties in which the resident does not ‘fiddle’ with the controls a far higher level of satisfaction was achieved.

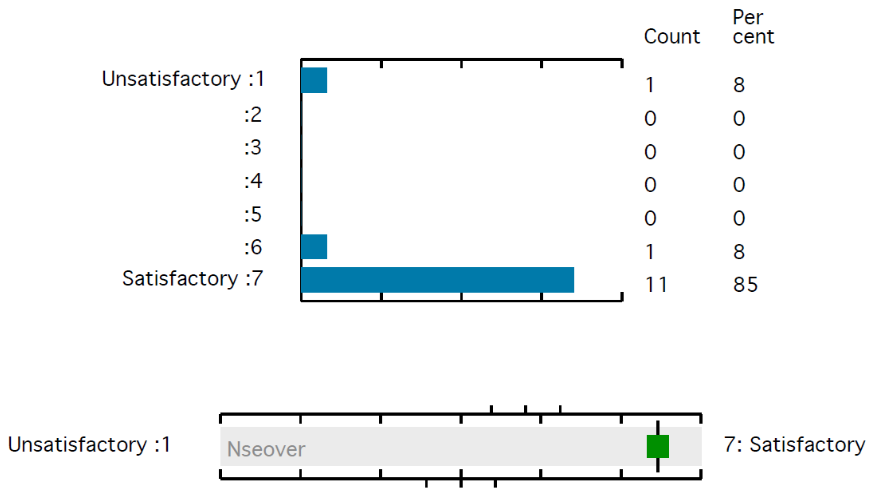
Natural daylight levels in much of the Ancion Court are low particularly in flats on the ground floor towards the rear of the development which are largely overshadowed by trees. Some residents stated that artificial lighting is required all day and that the standard light fittings have had to be added to with lamps to ensure enough light is provided. A way to rectify this issue may be for the installed lighting to be replaced with LED lights which create a much brighter light but are very low energy. This may reduce the number of lights and additional lamps required in the flats.

Figure 16: Natural and artificial light levels

Lighting – artificial	
Lighting – natural	

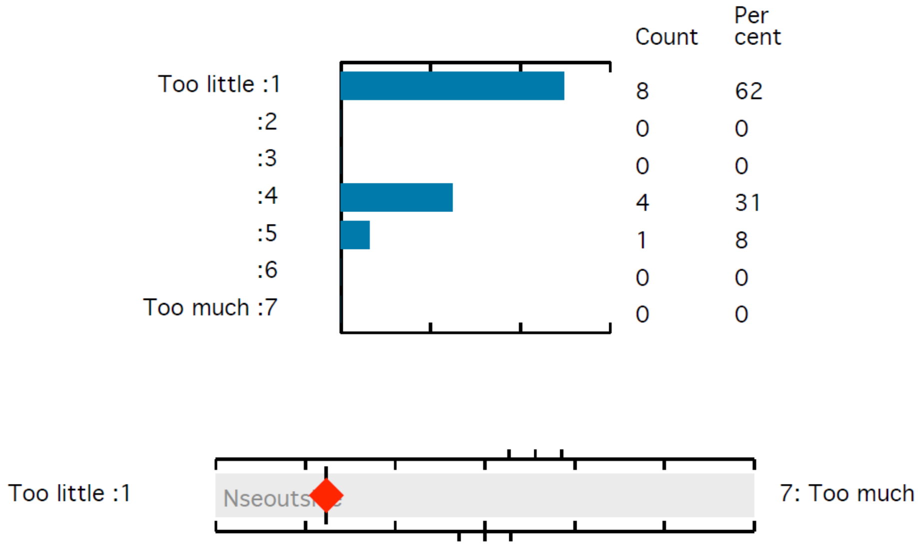
Similarly the level of noise within the properties is divided depending on location of the flat in relationship to the plant room and road. The plant room is under automated control and runs continuously; therefore those flats adjacent and above the plant room suffer from noise problems; with the flat above the plant room suffering the most, as shown in the image below. Overall however, noise levels were considered satisfactory.

Figure 17: Overall noise



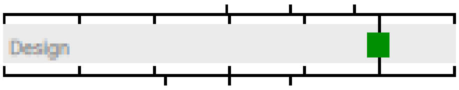
In contrast other residents on the front of the building away from the road and plant room say that there is very little noise, with some suggesting it is too quiet.

Figure 18: Noise from outside



It is interesting to note however, that even with the difficulties regarding the heating system and lighting, all of the residents are happy in their properties suggesting a high level of forgiveness or tolerance as a result of the outweighing positive aspects of Ancion Court. All residents rate Ancion Court highly with regard location, community spirit and ease of living. Many say that the flat access within the flats and to surrounding village is very beneficial and that being within walking distance to the village of Marsden is hugely important. Many say they feel their health has improved and are very happy in their homes. Overall the user needs are met with a high level of satisfaction.

Figure 19: Overall satisfaction

Overall satisfaction	Unsatisfactory :1  7: Satisfactory

It was originally considered a requirement of the BPE project that BUS analysis was carried out twice during the project. However, Connect Housing were keen to carry out a more focused study on the issue of heating controls which were by far the most verbally criticised aspect of the development. As a result, the budget available for the second BUS was instead used for a focused Energy Day discussed below.

5.2 Energy Day

During June 2013, Connect Housing held an Energy Day within the communal flat at Ancion Court to discuss various aspects of energy within the development. The day was open to all residents as a drop in session and members of Connect Housing Energy Team and Kiwa were present to answer any questions about the trial or energy use in general. Advice was offered on switching energy suppliers and eligibility for Warm Homes Discounts. Explanations were also provided on the operation of the heat pumps and how the heating and hot water is provided to the properties. A large poster and various smaller flyers were provided to offer residents take-home information regarding the system; these are included in the appendix.

As well as providing information, a main focus of the day was to trial a selection of heating thermostats and controllers. Five different models were available from various manufacturers and the residents were encouraged to examine each one and score them based on user preferences. The results of these were then reviewed by Connect Housing.

By far the most important aspect identified by the householders was ease of use and clarity of display. Many users did not like ‘flimsy’ covers on the units, suggesting these would quickly fall off; small timing pins were also not favoured. Large, simple to use displays with clear instructions were important aspects with users.

Connect have agreed to change all the heating controls at Ancion Court to the model chosen by the tenants during the energy day. This will be carried out in each property with agreement from the resident and is scheduled to take place as soon as possible.

The selected controller has already been specified as the standard controller (where required) for all new and replacement heating systems in the Connect housing stock and future developments.

5.3 Occupant Interviews & Walkthroughs

The tenants in two monitored flats were interviewed during the trial and a walkthrough carried out to discuss various aspects of living at Ancion Court. Both tenants were very happy with their homes although some aspects were raised that supported the results of the BUS and previous discussions between the residents association and Connect Housing.

Both tenants were happy with the induction process, although both commented that the home user guide was too big and very rarely used. The first complaint was that the heating controls were difficult to use and that a lack of control was felt with regard how hot the property was and when the heating was operational. Both stated that they were used to quick response radiator systems and that moving to underfloor heating was challenging at first. There were also comments that drying clothes was more difficult in these properties as radiators used to be used to hang wet washing.

Space was discussed in the bedrooms in both properties with comments that the plugs and aerial sockets limited where the furniture could be placed. There was also comment that the kitchens were smaller than those previously occupied by the tenants and that a lot of items had been disposed of when moving in to these properties. In addition to disposing of items it was suggested that the deep cupboards may not be suitable for elderly people who may struggle to reach the back of high cupboards without steps/ladders. Overall storage was considered satisfactory.

Cleanliness in the properties was considered good and easy to maintain. Similarly noise was not considered a problem. There was comment that due to the location in the corner the resident in Flat A sometimes felt a bit isolated due to the fact there are no front facing windows. This means that unless the resident goes out during the day there are no passers-by. Similarly the resident in Flat B who lives in an elevated position, enjoys the fact that she can see the other residents and at the same time check that people are ok if they have not been around for a few days.

Both considered access to be excellent with comment that the stairs in Flat B were wide and easy to manage. Also the flat access to the surrounding area was commended. The only comment was regarding the sap dripping from the neighbouring trees which made the flagstone slippery. This was addressed by Connect Housing after the occupant interviews and is now cleaned regularly.

Trickle vents and overall ventilation were areas of concern, with residents suggesting the trickle vents were flimsy and difficult to access. Ventilation was limited with some residents adding fans to aid air movement throughout the property.

The only other aspect which was given a negative comment was the level of light in the properties. Although Flat B said that daylight levels were good. Artificial lighting was a disappointment and needed to be brighter. This was supported by Flat A which suffers from poor natural and artificial lighting levels.

The results of the BUS suggest that the residents are on the whole satisfied with the cost of running their properties. Many thought that more electricity is required in this development because more artificial lighting is required. However some also commented that the properties are now smaller than previous dwellings and thus require fewer light fittings and less heating. Some were concerned that the heating is now on all the time compared to the old systems in previous dwellings, however some also suggested that secondary heating is now not required as the ambient temperature is warmer.

5.4 Potential Improvements

Based on the results of the BUS, occupant interviews and Energy Day the following outline the potential improvements that could be carried out within this development and/or considered for future developments to avoid some of the issues encountered at Ancion Court. Although some will not be immediate, some are 'quick fixes' which should see direct improvements.

Change the current low energy lighting to LED spotlighting; particularly in the communal areas and flats in which overshadowing by trees causes a significant problem with natural light levels.

Consider kitchen storage when dealing with older individuals; deep cupboards in which items have to be stacked, may not be suitable if movement or lifting is difficult. A better solution may be hanging rails for pots and pans or a combination of shallow draws and cupboards.

In properties in which ventilation is minimal it is important that windows can open in a manner that maintains security to allow air movement for the occupants. Particularly in areas such as kitchens and bathrooms where ventilation is required the windows should be easily accessible, have multiple fixing points for opening, and vents easy to reach. A main complaint from the walkthroughs is that kitchen windows and vents are inaccessible as they are behind the sink, and bathrooms lack any form of natural ventilation. For future developments it is important that vent locations are considered, perhaps with vents located on the side of high windows. It may also be possible to remove windows over sinks, however, this is not advisable as many consider it pleasant to be able to look outside whilst working in the kitchen, indeed several residents commented that they like to look out and see other people moving around the development as it gives a sense of security and community.

Review room layout, particularly the bedroom layout to ensure some flexibility is available. Both monitored flats commented that the current rooms do not allow bedroom furniture to be arranged in any way other than the current layout due to sockets and areal locations.

Replace heating controls within the properties (currently a combined timer and thermostat) and provide easy instructions at point of use to aid residents understanding.

6 Installation and commissioning checks of services and systems, services performance checks and evaluation

Technology Strategy Board guidance on section requirements:	Provide a review of the building energy related systems, including renewables, regulated and unregulated energy and additional energy users that fall in to different areas (such as pumps for grey water use) and any results found. This section should enable the reader to understand the basic approach to conditioning spaces, ventilation strategies, basic explanation of control systems, lighting, metering, special systems etc. Avoid detailed explanations of systems and their precise routines etc., which will be captured elsewhere. The review of these systems is central to understanding why the building consumes energy, how often and when. Where possible this commentary should be split into the relevant system types. Explain what commissioning was carried out, what problems were discovered and how these were addressed. Discuss as to whether the initial installation and commissioning was found to be correct and any remedial actions taken. Prompt for any training scheme or qualifications that were found to be required as part of the study. Comment on whether the original operational strategy for lighting, heating/cooling, ventilation, and domestic hot water has been achieved. Compare original specification with equipment installed, referring to SAP calculations if appropriate. Give an explanation and rationale for the selection and sizing (specification) of system elements. Use this section to discuss the itemised list of services and equipment given in the associated Excel document titled *TSB BPE_characteristics data capture form_v6.xls*. For each system comment on the quality of the installation of the system and its relation to other building elements (e.g. installation of MVHR has necessitated removal of insulation in some areas of roof). Describe the commissioning process Describe any deviation from expected operational characteristics and whether the relevant guidance (Approved Documents, MCS etc.) was followed. Explanation of deviations to any expected process must be commented in this section. An explanation of remedial actions, if any, must also be given. Describe the operational settings for the systems and how these are set. Comment on lessons learned, conclusions and recommendations for future homes covering design/selection, commissioning and set up of systems. Also consider future maintenance, upgrade and repair – ease, skills required, etc. The document for capturing commissioning information is titled *TSB BPE_Domestic_commissioning sheets.doc*, which can be downloaded from `_connect'.

Commissioning at Ancion Court was limited with very little information available from Connect regarding the commissioning process. It was unsure who from Connect was present during the initial handover, but it was commented that the maintenance team were not.

Overall, Connect Housing state that no real handover happened beyond the installer providing the instructions for the heat pumps, and no formal training or education took place. The absence of a formal handover resulted in poor operation of the heat pump system; this is discussed further below. Connect have learnt considerably from this process and are actively altering their commissioning procedures to include education of all parties.

Although overall tenant satisfaction within the development is high, there have been ongoing problems with several aspects of the scheme relating to the heating and hot water system which are still in the process of being resolved. These have included low COP of the Ground Source Heat Pumps (GSHPs), repeated faults in the system, continuous problems in hot water supply to one flat, heating controls that are difficult to operate, and high electricity bills.

Through the post-occupancy monitoring of this project and the investigations of a specialist heating engineer it is believed that the problems are a result of, and have been compounded by, a number of factors. These are discussed below.

6.1 Design and Installation

This scheme was designed as a code 4 development which requires significant consideration of energy saving measures and low carbon technology. Ground source heat pumps were installed as a result, however comment from Connect Housing suggests that there was no clear design strategy for the scheme. Although GSHPs were selected in preference to other renewable energy sources, it is not clear whether the costs and benefits of this system were compared with a conventional gas-fired system before they were commissioned. This is definitely something that should be reviewed by Connect and considered for future developments particularly when considering technologies that are unfamiliar.

Subsequent investigations into the heating system post installation by members of Connect customer service team and sub-contractors outside of this project consider the system to be unnecessarily complicated. Connect have stated that they consider the system to be installed with highly complex controls, valves, and back-up systems. They also consider some elements of the system not necessary, such as the remote programmers for the pumps, and suggest that these should not have been installed at the outset.

Feedback from residents to Connect have identified that the heating controls within the properties are poorly designed, fiddly to use and not suited to the heating system installed. As previously discussed these have been considered in detail with measures taken to resolve these difficulties.

It is the opinion of Connect Housing that there was little consideration of the suitability of the system for the proposed occupants. The development is designed for older individuals moving from traditional properties using conventional heating systems; these systems are known to give flexibility and control over the amount of heat delivered, the time of this delivery and the subsequent cost. Traditional radiator heating systems with a boiler respond quickly and can operate on an almost immediate demand and supply regime. Heat pumps coupled with underfloor heating do not operate in this manner and therefore residents should be educated as to the most effective way to utilise and benefit from the system. This should have formed part of the handover and induction process into the property; particularly important when dealing with elderly individuals. It is suggested that the differences in operation and performance of the heat pump system were not fully understood by Connect Housing and thus not disseminated fully to the occupants. This is understandable when operating a different technology but should be considered for future developments. This may mean Connect housing carry out a more thorough handover process with the heating contractors on site before and after the design and commissioning process thus ensuring a full understanding of the system and its operation before installation.

In support of this, is the comment from Connect Housing that the level of specialist knowledge required to design and install this system was underestimated. A design and build contract may not have been the best model for using technology new to the contractor and end users.

Since installation there have been several problems with the system which have included replacement of one of the heat pumps, replacement of two cylinders and several zone valves; there have also been leaks in the system. In addition there was no inhibitor added to the system during commissioning which has subsequently resulted in a build-up of ‘sludge’ in the underfloor pipework.

6.2 Commissioning and Maintenance

The commissioning and handover procedure to Connect Housing has been challenging with difficulties experienced with regard controls and general ongoing operation, particularly when system faults have occurred. As discussed above there was no formal handover carried out beyond the installer providing the operating instructions to Connect Housing and the maintenance team.

It was also identified that training for the maintenance contractors was not adequate for the complexity of the system; with the maintenance team having little or no knowledge of heat pumps. The lack of diagrams and clear labelling has also hampered subsequent attempts to remedy faults when they have occurred. The level of specialist maintenance required was underestimated from the outset, resulting in delays in repairing faults, inconvenience for occupants and potentially more serious problems.

It has been summarised that a 'soft landings' approach to the handover would have saved many of the later problems encountered. This approach aims to ensure the transition from construction to occupation is as successful as possible and that operational performance is optimised. The soft landings framework is a joint initiative between BSRIA (Building Services Research and Information Association) and UBT (Usable Buildings Trust) and encompasses all stages of the design, construction, commissioning and operation process. It includes 5 key stages[3]:

- Inception & briefing – ensures the clients' needs and requirements are defined
- Design development & review – reviews comparable projects and assesses project proposals in relation to building use and management
- Pre-handover – Ensures operators properly understand the installed system before occupation
- Initial aftercare – Appointing an individual or team of people to receive feedback from users, make minor adjustments to the system and ensure proper operation
- Extended after care and post occupancy – Continuing issues and reviews are evaluated and fed-back for future projects.

It is suggested that this type of approach is considered and implemented for future developments, using the lessons learnt from Ancion Court.

The hand over to occupants within the development has been directly impacted by the hand-over process experienced by Connect Housing and the lack of information and knowledge regarding the heat pump system installed. It has been identified that clearer operating instructions to occupants at the outset would have greatly helped, in addition to a simplified Home User Guide. The handover process to new occupants needs to be improved to reflect experience to date.

[3] http://www.designingbuildings.co.uk/wiki/Soft_landings

7 Monitoring methods and findings

Technology Strategy Board guidance on section requirements:	This section provides a summary breakdown of where the energy is being consumed, based around the first 6 months of metering results and other test results. Where possible, provide a simple breakdown of all major energy uses/producers (such as renewables) and the predicted CO_2 emissions. Explain how finding are affected by the building design, construction and use. This section should provide a review of any initial discoveries in initial performance in-use (e.g. after fine-tuning). If early stage interventions or adjustments were made post handover, these should be explained here and any savings (or increases) highlighted. Does the energy and water consumption of the dwelling meet the original expectations? If not, explain any ideas you have on how it can be improved. Are there any unusual design features that have not been accounted for previously (e.g. grey water recycling pumps). Summarise with conclusions and key findings.

7.1 Monitoring Procedure

Data was collected from numerous meters and data logging sensors throughout the development for 2 years. Two properties and the plant room were monitored in depth with data collected from various transmitters at 5 minute intervals for the duration of the programme.

The following shows the monitored aspects, first in the properties, secondly in the plant room.

Properties:

- Internal ambient temperature and humidity in:
  - Kitchen
  - Lounge
  - Bedroom
  - Hallway
- CO_2 in Lounge
- Electricity to:
  - Shower
  - Cooker
  - Lighting
  - Ring main/sockets
  - Whole House
- Central Heating

- Whole house water
- CH & DHW flow and return temperatures

Plant Room:

- External ambient temperature
- Internal temperature
- Electricity to:
    - Heat pump 1
    - Heat pump 2
    - Immersion heaters 1 to 5
    - Back up boiler
- Heat to DHW
- Heat from heat pump 1
- Heat from heat pump 2
- Flow and return water temperatures (DHW & Central Heating)
- Ground loop temperatures

The following shows a simple schematic of the monitoring configuration in the plant room.

Figure 20: Plant room schematic

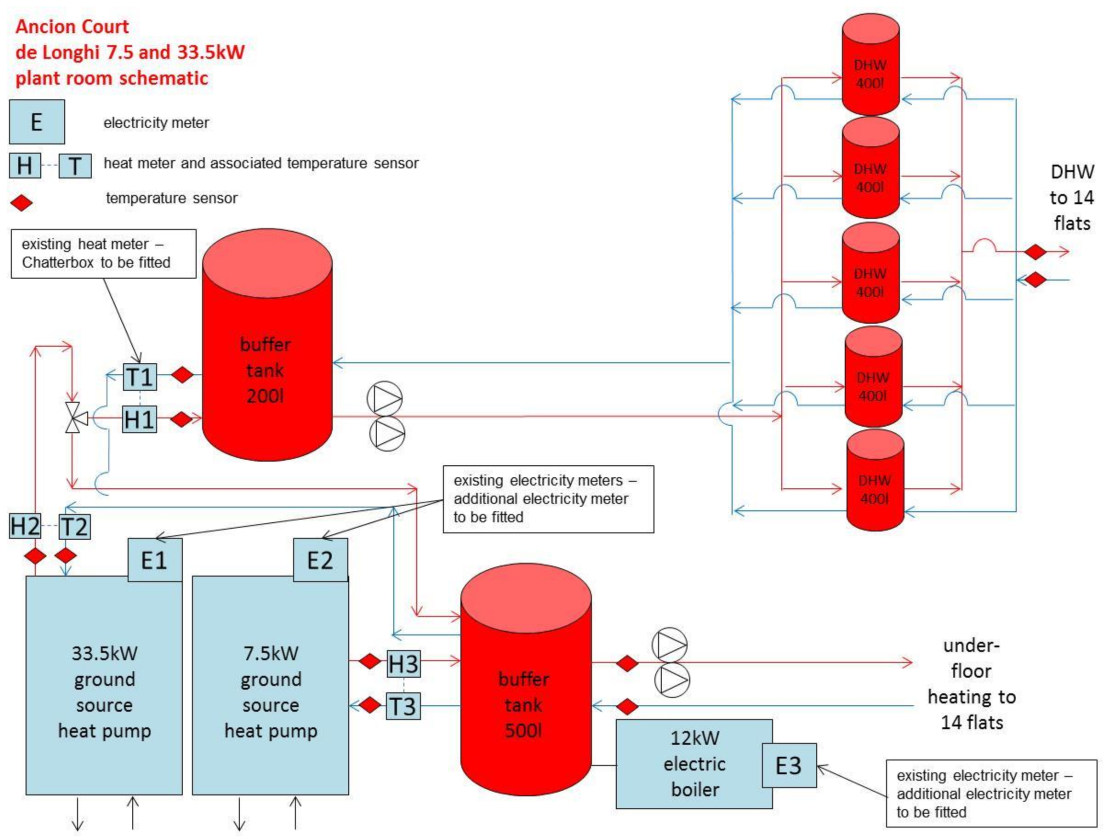
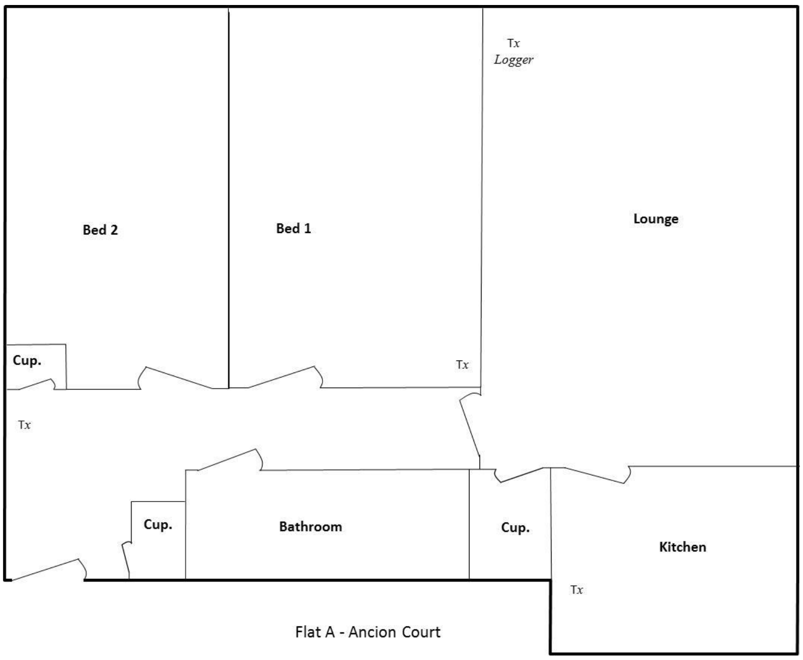
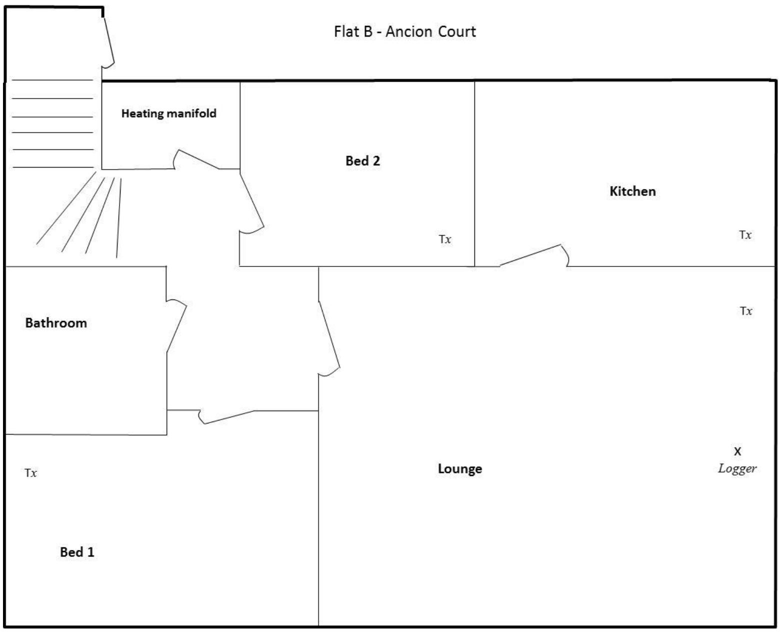


Figure 21: Property lay out showing temperature sensor (Tx) and data logger (Logger)





The monitoring system was a wireless configuration with stand-alone transmitters sending data to a central data logger without any hard wiring; thus ensuring minimal disruption to the resident. The raw collected data was downloaded from the data loggers on a weekly basis where it was then transferred to a database. The data was processed using a serious of automated and manual processes to form daily and monthly summaries. At each download the data was checked for erroneous data pulses or readings. Single erroneous pulses were removed and if any data looked suspect this was then further investigated. Each data channel was cross checked using theoretical calculations to ensure the collected data was in line with expected values. The following sections outline the collected results.

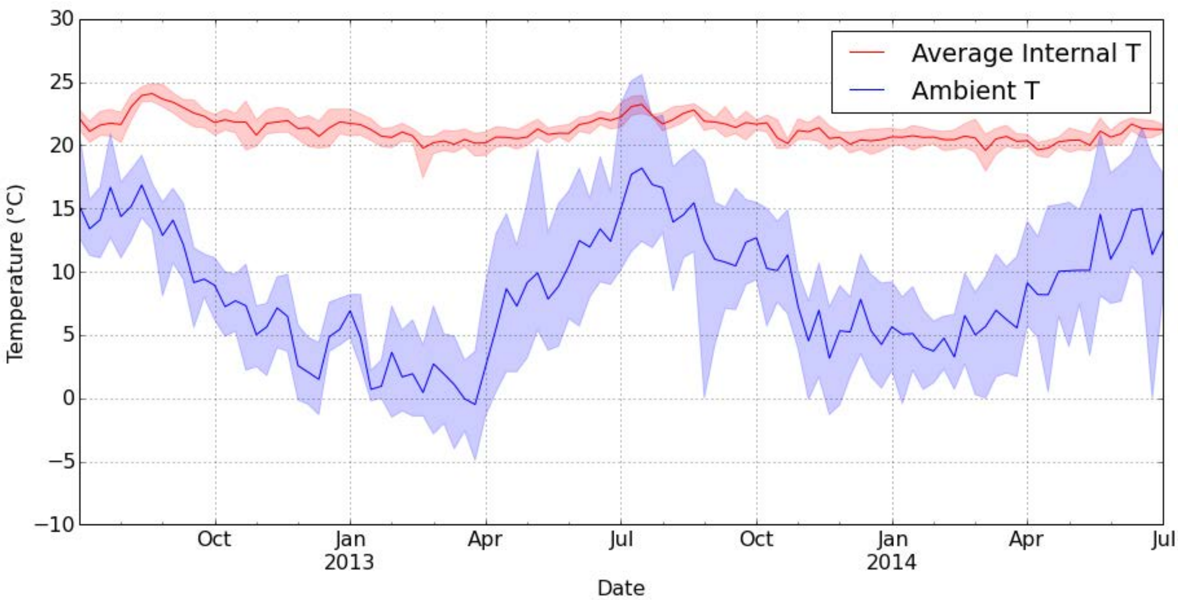
7.2 Internal Conditions

The internal conditions of two properties were monitored for two years and remained remarkably consistent. The following sections detail the various monitored aspects of the flats.

7.2.1 Temperature

Average internal temperatures vary by only 3°C throughout the trial. The following figures show the internal temperatures of the monitored flats. The shaded area shows the 5 to 95% percentiles of the average internal temperatures of the property on a weekly basis throughout the duration of the trial.

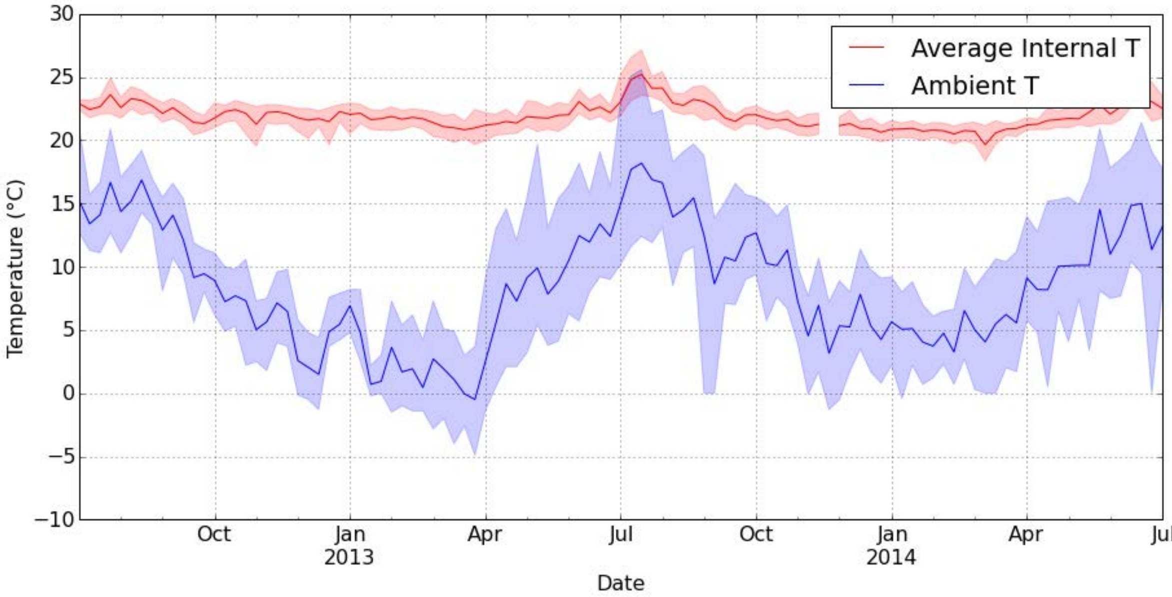
Figure 22: Flat A average internal temperature



Although external temperature (as depicted by the blue line) varies throughout the year, the internal temperature is very consistent with only minor temperature increases during the summer months when the highest external temperatures were observed. This supports the suggestion that the building is well insulated and does not suffer under or overheating.

The same was then plotted for Flat B as shown below.

Figure 23: Flat B average internal temperature



Again the internal temperature is very consistent with only minor temperature increases during the summer months when the highest external temperatures were observed. These are more marked than in Flat A, which is likely to be the result of the fact that Flat B is on the first floor on the end of the development, whereas Flat A is on the ground floor in a corner position. This means Flat B is far more influenced by solar gains than Flat A which is largely overshadowed by the other properties and the trees to the rear of the development.

Flat B did complain of cold draughts from the entrance hall and comment from Connect is that this was a common complaint for all upstairs flats with the front door at the base of the stairs. These areas are not heated by the underfloor system and the problem was resolved using electric heaters supplied by Connect Housing. This is further discussed in section 7.3.

The average internal temperatures for the properties are shown in the table below for the monitoring period.

Table 5: Internal Temperatures

	Year 1	Year 2	Average
Flat A	21.4	21.0	21.2
Flat B	22.1	21.9	22.0

These levels are very acceptable for the tenure of the residents within the development and although warmer than predicted in the SAP calculations offer support that the building is well insulated and internal temperatures are well controlled.

7.2.2 Relative Humidity

Relative humidity was measured for the duration of the trial at the same locations as the internal temperatures. The humidity of the air impacts the comfort of occupants, with high levels of humidity increasing the temperature felt by the occupants, whereas low levels of humidity creating a cooling effect. The comfort range for humidity is wide, although 50 to 60% is considered favourable. In addition to comfort levels experienced by occupants, humidity can have a profound effect on the building fabric. If temperatures and humidity are high then problems with mould and damp can occur, particularly in areas where ventilation rates are low. In contrast if humidity is low but temperatures are high then materials can shrink; this can be especially apparent in new build developments where the building fabric cracks after completion.

The following figures show the RH of the two monitored properties. There are variations between the rooms in Flat A, particularly the kitchen and lounge. For safety reasons (visited by lots of grandchildren) the resident in this flat requested the temperature and humidity sensor in the lounge was boxed in. Although discouraged this was carried out by request by Connect Housing. As a result the humidity recorded from this sensor may not be a true representation of the lounge environment and may explain the lower readings from this sensor.

In the kitchen, RH is affected by the activities carried out in the kitchen space, particularly cooking and in the case of Flat A the use of a tumble drier. The resident in this Flat did comment that when it’s dull outside, the flat does feel damp. Indeed in autumn months humidity reaches approximately 70%, which coincides with increased use of the tumble drier as it is difficult to hang washing outside. However, this perception of feeling damp could also be exacerbated by a combination of low lighting levels, underfloor heating instead of radiator heating (where the surface can be hot to touch as thus makes the occupant feel warmer) and the significant over shadowing of the trees.

In comparison Flat B does not contain a tumble drier and is also located in an elevated position far less overshadowed by trees. In this flat humidity levels remain consistent and within a comfortable range.

Figure 24: Relative humidity Flat A

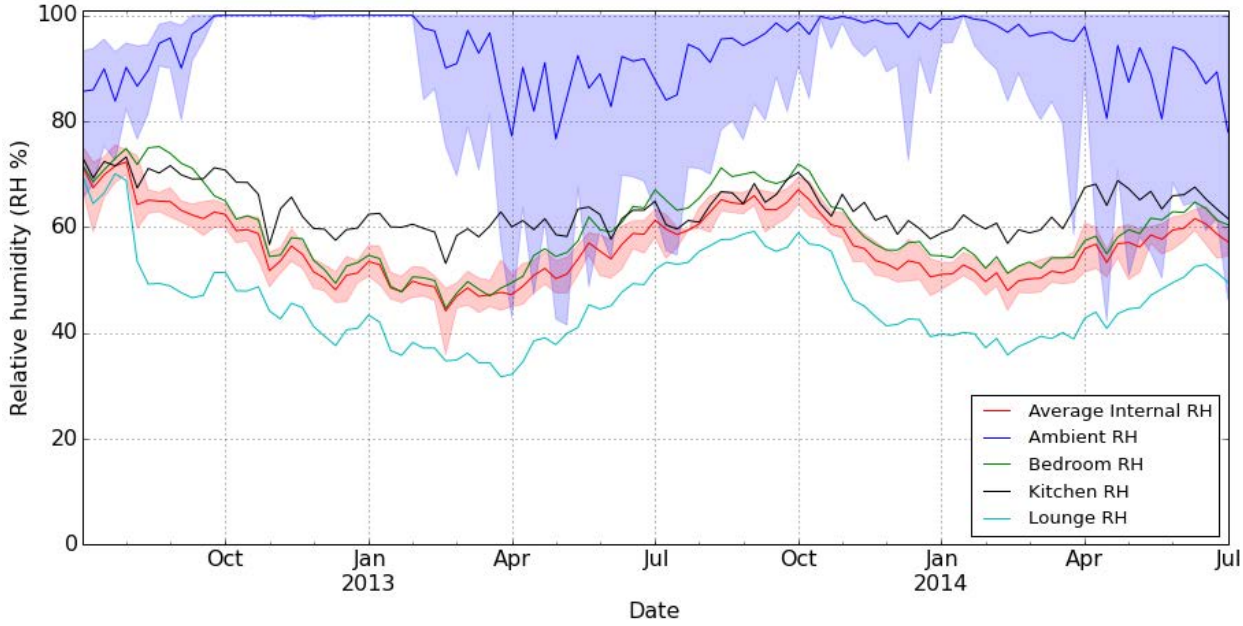
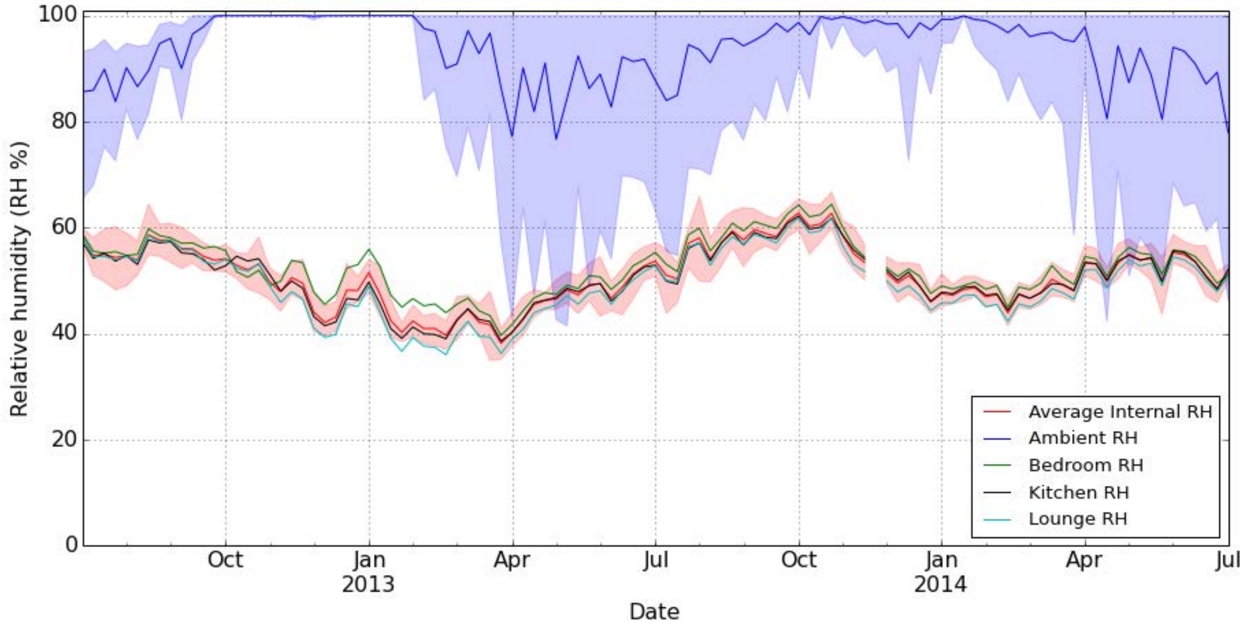


Figure 25: Relative humidity Flat B



7.2.3 Carbon Dioxide

Carbon dioxide (CO_2) accumulation is usually directly related to the number of occupants present within the property and is likely to be higher in areas of limited ventilation. CO_2 levels range from 300 to 1000ppm in a standard home and a rarely cause any significant issues. If too high a concentration is observed then this can lead to headaches, dizziness, increase in heart rate and breathing difficulties, although this is very rare in a domestic setting. The following is offered by Kane[4] as the effects of varying levels of CO_2 within rooms.

250-350ppm	Normal background concentration in outdoor ambient air
350-1,000ppm	Concentrations typical of occupied indoor spaces with good air exchange
1,000-2,000ppm	Complaints of drowsiness and poor air.
2,000-5,000 ppm	Headaches, sleepiness and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present.
5,000	Workplace exposure limit (as 8-hour TWA) in most jurisdictions.
>40,000 ppm	Exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma, even death.

The following figures show the concentration of CO2 observed in the two properties. Both are well within the expected limits although both are higher than the concentrations observed in air. This may relate to the limited levels of ventilation within the properties.

[4] https://www.kane.co.uk/knowledge-centre/what-are-safe-levels-of-co-and-co2-in-rooms

Figure 26: Flat A CO2 concentrations

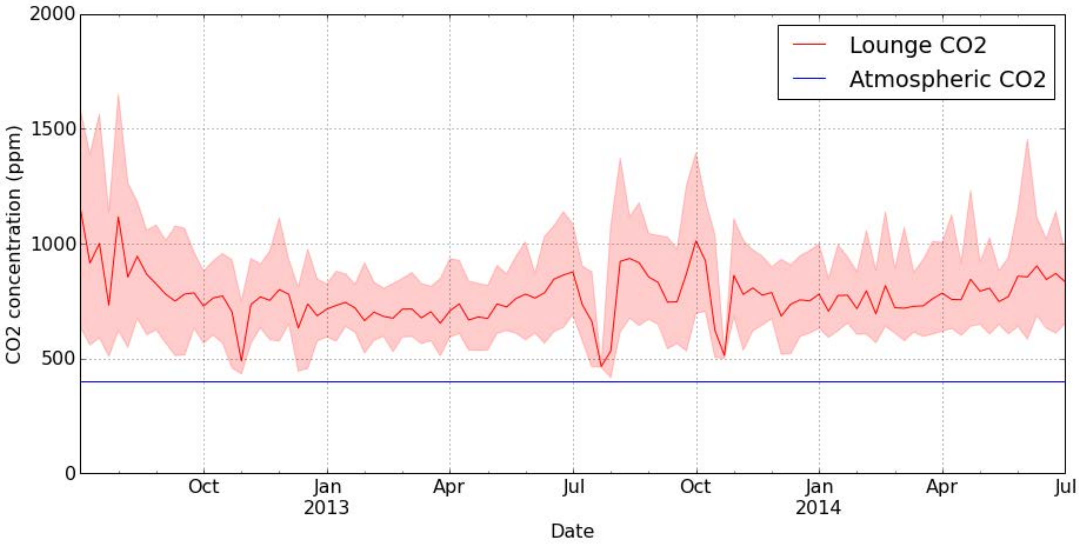
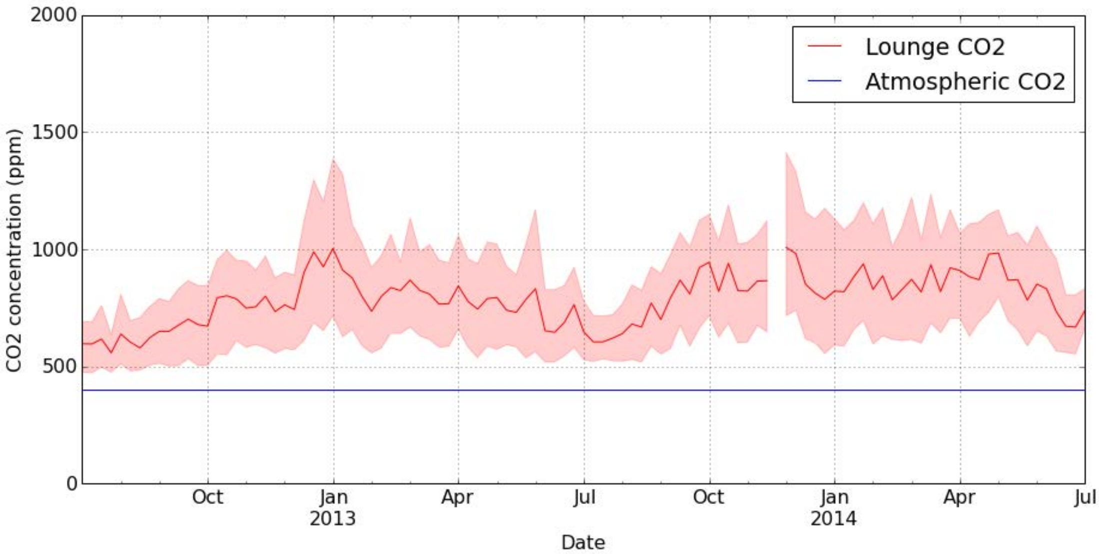


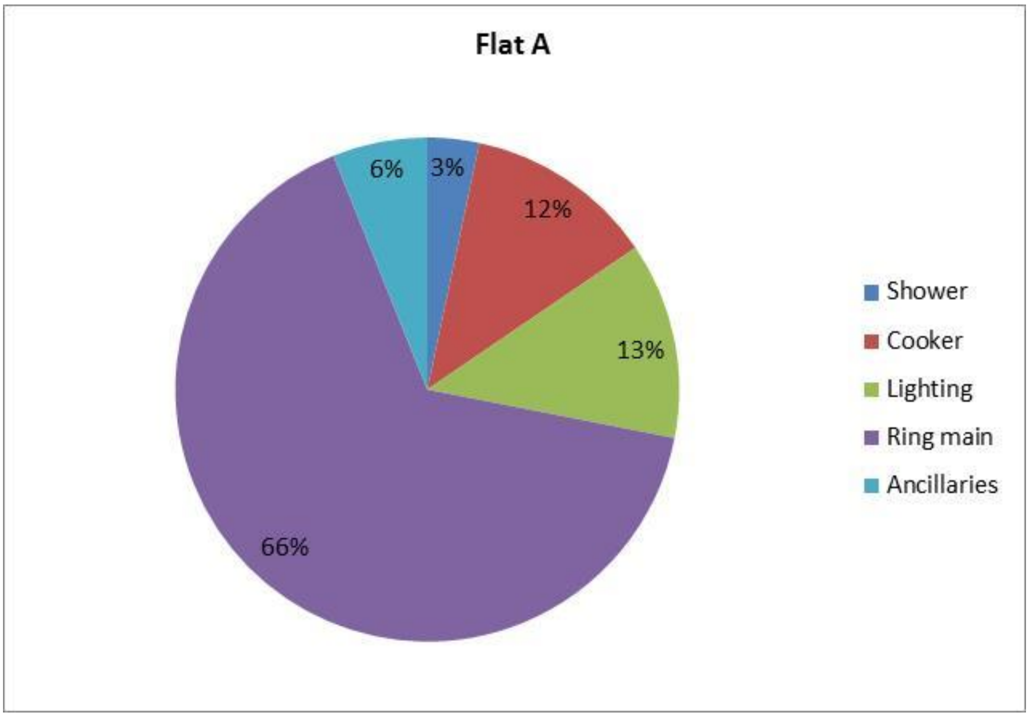
Figure 27: Flat B CO2 concentrations



7.3 Electricity use in monitored properties

Each of the electricity circuits in the monitored flats was sub-metered and the distribution of electricity use is shown for the two properties below. In both, by far the highest aspect was the ring main, feeding the sockets within the property. The following graphs show the distribution of electricity by percentage for the trial period which is then broken down by month to show seasonal variations.

Figure 28: Electricity use throughout the trial by %



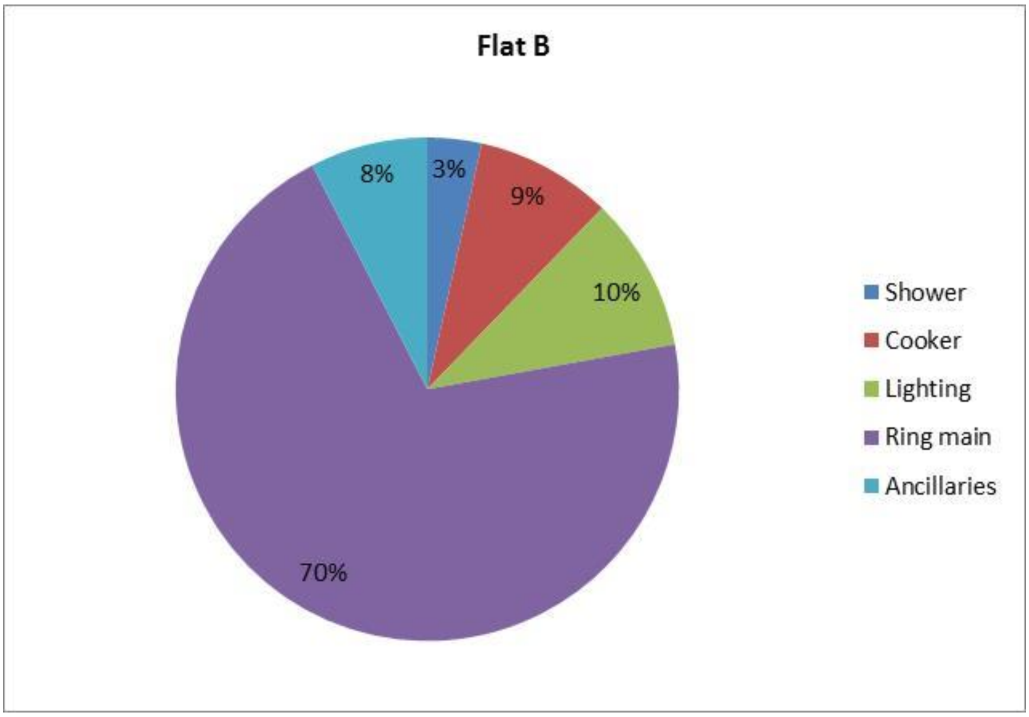


Figure 29: Flat A Electricity use

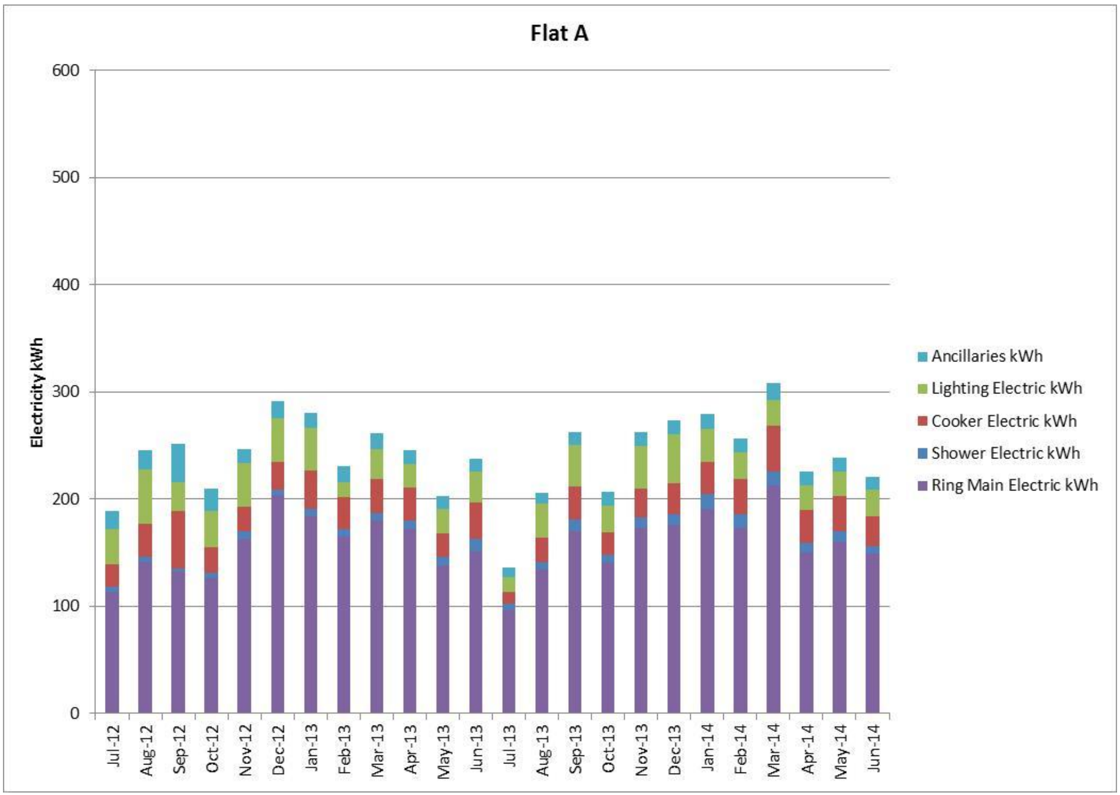
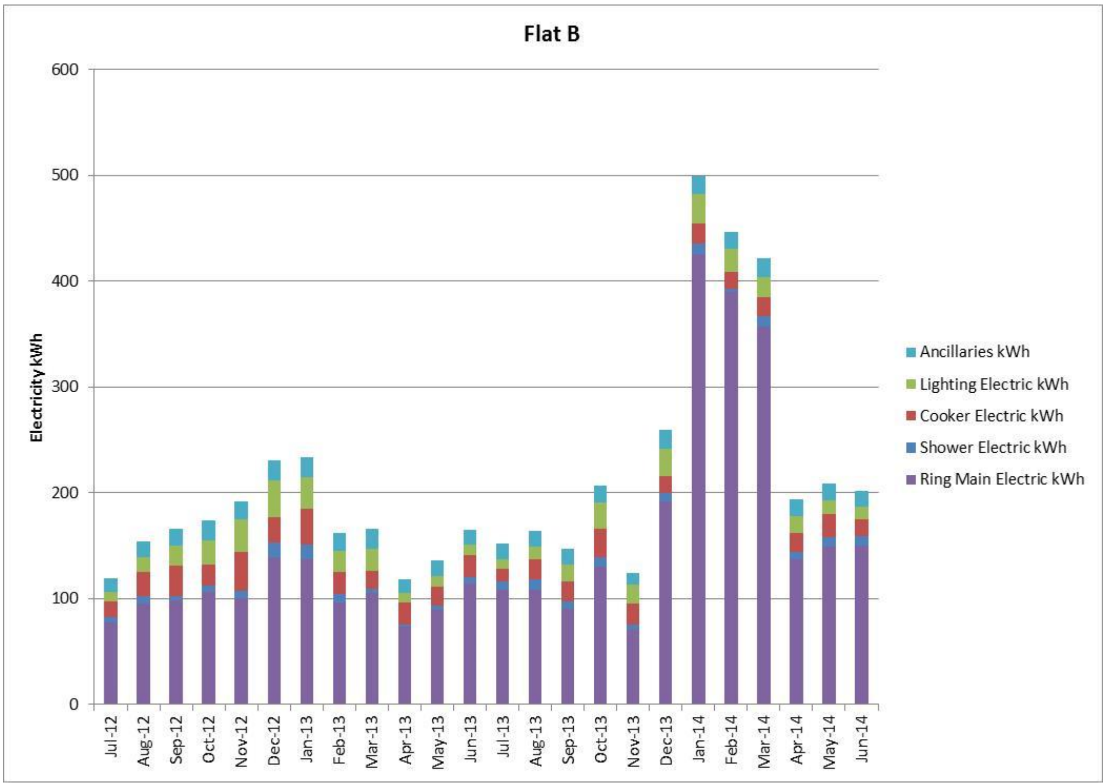


Figure 30: Flat B Electricity use



The following table shows the distribution by percentage to the different aspects within the flats on an annual basis.

Table 6: Electricity distribution by %

	Shower	Cooker	Lighting	Ring Main	Ancillaries	Total
Flat A 2012/2013	3%	12%	13%	65%	7%	100%
Flat A 2013/2014	4%	12%	12%	67%	5%	100%
Flat B 2012/2013	4%	13%	11%	62%	10%	100%
Flat B 2013/2014	3%	7%	7%	77%	6%	100%

On average 66% and 69% of the total electricity for flats A and B respectively is used on the ring main; followed by lighting and cooking with comparable values. In general Flat A uses more electricity than flat B which is likely the result of additional lighting required in this property and the fact there are two residents living here in comparison to one in Flat B. Flat A also has more electrical 'gadgets' than Flat B, used by a younger occupant who is home for a large proportion of the time; this is likely to impact on the consumption seen. Overall electricity consumption in both flats remains consistent for the majority of the metered circuits, with only minor seasonal variations shown for lighting (fixed lighting) and cooking.

The ring main shows much greater seasonal variations, likely the result of increased use of 'stand-alone' lighting and general electrical equipment such as TVs during colder winter months. Certainly the resident in Flat A made a comment that additional lighting has been introduced due to poor fixed lighting levels, the lighting in this property is kept on throughout the year. Both flats also use electric blankets during the winter months.

Also notable is the significant increase in electricity use in Flat B during January, February and March 2014, with a corresponding peak in March 2014 in Flat A. To investigate this further, ring main consumption was then compared to degree day requirements to assess if there was a correlation with external temperature and increased use.

The individual circuits and the degree day plot are shown below.

Figure 31: Flat A electricity by circuit

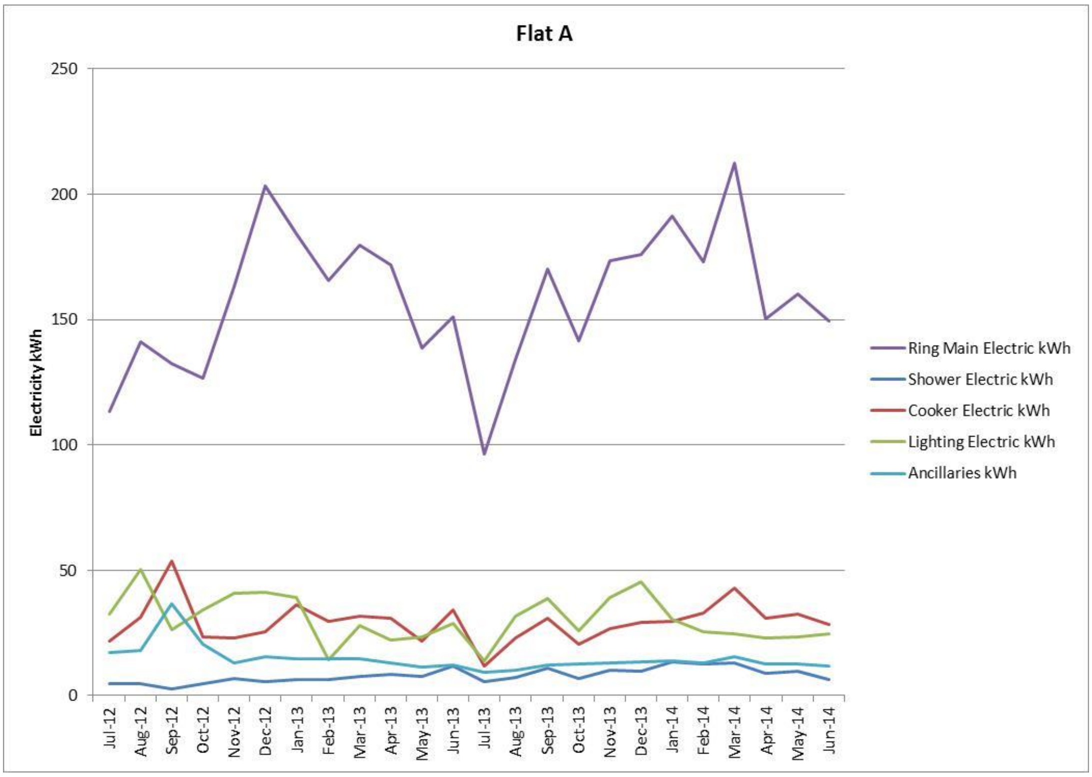


Figure 32: Flat B electricity by circuit

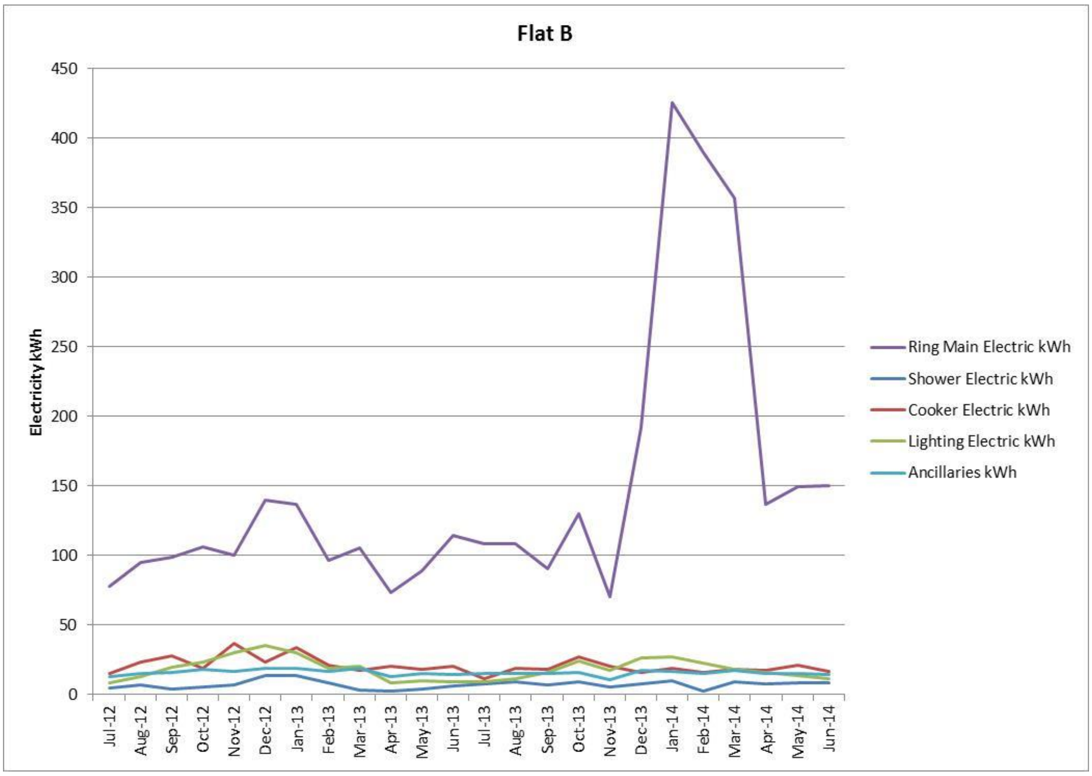


Figure 33: Ring main electricity use and degree days – Flat A

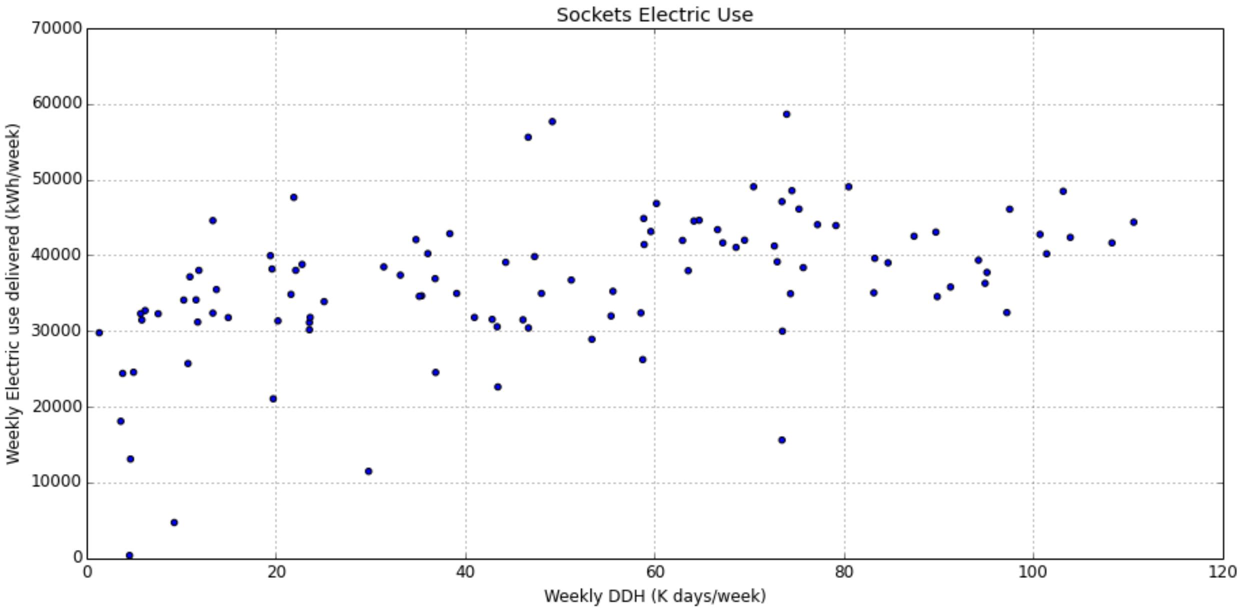
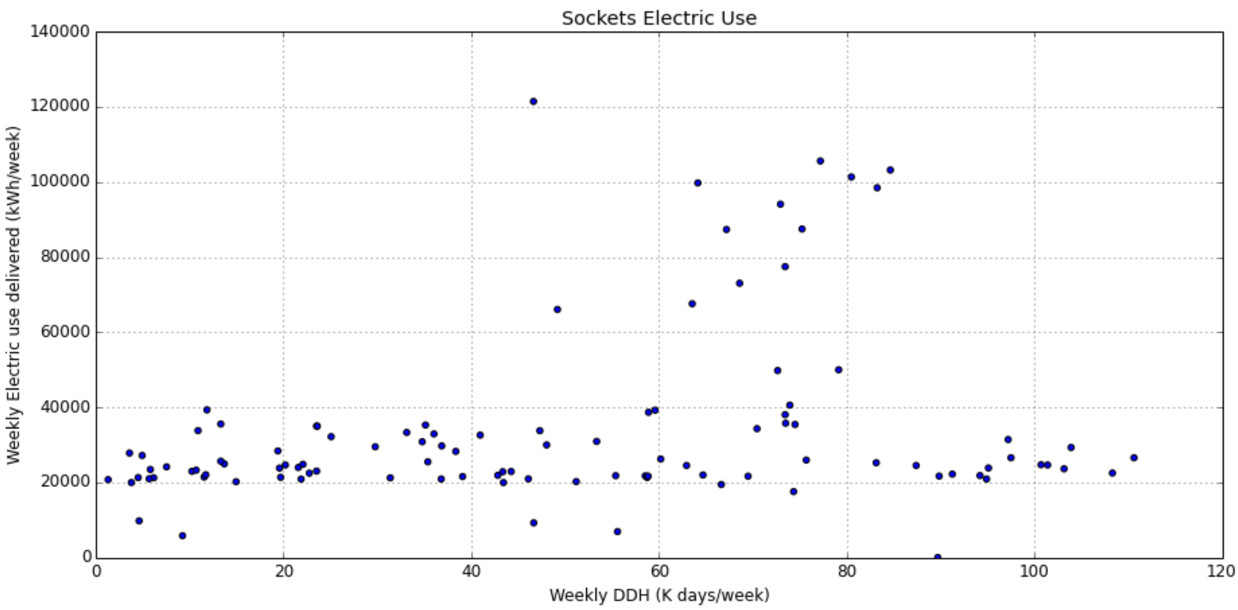


Figure 34: Ring main electricity use and degree days – Flat B



Flat A shows a linear relationship between ring main electricity and degree days as discussed above. In comparison, Flat B also has a largely linear relationship between degree days and electricity to sockets apart from the obvious peak in December 2013 to March 2014. It is suggested that this indicates the use of additional electric heaters in the property. Following complaints from some residents that downstairs hallways felt cold, Connect Housing introduced additional electric heaters at the foot of the stairs in upstairs properties (including

Flat B). These heaters were introduced in October 2013 and coincide with the significantly higher electricity use shown between October 2013 and March 2014 in flat B. It is suggested that this resident uses the electric heaters now available for top-up heating.

Total annual consumption for both flats has been compared to householder Archetypes which have been developed by Ofgem in partnership with Centre for Sustainable Energy. These Archetypes are used to identify energy trends in households of differing fuel use and tenure[5]. The group used for comparison was Archetype 7: Low-income single adults (lone parents or elderly) in social rented houses. This category consists of 77% single adults and so is directly comparable to Flat B. It also gives a good benchmark for Flat A, although as there are two occupants in this property consumption may be expected to be slighter higher. The following table shows the annual kWh electricity used by the property in comparison to these average figures.

Table 7: Annual electricity consumption kWh

	kWh consumption			
Year	Flat A	Flat B	National Average	Archetype 7 Average
2012/2013	2,856	2,050	3,300	2,474
2013/2014	2,741	2,874	3,300	2,474
Average	2,799	2,462	3,300	2,474

7.4 Heat Pump Performance

The plant room at Ancion Court is located within the communal flat in the centre of the development. This flat is within the main complex and is surrounded on either side and above by other occupied dwellings.

The primary source of space and domestic hot water heating for the Ancion Court complex is a pair of ground source heat pumps (rated at 33.3kW and 7.5kW). This is backed up with an electric flow boiler for emergency heating use. The domestic hot water (DHW) is held in 5 cylinders each fitted with an immersion heater. The DHW is heated by a combination of the heat pump via a buffer vessel and the immersion heaters.

[5] Beyond Average Consumption, Summary document. Ofgem

7.4.1 Annual energy output from the plant room

The following table shows the sum of the total energy output from the heat pumps, plus electric input from the immersions and electric flow boiler (assumes 100% efficiency for the electric heating). It has been assumed that the demand is spread evenly over all the flats (although one flat is used for plant room/ communal area). Also there will be considerable losses from the 5 DHW tanks and 2 buffer vessels in the plant room, these are not accounted for here.

Table 8: Energy supplied from plant room

Period	Total Energy Supplied (kWh)	Average Per Flat (kWh)
July 2012 to June 2013	125386	8956
July 2013 to June 2014	116141	8296

Making allowance for the losses this compares reasonably well to the Kiwa calculated SAP heating + DHW energy requirements; which were:

Table 9: SAP derived energy use

	SAP derived annual energy use (kWh)
Ground floor flat (2 bed)	5575 (Stroma) / 7425 (Kiwa)
Upper floor flat (2 bed)	4691 (Stroma) / 7177 (Kiwa)

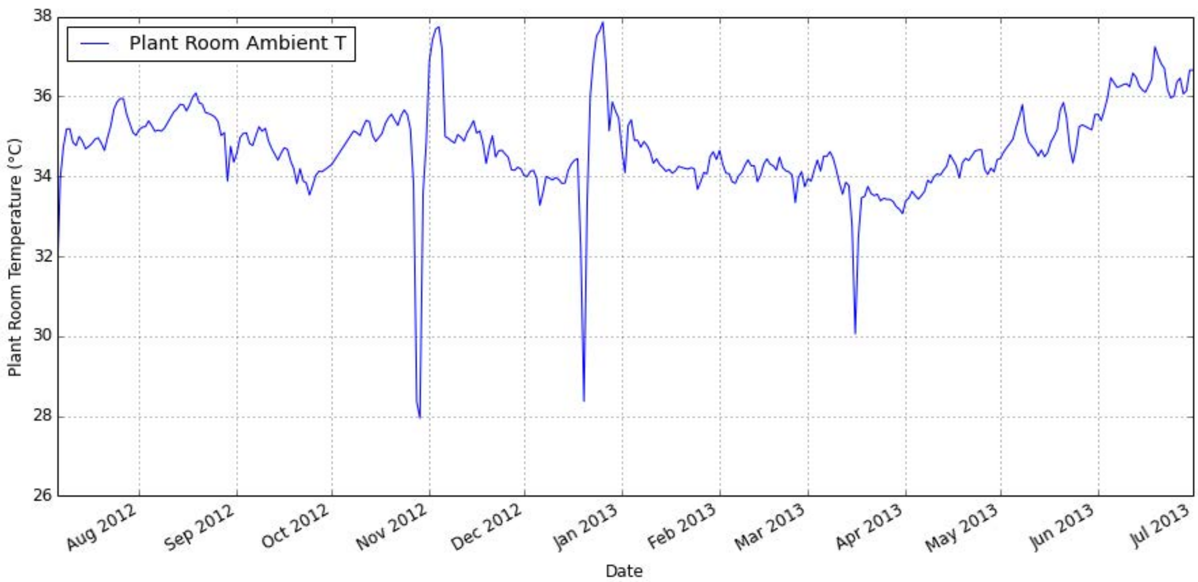
A large proportion of the energy use is consumed in the DHW circuit.

Table 10: Energy to DHW

Period	Energy to DHW (kWh)	% of total energy
July 2012 to June 2013	35919	28.6
July 2013 to June 2014	41569	35.8

The DHW system works by continually circulating the hot water around a circuit in the building, this system commonly used in commercial buildings (e.g. Hotels) ensures that hot water is always available at the tap and no excessivly long wait times (for the hot water to get hot) are experience by the tenants. However, the continual circulation of the DHW around the building also contributes towards the heat demand of the building. This is further influenced by the considerable heat loss from the DHW cylinders and pipework within the plant room, which can be confirmed by the very high temperatures recorded in the plant room (an average of approximately 35°C); daily average plant room temperature shown in the graph below. It would be useful for Connect to ask their maintenance contractors to survey the plant room and install additional insulation on any exposed pipework, connections and valves.

Figure 35: Ambient plant room temperature



This is also an important message for industry in the fact that heat given off by un-insulated valves and pipework is not controlled and therefore can have a negative impact on the internal temperatures of the building, particularily during summer months. This needs to be understood by specifiers at the design stage to ensure methods are put in place to insulate all aspects of the plant room including, valves, pipe connections and pipework.

Figure 36: Images of pipework and cylinders in plant room

7.4.2 Heat pump performance

The primary heat pump (identified as heat pump 1 (HP1) in this document) is a DeLonghi BWR MTD 0121 with an output of 33.3 kW

The secondary heat pump (identified as heat pump 2 (HP2)) is a DeLonghi BWR MTD 0025 with a output of 7.5 kW

The predicted performance of the heat pumps based on their EN14511 test results is shown below:

Table 11: Heat pump performance as per EN14511

Heat Pump	Conditions (Condenser temperatures) (EN14511)	Output (kW)	Electric required (kW)	COP
0121 (HP1)	30/35°C	33.3	8.03	4.15
	40/45°C	32	9	3.56
0025 (HP2)	30/35°C	7.5	1.87	4.01
	40/45°C	7.0	2.2	3.18

In practice, heat pump performance depends strongly on the conditions of the specific installation and also what is included in the analysis of performance. Much of the current heat pump analysis uses approaches proposed by Sepemo[6], which proposes a variety of methods which include different aspects of the system. These are reported as a series of Seasonal Performance factors (SPF) and can be summarised as follows:

[6] SEPEMO Seasonal Performance Factor and Monitoring for heat pump systems in the building sector, SEPEMO-Build. Nordman et el, Supported by Intelligent Energy Europe; 2012-07-31.

Figure 37: SEPEMO SPF calculations

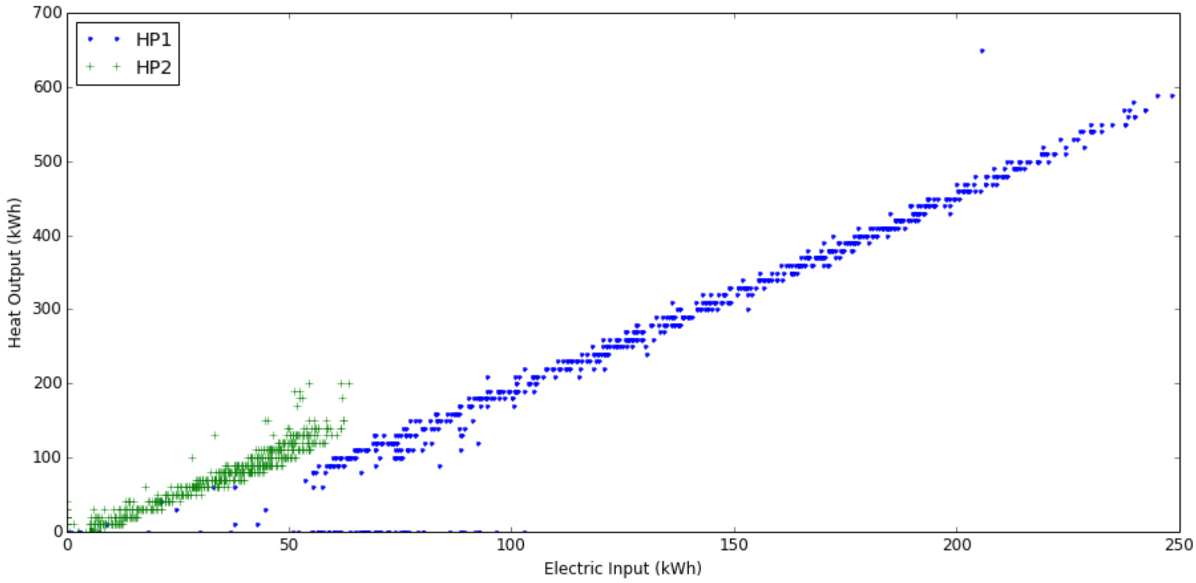
	Heat included	Power included
SPF_{H1}	Heat to Space Heating Heat to DHW	Electric energy to heat pump for SH and DHW
SPF_{H2}	Heat to Space Heating Heat to DHW	Electric energy to heat pump for SH and DHW. Electric energy to pump or fan
SPF_{H3}	Heat to Space Heating Heat to DHW Heat from Backup heater	Electric energy to heat pump for SH and DHW. Electric energy to pump or fan Electric energy to backup heater
SPF_{H4}	Heat to Space Heating Heat to DHW Heat from Backup heater	Electric energy to heat pump for SH and DHW. Electric energy to pump or fan Electric energy to backup heater Electric energy for building pumps Electric energy for buffer pump

SPF_{H1} is the closest to the EN14511 COP if the heat pump was run at the same operating conditions. However, in a practical installation this is rarely the case as the heat pump does not operate at test conditions.

The recorded field trial data (for the heat pumps) includes all the electrical energy supplied, so the majority of the analysis carried out in this document is equivalent to an SPF_{H4} analysis.

The figure below shows the relationship between the measured daily heat output and daily electric supplied to both the heat pumps.

Figure 38: Heat output and electricity used by the heat pumps



It can be seen that both heat pumps follow an approximately linear load pattern. The ratio of heat to power is reasonably constant over the whole demand range, with heat pump 1 showing a fairly large offset from the origin, indicating a large standby/base electric consumption. This is discussed in further detail later.

Heat pump 2 shows a much smaller offset, but there is still a standby use that needs to be taken account of.

These values included all power to the heat pump and therefore are equivalent to the SPF_{H4} value.

Table 12: Heat pump performance SPF_{H4}

Heat Pump	Trial total electric*(kWh)	Trial total heat output* (kWh)	SPF_{H4}
1	88627	187930	2.12
2	19078	42470	2.23

* Valid data only

Using manufacturer's data for the ciculation pumps on the ground loop and the heating loop to the buffer tank, it is possible to estimate the SPF_{H1} value, to allow a better comparison with the test standard.

For heat pump 1, the system pump is rated at 1.1 kW and the source pump is rated at 1.5 kW giving a maximum energy usage of 62.4 kWh per day. For heat pump 2, both are rated at 0.2 kW. However, data from periods in which the heat pumps were not operating show much lower pump electric power consumption than this, with HP1 using less than 1 kWh per hour when off and HP2 using less than 0.25 kWh per hour.

Allowing for the number of on periods of each heat pump, we can estimate the electric use of the circulation pumps (whilst operating) as 24415 kWh and 2368 kWh for HP1 and HP2 respectively. The non-operational pump electric use was measured as 6608 kWh and 2491 kWh respectively. These figures are subtracted from the total electricity measured to give figures comparable to SPF_{H1}. SPF_{H1} is more comparable to the EN14511 testing standard, however the operating temperatures experienced in the field trial are very different to test conditions and thus still cannot be directly compared.

Table 13: Heat pump performance SPF_{H1}

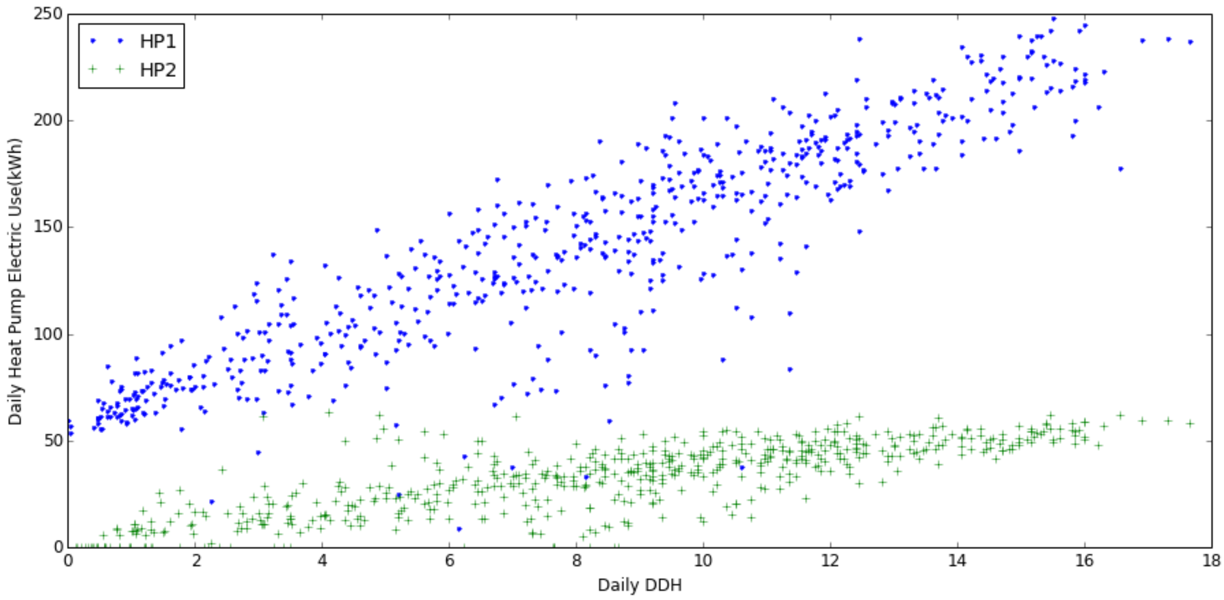
Heat Pump	Trial total electric (kWh)	Circulation pumps usage (kWh)*	Electric Use for analysis (kWh)	Trial total heat output (kWh)	SPF_{H1}
1	88627	24415+6608	57604	187930	3.26
2	19078	2368+2491	14219	42470	2.99

* Estimated plus measured

These values are lower than the published COPs as operational temperatures are much higher than the test conditions. This is discussed later.

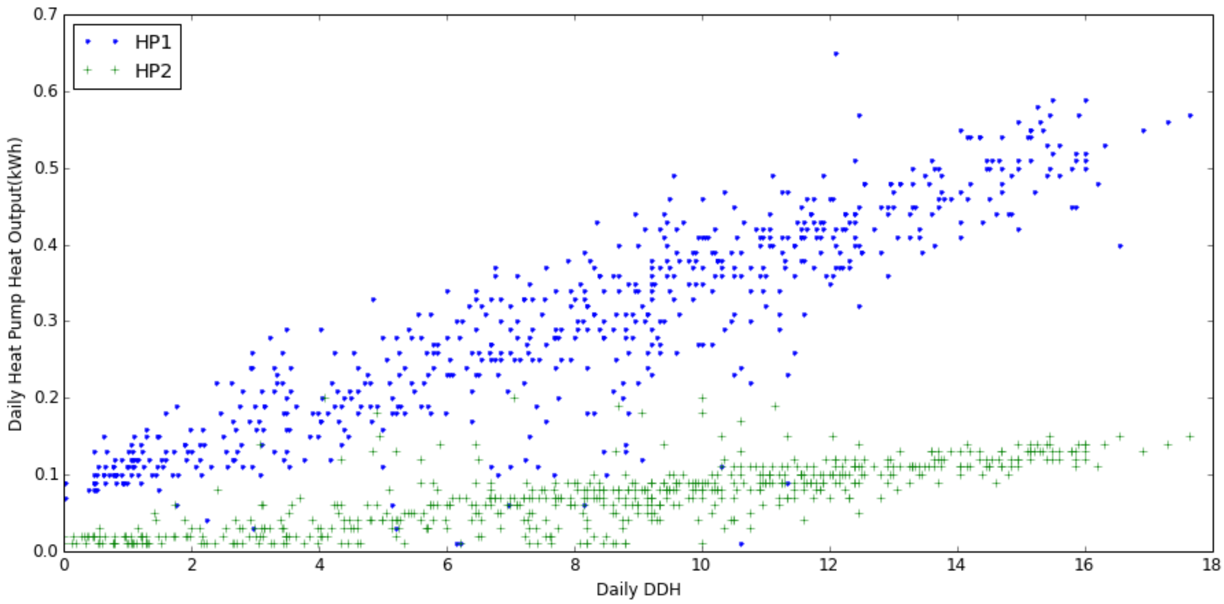
The heat pump electric use and heat pump heat output compared to the degree day heating requirements are shown in the figures below.

Figure 39: Degree days and electricity used by heat pumps



It can be seen that the heat pump electric demand and heat output, in the main, increase in a linear manner as the heating demand increases indicating that control on the whole is reasonably good.

Figure 40: Degree day heating and heat output from heat pumps



Heat pump 1 shows a positive intercept on the heat output graph indicating there is a base load to cover, which in this case, is clearly the DHW demand.

7.4.3 Heat pump operating times

The following graphs show the percentage of maximum operation based on time.

Figure 41: Percentage of maximum operation achieved HP1

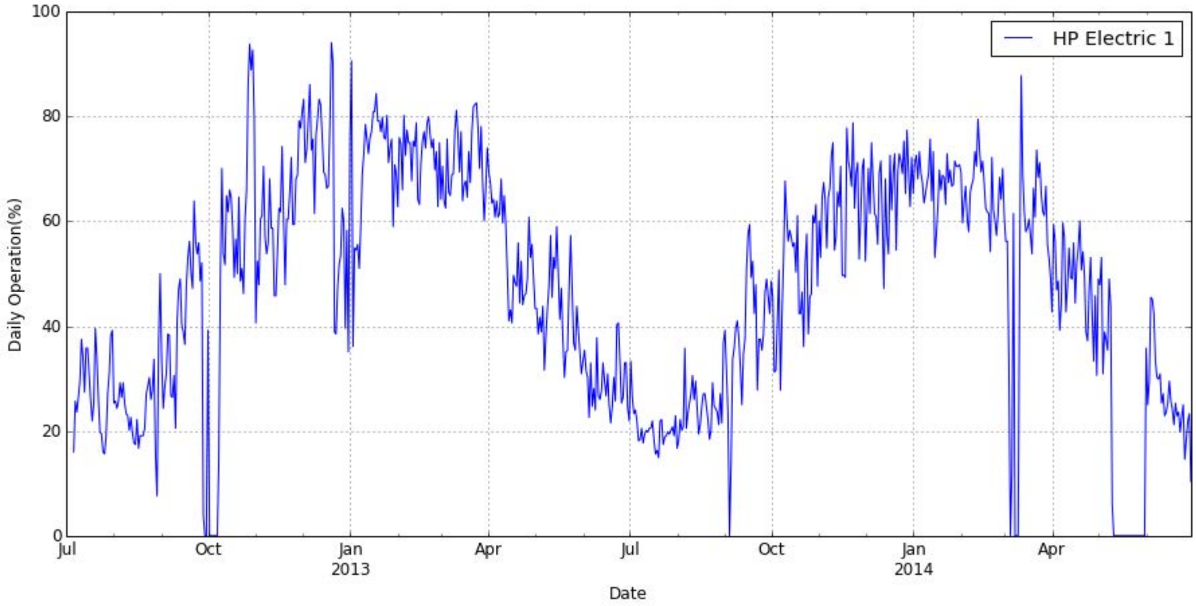
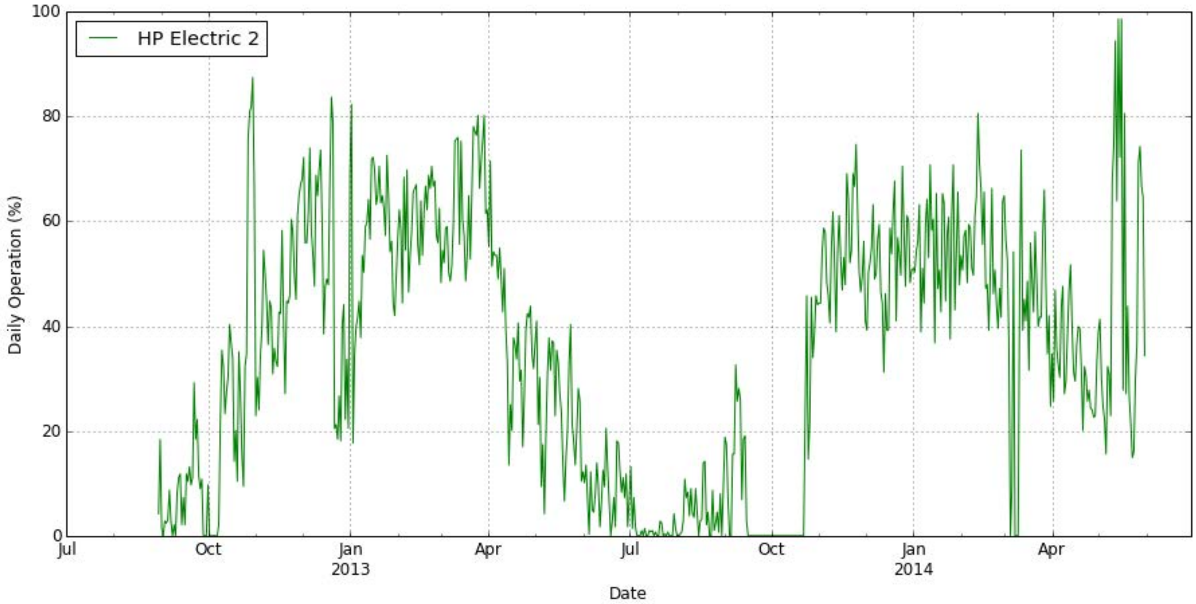
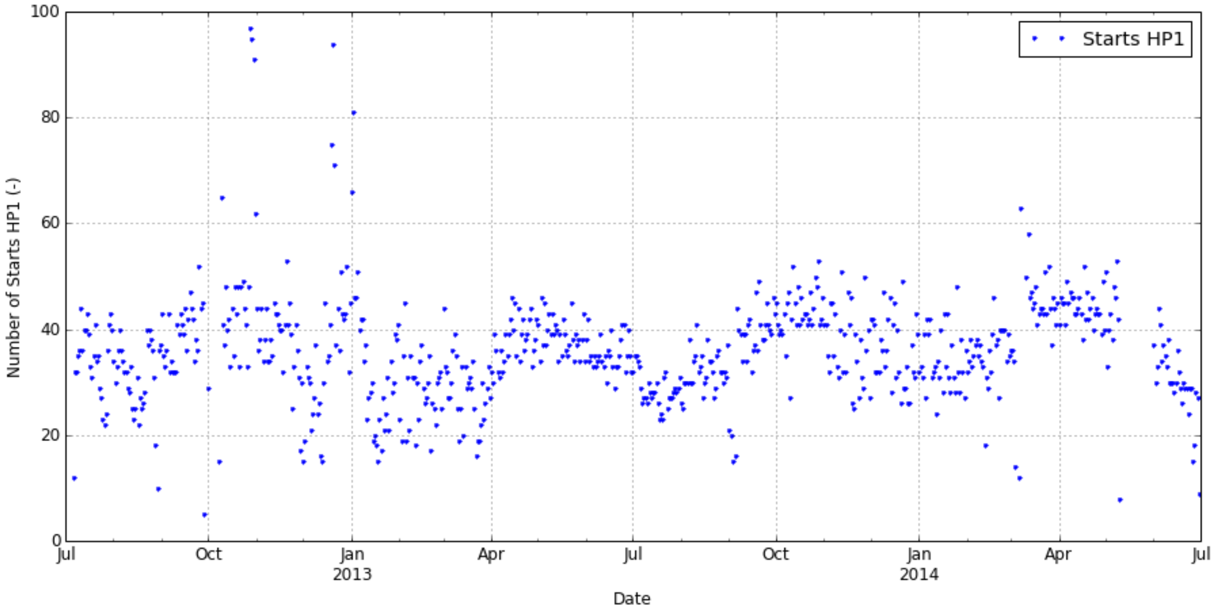


Figure 42: Percentage of maximum operation achieved HP2



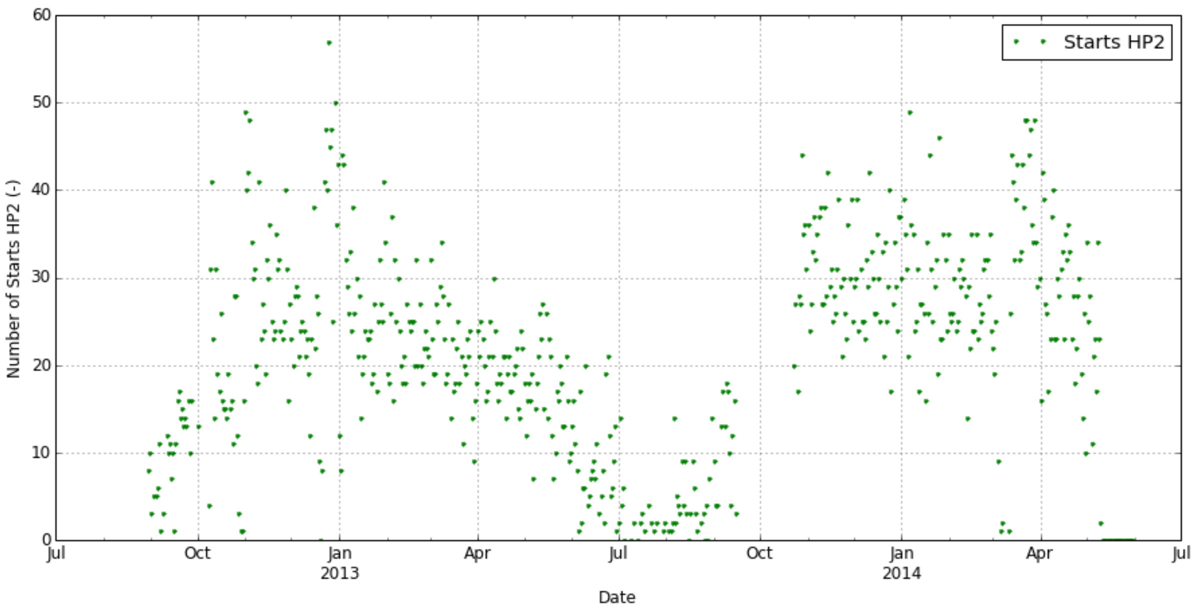
These graphs show that the majority of the load is covered by the HP1 with the smaller HP2 mainly active over the colder months. It is clear that even in the cold winter of 2012/2013, HP1 was operating in a cyclic mode. This may point to the small heat pump turning on slightly too soon, as ideally the full load should come from the lead heat pump (HP1). The number of starts per day (see following figures) is relatively high.

Figure 43: Number of starts HP1



For HP1 the number of starts is quite consistent throughout the test period, but HP2 follows a seasonal trend. On some days there are an exceptionaly high number of starts, in excess of 90 starts/day for HP1 and over 50 starts/day for HP2. Cycling has several detrimental effects including increase in wear on the heat pump and compressor, as well as difficulties with the heat pump mass heating and cooling regularily reducing efficiency. This cycling needs to be investigated further but may suggest the buffer storage has insufficient volume to maintain consistent operation.

Figure 44: Number of starts HP2



When operational the run length of both heat pumps is predominantly very short – less than 1 hour as can be seen by the high density of the dots near the x-axis of the following graphs. This supports the high number of starts and cyclical nature discussed above and leads to poor performance of the heat pump.

The very long runs for HP2 occur when HP1 is out of action.

Figure 45: Length of run hours HP1

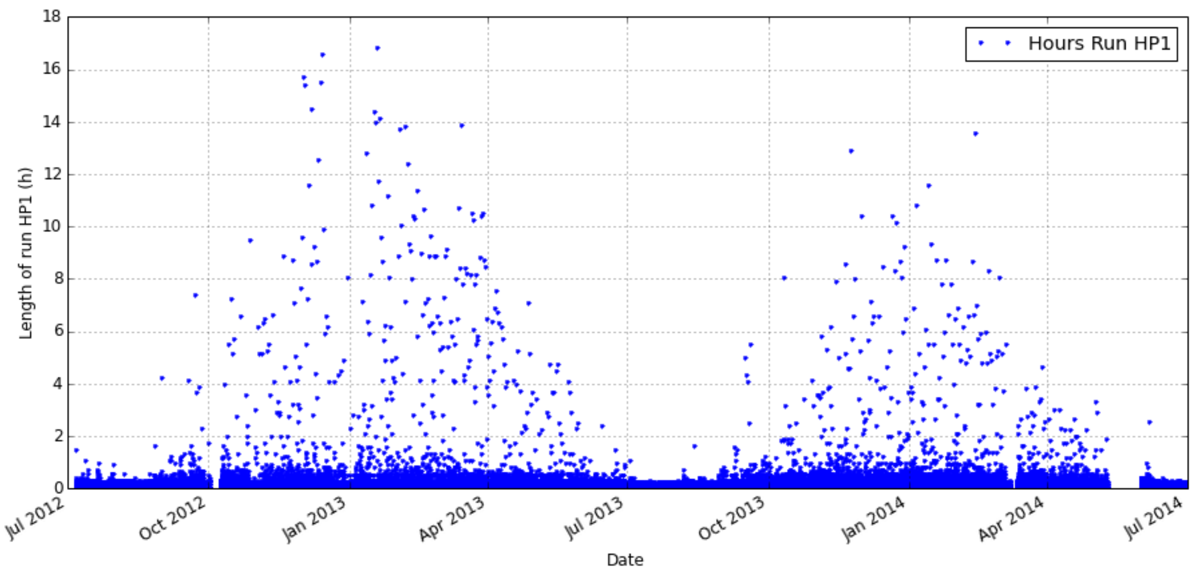
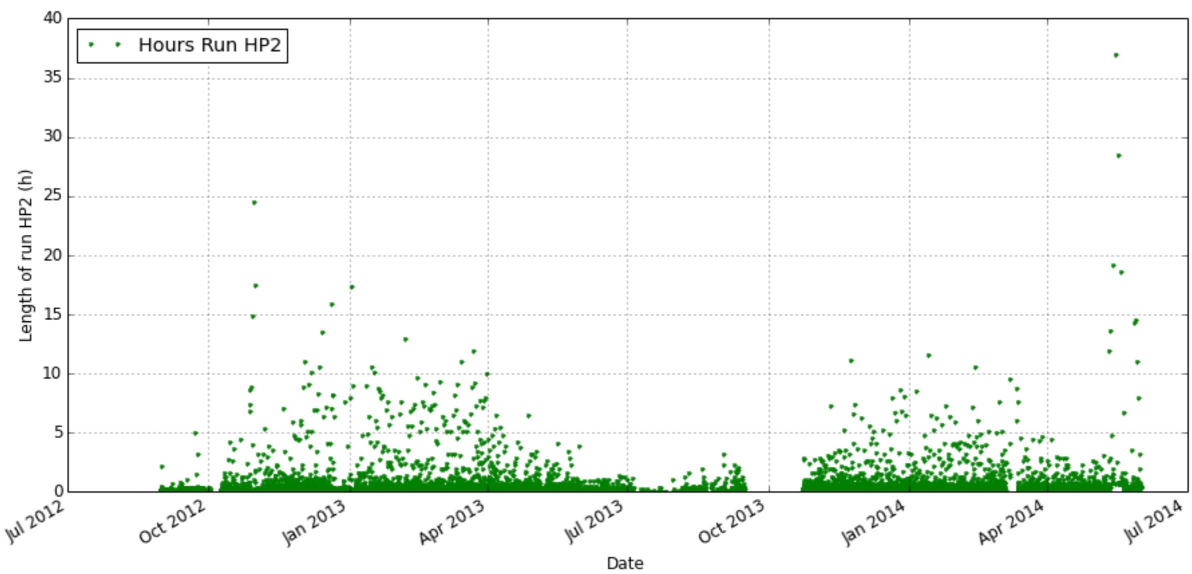


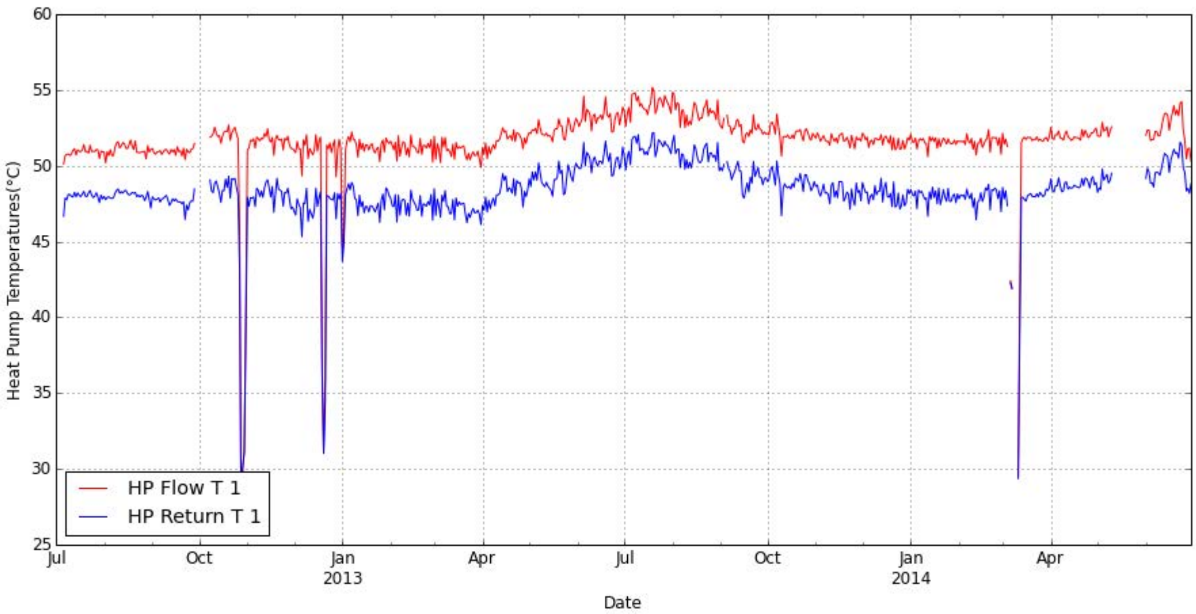
Figure 46: Length of run hours HP2



7.4.4 Heat pump temperatures

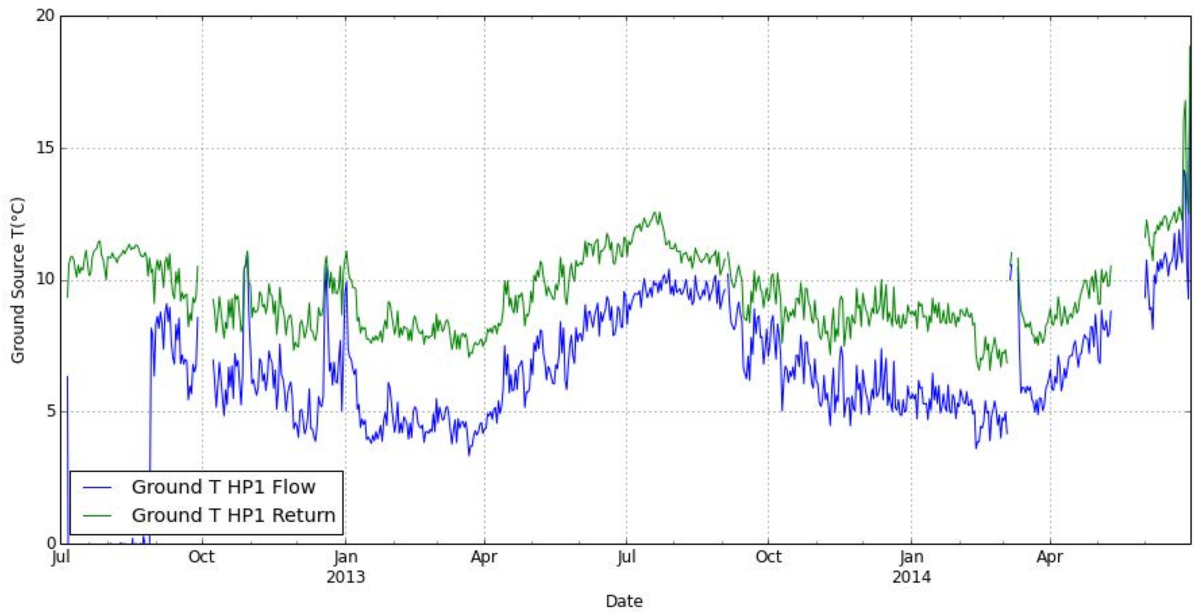
The figure below shows the flow and return temperatures (averaged over the 'on' periods on a daily basis) on the delivery side of HP1. It can be seen that the flow temperature is on average between 50 and 55°C with the return temperature being approximately 2-3°C lower (on average). This is a fairly high temperature for a heat pump to sustain, with ideal operating tempertures between 30 and 45C; operation at these conditions will lower the efficiency of the pump.

Figure 47: HP1 flow and return temperatures



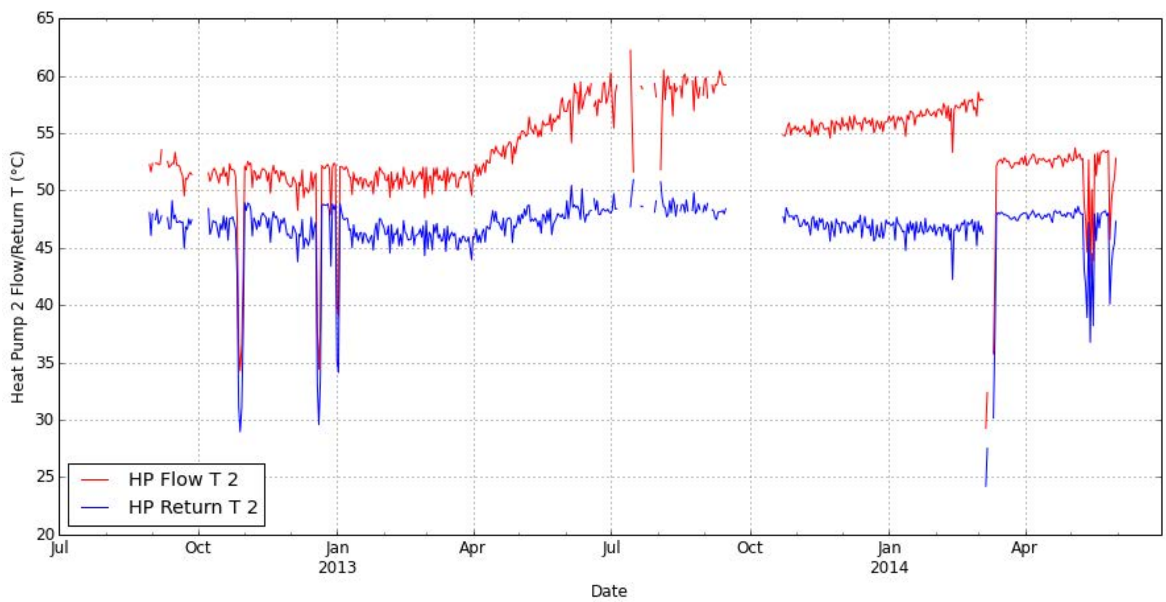
Temperatures from the ground loop (again daily averages, during 'on' periods) seem to be maintained at very acceptable levels. There is a noticeable dip during the winter months, but this is recovered in the summertime. There does not appear to be a continual decrease, so it can be assumed that the amount of heat taken from the ground by the heat pump is currently not causing any sub-soil issues. This would include freezing of the ground loops which can occur if the boreholes are too close together or incorrectly sized. If the ground loop freezes, heat extraction becomes difficult and thus the system will fail to operate successfully.

Figure 48: HP1 Ground temperatures



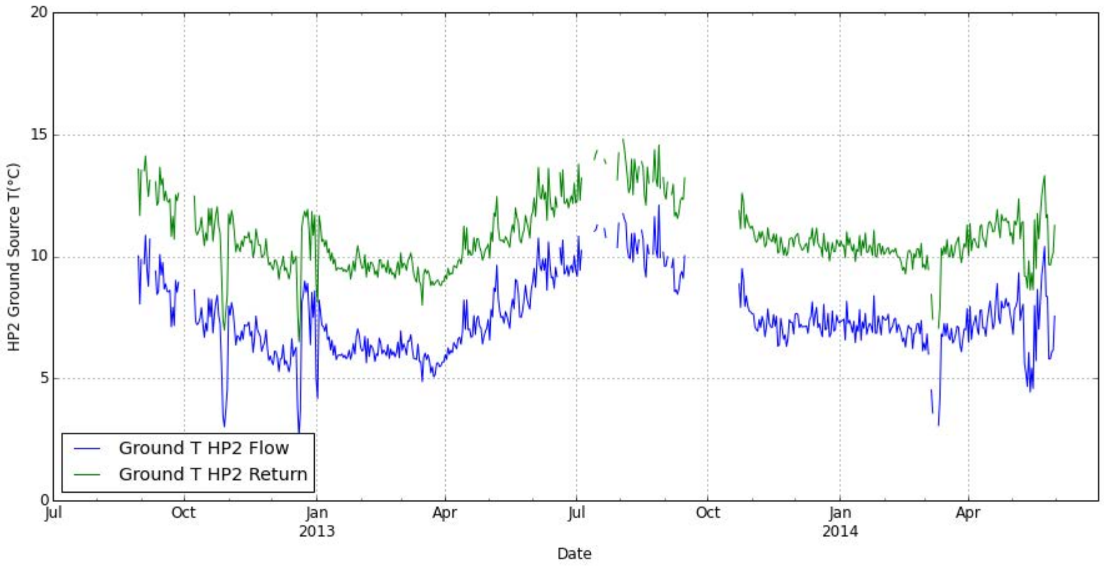
For heat pump 2 flow temperature are very high again at nearly all of the operating times, reaching close to 60 °C during the summer of 2013. This will impact on the efficiency of the heat pump. Ideally, a normal maximum operating temperature of 45°C would give a much enhanced performance.

Figure 49: HP2 flow and return temperatures



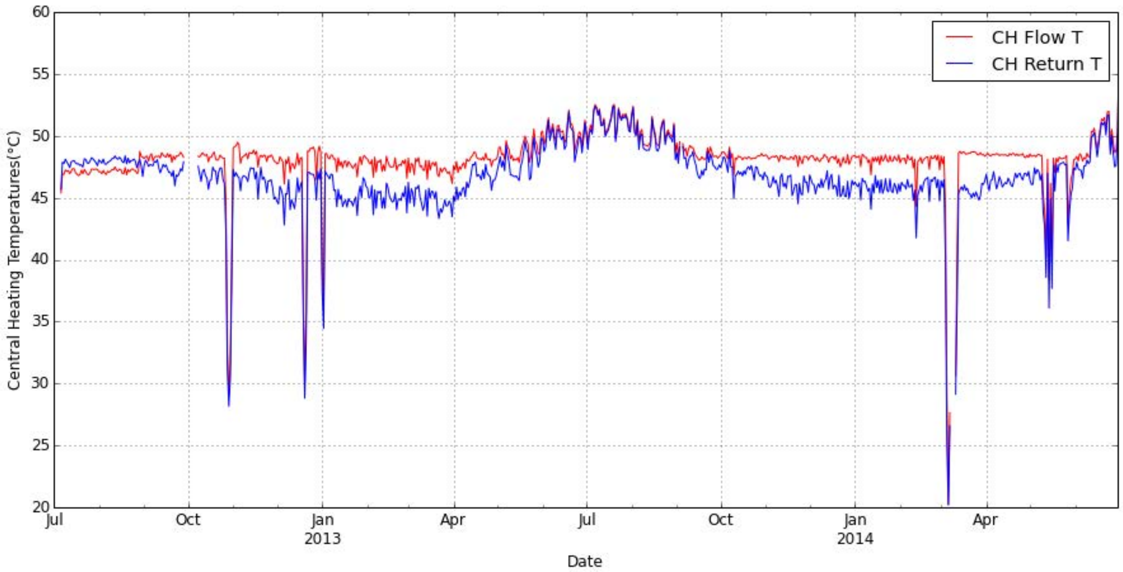
The ground loop temperatures again look very reasonable, showing a seasonal decrease during the winter months and then recovering during the summer. There are no signs of sub-soil freezing, or that too much heat is being removed from the ground surrounding the ground loop.

Figure 50: HP2 Ground temperatures



Similarly to the heat pump temperatures, central heating (CH) flow temperatures are high but marginally lower than the HP flow temperature as shown below. The return CH temperature is very close to the flow CH temperature. It would be beneficial to reduce return temperatures by trying to increase delta temperature (between CH flow and return). It may be possible to achieve this by reducing flowrate around system, so long as all flats still remained evenly heated.

Figure 51: Central heating flow and return temperatures



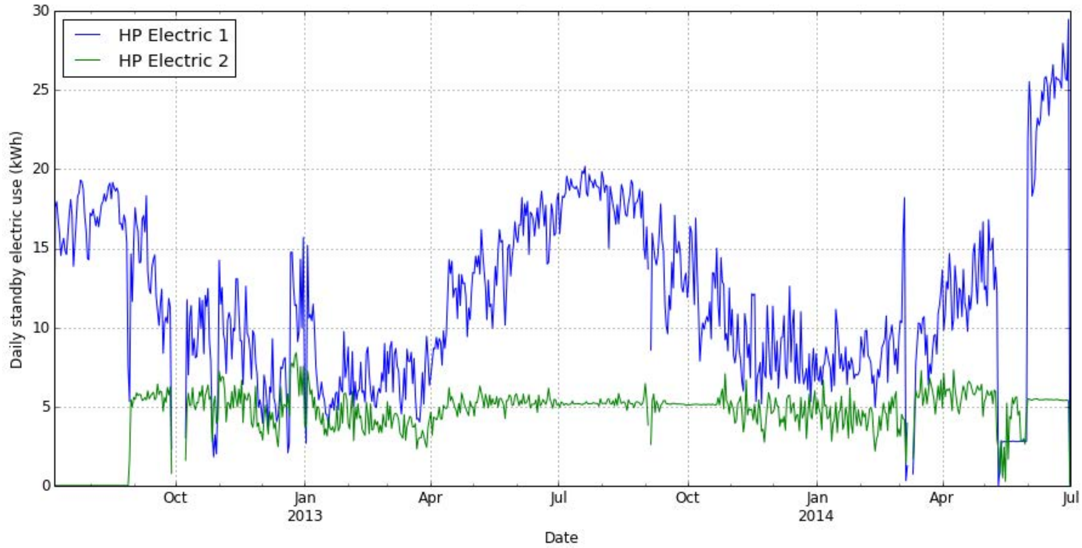
Both heat pumps are operating at temperatures that are 5 to 10C above those that would be suggested for most efficient operation. Part of the problem is using the heat pump to heat the DHW, which needs to be raised to a much higher temperature than the space heating water. Since the space heating is only for underfloor heating this should be controlled to a much lower temperature, preferrably less than 40°C for the flow temperature. This means that the heat pumps need to be separated from the DHW. One possible way to do this could be to only use the heat pumps to preheat the incoming water to the same temperature as the underfloor space heating water. It may be possible to use the existing 200 litre DHW buffer vessel to do this, as the internal coil will hydraulically separate the space heating water and DHW.

Obviously, this means that the difference needs to be made up by the immersion heaters, back-up electric boiler, or possibly by installing some solar thermal to 'top up' the system. Whilst this uses electricity with an effective COP of 1, this should be compensated for by the heat pumps running at a much higher COP than they do currently. It may be useful for Connect to carry out a cost analysis on these options to consider the most viable option.

7.4.5 Standby electric use

When the heat pumps are not actually producing heat there is a substantial amount of energy still used, primarily pumping water round the primary circuit. The graph below shows the daily total standby usage. HP1 has significantly more standby usage during the summer months, HP2 is more consistent throughout the year. The electric use over the monitoring period totals 8313 kWh for HP1 and 3236 kWh for HP2. It would be advantagous to try to reduce the standby power requirements, to improve overall energy efficiency. This may not be possible, but interlocking the primary circulation pump with the heat pump demand may be a solution.

Figure 52: Daily standby electricity usage

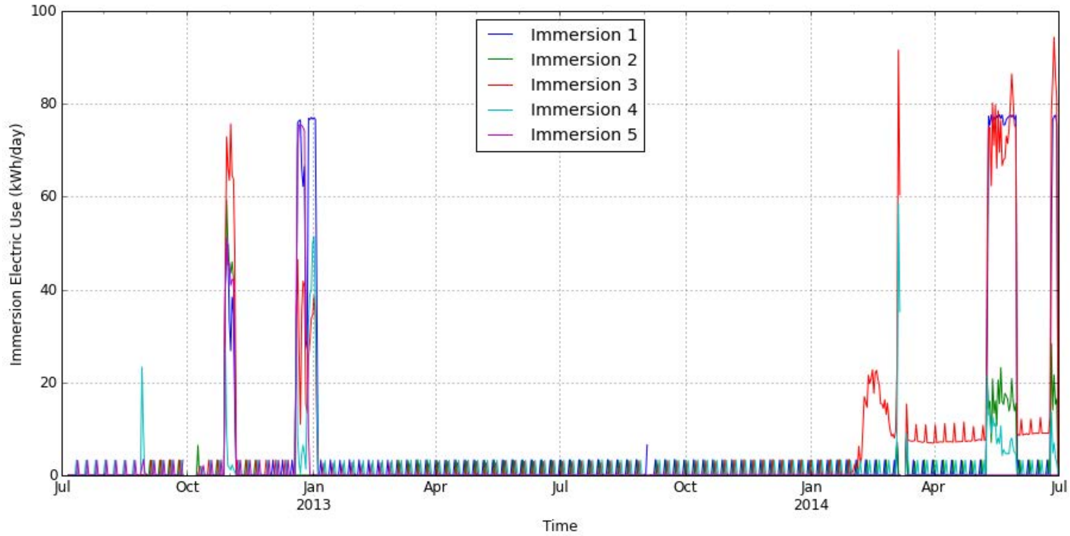


7.4.6 Immersions and flow boiler

The emergency flow boiler appears to have been turned on only once during the monitoring period, despite there being a couple of occassions when the main heat pumps have been out of operation. It is believed that this is because it requires manual intervention to initiate its operation and this has been highlighted to Connect for further investigation.

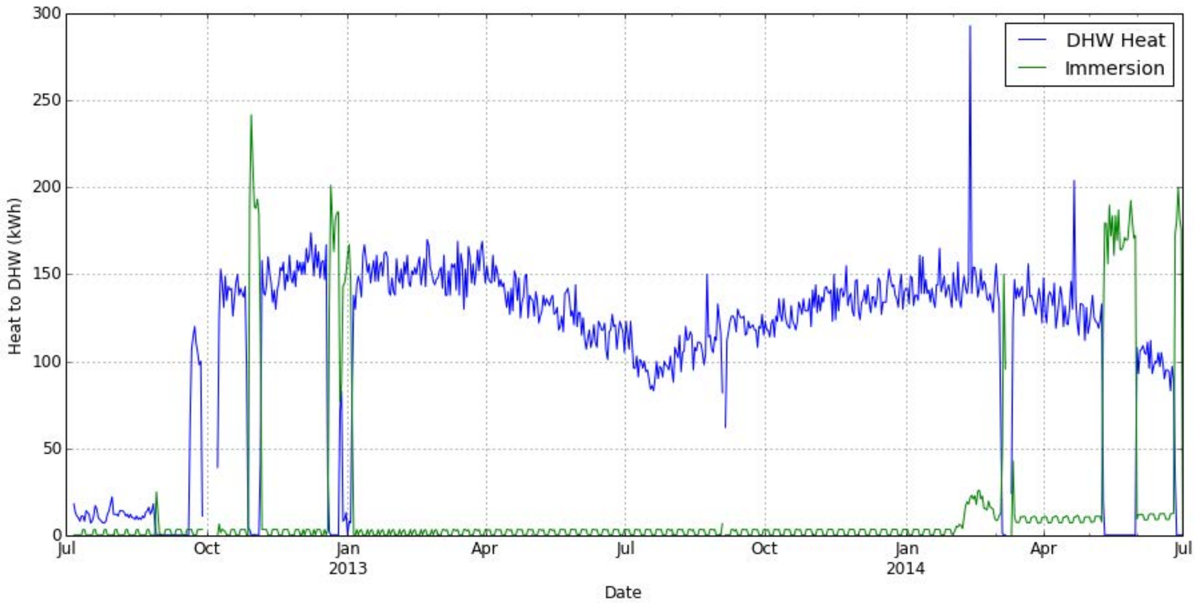
Immersions have mainly operated on an automated cycle to reduce the risk of Legionella developing in the DHW storage cylinders, the graph below shows this short operation of each cylinder once per week quite clearly. The immersions are set to come on once / week to raise the DHW store tank temperature to in excess of 60°C.

Figure 53: Immersion electricity use



There are a number of other instances of higher immersion use, these are shown below (with heat from all immersions summed), these higher uses conincide with the periods when the heat pumps were not providing any (or sufficient) heat to the DHW system. It is interesting to note that the energy provided by the immersion heaters exceeds that normally provided by the heat pump at these points. This indicates that the immersions are set to a higher temperature than that normally supplied by the heat pump, and this is confirmed by the use of the immersion heaters for legionella protection (e.g. used to heat the cylinders to 60C on a weekly basis)

Figure 54: Heat to DHW



It has also been noted that since early February 2014 Immersion 3 has been contributing energy continuously at a rate of about 9 kWh/day. It is unclear as to whether this is intentional or an accidental change in settings.

7.5 Central Heating

Central heating in each of the properties is supplied via a constantly circulating heat main from the central plant room to manifolds in each of the properties. The heat pumps supply a 500 litre buffer vessel which is then pumped throughout the building through the roof space, before being distributed in each of the properties via underfloor heating. Each of the flats is zoned, with individual heating controls in each zone.

Space heating provision to the properties is shown against the Degree Day Heating requirement. Both flats can be seen to have a very linear relationship between the degree day requirement and the heat used in the dwelling. This suggests good control of the heating system.

Figure 55: Flat A Degree day heating requirement and heat provided

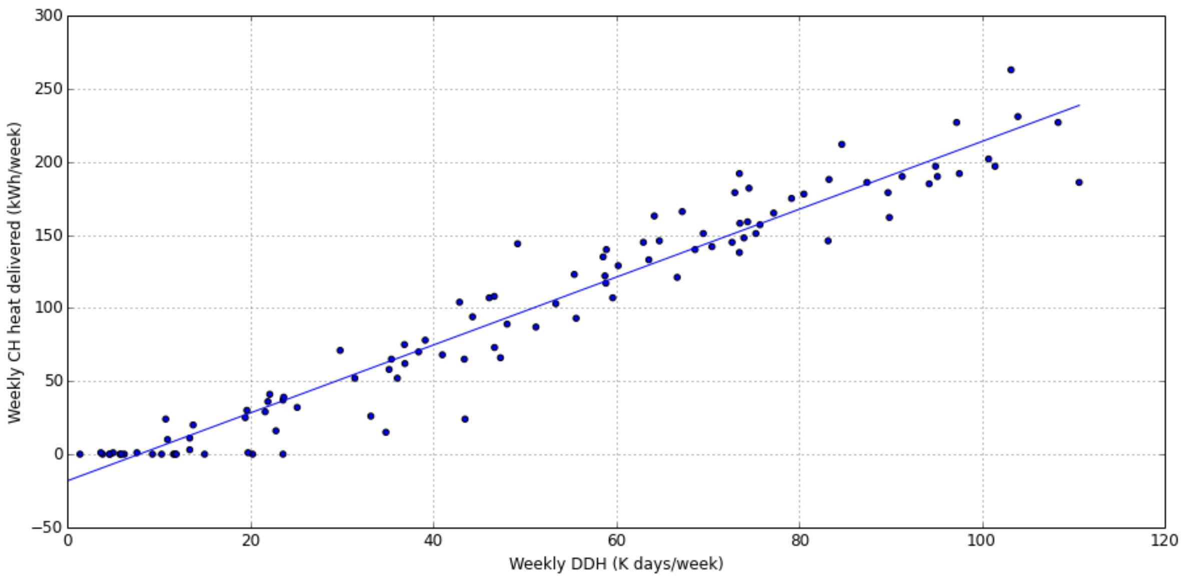
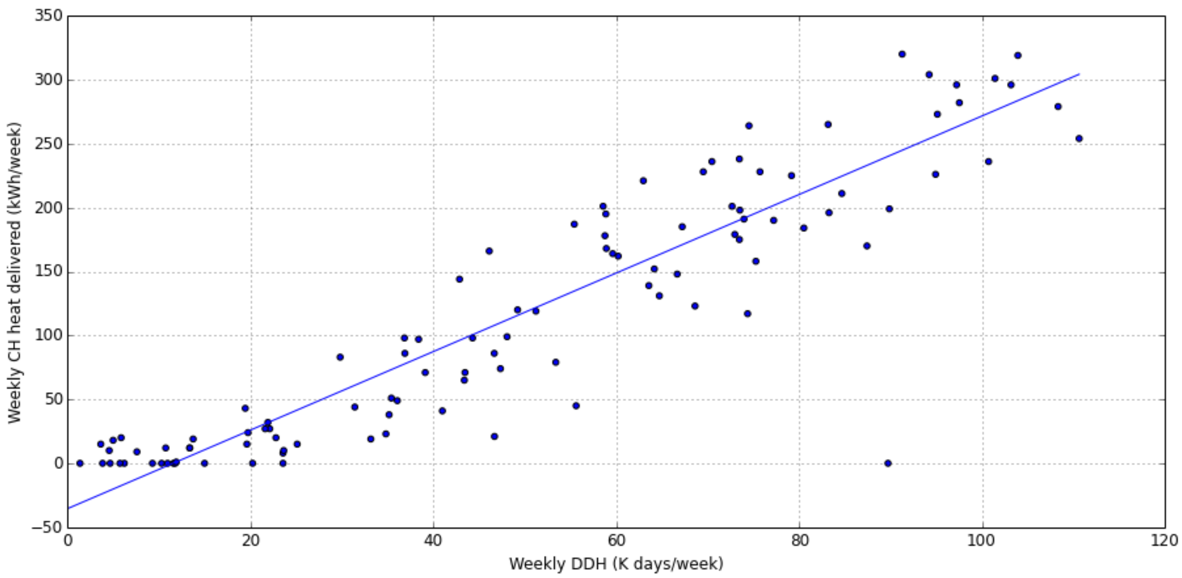


Figure 56: Flat B Degree day heating requirement and heat provided



The measured values have also been compared to the SAP predicted values and are shown below. Interestingly the Kiwa SAP assessments carried out once the building was built and occupied show a far closer assessment compared to the real data, compared to the Stroma SAP reports carried out during the design and development phase. Connect Housing have confirmed that they are not aware of any alterations made to the materials used in the construction of the building compared to the designs.

Property	Measured Annual Heat Demand kWh	Kiwa SAP Predicted Annual Heat Demand kWh	Stroma SAP Predicted Annual heat Demand kWh
Flat A 2012/2013	5761	4437	2633
Flat A 2013/2014	4480	4437	2633
Flat B 2012/2013	7755	4486	1941
Flat B 2013/2014	4899	4486	1941

It is clear that Flat B has a higher heat demand than flat A and this is supported by the higher average internal temperatures experienced in Flat B compared to Flat A; 22 compared to 21 in Flat B and A respectively. However, it is likely that the higher air permeability found in Flat B also impacts the heat required in the property to maintain the desired temperature.

In addition to the SAP values, the measured heat demand has been compared to the average gas consumption as stated by Ofgem for Archetype 7[7]. An average gas consumption of 11,515kWh is stated which when considering a gas boiler operating at approximately 86% efficiency, equals an average heat demand of 9900kWh per year. This means the heat demand of the monitored properties is far lower than that suggested as the national average for elderly individuals in social rented accommodation.

7.6 Hot Water Provision

Hot water on site is provided by the heat pumps which supply 5 x 400litre hot water cylinders before circulation throughout the site. An immersion heater is also present in each of the cylinders to provide back-up heating and protection against legionella. Each immersion is set to operate once a week to heat the cylinder above 60C.

Although the taps within each of the properties are fed from the circulating DHW main, the majority of the flats within the development operate an electric shower. This seems

[7] Typical domestic energy consumption figures; Factsheet 96. Ofgem 18.01.2011

counterintuitive as by far the highest demand for hot water, apart from a bath, will be the shower. As the showers are electric it means a large proportion of the circulating hot water remains unused within the circulating main for large periods of the day. Hot water demand at taps is limited and although baths are present in the flats, it may not be the preferred option when considering the use of a bath or shower. As a result heat is lost through constant water circulation which could be avoided and the heat pumps suffer inefficient operation as discussed above. There are several options to combat this.

It is suggested that a preferred option would be to install small hot water cylinders in each of the flats which are fed from the central heat pumps. These cylinders are then connected to the taps and showers in the properties and would supply all the DHW demand. An electric immersion heater would also be fitted within the cylinder as back-up and to ensure the cylinders exceed 60C at least once a week. Although this would reduce the space available in each of the properties it would mean the heat pumps supply the full DHW demand reducing the need for additional electric heating and potentially reducing the losses from the circulating DHW main.

An alternative option would be to remove the circulating DHW heat main and install point of use electric heaters in each property. This would also mean removing the bath as point of use electric heating is not advisable when heating a bath; however each flat could have an electric shower and point of use electric heaters at each tap delivery point. This significantly reduces the losses from the circulating heat main as it would no longer be operational and also reduces the operating temperature of the heat pumps thus improving their performance.

7.7 Conclusions and key findings for this section

Overall, conditions within the monitored properties were comfortable; the temperatures were well maintained and humidity and CO_2 were within very acceptable levels.

When considering electrical consumption of the properties by far the highest use was within the ring main feeding the sockets. This also shows seasonal variations, with increasing electricity use within colder months. This is likely due to the increased use of stand-alone lighting and additional electrical equipment such as TVs and electric blankets. In Flat B the use of additional electric heaters after they had been introduced by Connect Housing was also evident. It is known that most residents within the development have introduced additional lighting on top of the fixed units as artificial lighting levels particularly for flats on the ground floor at the rear of the development are poor.

Similarly to many new developments Ancion Court has been built using generic designs that meet the building regulation requirements rather than catering for the specific needs of the particular site in question. Although this method produces buildings with a reasonable level of air tightness which meet the energy requirements; it fails to take into account the external and environmental factors which the residents then have to live with on a daily basis, such as dark overhanging trees. This often means that residents take matters into their own hands such as adding additional lighting and electric blankets. This is an important issue when considering new buildings and should be a focus of designers and specifiers at the very beginning of the design and development phase.

Heat and DHW to the properties is provided by two heat pumps within a centralised boiler plant supported by electric immersion heaters and an electric boiler. The performance of the heat pumps has been analysed using the SEPEMO SPF_4 category as this provides a true representation of the electrical load on the system, compared to the heat out of the heat pumps. This is not directly comparable to how the heat pumps are tested in EN14511 (SPF_1 is the closest to the test standard) and thus often lower SPFs are experienced in reality than shown in the test standard. The performance is shown below:

Heat Pump	SPF_{H4}	SPF_{H1}
1	2.12	3.26
2	2.23	2.98

Both heat pumps show consistent performance whilst operational and a linear relationship when compared to the degree day heating requirement. There is a considerable stand-by or background electrical load on the system when the heat pumps are not supplying heat; likely to be the result of pumps running whilst the heat pumps are not operational. This should be addressed so that, certainly in the primary supply circuits between the heat pumps and the hot water cylinders, the pumps are interlocked to the heat pump operation.

The majority of the load is covered by HP1, however both heat pumps cycle considerably during operation; this increases wear on the appliance and reduces performance. It is possible that the storage capacity is not sufficient to maintain longevity of operation and further investigations should be made regarding this.

The flow and return temperatures of the heat pumps are also quite high compared to the test conditions of a heat pump. This will lower the efficiency of the heat pump and may be difficult to sustain. Normal operating temperatures are approximately 45C (flow), and reducing the temperature output of the heat pumps is likely to improve their performance. In addition to this the temperature difference between the flow and return temperatures is very small and this adds to the cyclical nature of the units. It may be possible to increase this temperature difference by reducing the flow rate around this system as long as all flats are still adequately heated.

Unfortunately part of the issue with high temperatures is the use of the heat pumps for DHW which obviously needs to be heated to a higher temperature than space heating (using an underfloor system). It is suggested that the system could be altered so that the heat pumps are used to pre-heat water which is then subsequently ‘topped up’ using another appliance such as an electric boiler or immersion heaters. This would then ensure the DHW is supplied at the correct temperature but would also improve the performance and longevity of operation of the heat pumps.

The electric back-up boiler on site has not been operational throughout the trial, even during periods of heat pump failure. It is thought that there is some confusion as to how this integrates into the system and this needs to be rectified to ensure the back-up system is available when needed. The immersion heaters present operate on a timed legionella cycle and when the heat pumps fail to provide the required DHW demand, however, some continual operation displayed by the immersion heaters suggest that there may have been a change in setting (accidental or otherwise) and this should be checked to reduce potentially unnecessary electricity consumption.

Heat provision to the flats follows linear degree day relationships suggesting good control within the properties. Flat B uses more heat than Flat A, likely a result of a higher average internal temperature and the increased air permeability shown in this flat.

8 Other technical issues

Technology Strategy Board guidance on section requirements:	This section should review the underlying issues relating to the performance of the building and its systems that have not been adequately captured elsewhere in this report. These could be technical issues detected through through testing, building use data and occupant issues etc. What technical issues have been discovered which could be leading to comfort or energy problems? Are the automated or manual controls being used effectively by the occupants or are they still becoming familiar with their operation? Did the commissioning process actually setup the systems correctly and, if not, what is this leading to? Are there design related technical issues, which are already becoming apparent and need to be highlighted for a future Phase 2 BPE study? Are there challenges being created through the dwelling usage or operation patterns? Summarise with conclusions and key findings.

8.1 Design and Set-up Issues

Ancion Court is designed with the residents in mind, whilst meeting the building requirements of Code for Sustainable Homes level 4. The general aesthetics of the development are very positive with residents very happy with ease of access and the outside space and facilities available to them such as the garden and allotment areas and sense of community. The building materials have been chosen with attention to the surrounding area and measures are in place to reduce energy use throughout the development.

The central plant room has enabled low carbon technologies to be utilised whilst trying to ensure each resident has sufficient heating and hot water available. This comes with many advantages as all aspects of control and maintenance are within the plant room allowing ease of access and limited disruption to the householders if problems occur. The control aspects of the heat pumps are also removed from the householder which should in theory ensure optimum performance, as the individual and fairly small heating demands of the properties will not directly impact the instantaneous operation of the heat pumps (as discussed above). The fact the plant is within the building envelope also negates any distribution losses during the winter months as although the heat is constantly circulating the heat losses from the pipework will add to the space heating of the properties. In the summer months the constant circulation may be less favourable as the uncontrolled heat losses from pipework may lead to overheating, however this has not been evident during this trial. When the properties do get too warm, the residents compensate by opening windows and using circulation fans.

In contrast, the central plant room does mean that if there are any issues with the heat pumps then all of the properties are affected, and provision of other heating methods have had to be provided by Connect Housing to each property as a result of heat pump failures over the monitoring period. When the heat pumps have failed the immersion heaters present in the DHW cylinders within the plant room operate to supply the DHW demands. An electric boiler is available in the plant room; however, this was not used throughout the monitoring period. Comments received from the residents suggest that the boiler has never been operational and it has been suggested to Connect Housing that this is investigated. If manual switching is required then it may be advisable that members of the residents association know how to do this and thus ensure a back-up supply is available if needed. This may require a short training session from Connect Housing or their maintenance team. Alternatively (and preferably) automatic controls could be added to the system to ensure the back-up heating operates when needed.

8.2 Resident Feedback

From the onset of the trial the main feedback received from residents within Ancion Court was the difficulty in operating and controlling the central heating. All of the residents complained that the controls available to them were difficult to use and not effective in their operation. Many of the residents were not used to living with underfloor heating and to some extent this may have caused some of the initial discomfort; many were using the thermostat as they would a thermostat coupled with a radiator system, thus expecting a quick response to their demands. In reality many felt the response time of the underfloor was slow and thus gaining and maintaining a suitable level of comfort was difficult.

Feedback gained through the occupant survey also identified the need to consider ease of use of fixtures within the home particularly when designing for older residents. It was mentioned that low, deep cupboards or excessively high deep cupboards were not suited to older physiques and were difficult to reach. It was suggested that pull out draws could be better suited to those that could not bend easily. It was also suggested that windows with a work surface or sink in front of them were not ideal as it was difficult to reach the window to open particularly as the flats are warm during summer months. The same also applied to the trickle vents at the top of the windows which in future developments could be moved to a side positioning to enable easier access.

Consideration should also be made with regard the external factors that will influence the occupation of the properties such as overshadowing by trees causing low natural light levels and slippery surfaces.

Overall however, residents are very happy at Ancion Court.

9 Key messages for the client, owner and occupier

Technology Strategy Board guidance on section requirements:	This section should investigate the main findings and draw out the key messages for communication to the client / developer and the building owner / occupier. Drawing from the findings of the rest of the report, specifically required are: a summary of points raised in discussion with team members; recommendations for improving pre and post handover processes; a summary of lessons learned: things to do, things to avoid, and things requiring further attention/study. Try to use layman's terms where possible so that the messages are understood correctly and so are more likely to be acted upon.

9.1 Key Messages

It is clear that this development has been designed and constructed with the aim to provide an energy efficient, low carbon development in pleasant surroundings. A lot of effort has been made to ensure the residents are comfortable within their homes and the surrounding area is easily accessible, with good local amenities.

Overall, good levels of comfort are maintained and the residents seem very satisfied with their properties, with very positive results from the BUS research, walkthroughs and general feedback from the residents.

The development has not been without difficulties however, with one of the properties failing to meet the air tightness requirements and residents complaining of stuffy conditions and poor levels of natural lighting.

One of the most significant aspects was the lack of knowledge and understanding of those on the ground as to the operation of the technology installed, and the ability of the residents to independently control the installed system within their homes. These have been addressed by Connect with new heating controls selected and the handover process being reviewed and potentially improved in the future. This was coupled with installation issues such as uncontrolled circulation and standby losses which can lead to overheating (although not evident from the monitored aspects in the trial), which should be addressed by additional insulation within the plant room on valves and pipework connectors.

Lighting levels have been identified as an area of concern for the residents and is also leading to the need for supplementary lighting in the form of standard or table lamps in many of the flats particularly those at the rear of the development overshadowed by trees. To improve the fixed lighting it is suggested that Connect Housing replace the current energy efficient fixtures with LED lighting; this would significantly improve the lighting level without increasing the energy requirement of the properties.

Education of users and installers has been shown to be important, particularly when individuals are moving from one type of heating system to another and this must be considered for future developments. Similarly, education for the design team is equally important with aspects such as cold entrance halls in upstairs flats, poor lighting and difficult controls needing consideration at the design stage, before implementation. It is very important that building design is tailored for the specific requirements of the site, rather than using generic design features which are unlikely to be suitable for the tenure within the property or the environmental conditions in which it is to be located.

The SPF of the heat pumps has been lower than expected based on the test standard, however, these are very specific conditions not always experienced in reality. The operating temperatures of the heat pumps are also quite high which decreases the performance of the heat pump. For the space heating the water delivery temperature does not need to be excessive as the system runs underfloor circuits. However, because it also supplies the DHW the output temperatures have been set higher, particularly as one of the properties has complained of cool DHW delivery. It is suggested that the operating temperatures are reduced to improve the performance; potentially using the heat pumps as preheat for a back-up boiler or electric immersion heater in the DHW system. This may require alteration of the plant room but should improve the output of the system.

Integration of technologies should be considered at the design stage, with heating system designers understanding the requirements of the site and the best combination of technologies to satisfy these needs. This is particularly important if optimum operational conditions are different for the installed technologies.

The heat pumps also suffer from a considerable number of starts which increases wear and reduces performance. It is suggested that the settings are altered so that HP1 covers the vast majority of the load with support from HP2 when required. The regular stop/start cycles may also indicate that there is not sufficient water storage to successfully ‘dump’ the heat and thus ensure longevity of heat pump operation. It is suggested that this is further investigated by the heating contractor and should be an area of consideration for the designer in future developments.

Standby electricity used by the heat pumps is reasonably high and thus will be influencing the cost of operation of the heat pumps. Although there will be standby power consumption when the heat pumps are not running, it is likely the high use seen is also related to the circulation pumps. A possible solution to this problem would be to better control the circulation pumps so they are not pumping continuously. Certainly the pumps between the heat pump units and the cylinders could be interlocked to the heat pump operation so they only operate when the heat pump is supplying heat to the storage cylinders.

The back-up systems within the plant room have been found to be unsuccessful throughout the trial period and it has been suggested that this is an important area of consideration for Connect Housing. It is thought that the electric back-up boiler needs to be manually activated in the event of a breakdown and is not on an automatic control system. It is not certain whether the residents are aware of this and certainly there has been no back up operation even when the heat pumps have failed. It is highly recommended that Connect investigate the interaction of the back-up boiler with the heat pump system and if it does require manual intervention ensure that a group of residents or a member(s) of the maintenance team are made aware of this and how to instigate the back-up boiler operation. Alternatively, automatic controls which switch over to the electric boiler in the event of an emergency could be considered and implemented. Again this is an area in which the design team need to focus. If a site is reliant on a centralised plant room, there must be sufficient back-up in the event of a failure and this shouldn’t require the residents to interact with the system; particularly if the residents are elderly.

10 Wider Lessons

Technology Strategy Board guidance on section requirements:	This section should summarise the wider lessons for the industry, including, but not limited to clients, other developers, funders, insurance bodies, skills and training groups, construction team, designers and supply chain members to improve their future approaches to this kind of development. Provide a detailed insight in to the emerging lessons. What would you definitely do, not do, or do differently on a similar project. Include consideration of costs (what might you leave out and how would you make things cheaper); improvement of the design process (better informed design decisions, more professional input, etc.) and improvements of the construction process (reduce timescale, smooth operation, etc.). What lessons have been learned that will benefit the participants' businesses in terms of innovation, efficiency or increased opportunities? These lessons need to be disseminated through trade bodies, professional Institutions, representation on standards bodies, best practice clubs etc. Please detail how dissemination will be carried out for this project. As far as possible these lessons should be put in layman's terms to ensure effective communication with a broad industry audience.

10.1 Wider Implications of the findings from this study

The aspects listed in Section 9 above are predominantly focused on the specific requirements of Ancion Court and future developments carried out by Connect Housing. However, there are some wider aspects that can be considered throughout the industry.

10.2 Building & Construction

The building and construction at this development was shown to be of consistent quality. The flats maintain a very comfortable internal temperature and the thermal imaging surveys shows uniform and limited heat loss throughout the building fabric (apart from window trickle vents as would be expected). However, the pressurisation tests did not show the same level of air tightness across the two dwellings, with numerous aspects within Flat B that had not been completed fully. When completing the sealing within the final stages of construction it is important that the smaller details are not forgotten. This includes sealing cable penetrations, skirting and pipe box work; to achieve this several routes may be required:

- It is important that the contractors understand the design specifications they are working to and the requirements within the development to achieve these.
- This may include training sessions to identify the smaller 'finishing touches' which are required to achieve the air tightness required under the regulations/standard specific

to the development on which the work is being carried out. These final touches should not be overlooked.

- It is also important that regular and thorough inspections are carried out during the development and construction phases to check that these aspects are being considered and completed as necessary.
- It may be worthwhile carrying out additional pressurisation tests (where practical) to review the progress of the development and enable changes to be made as required.

Although the above will resolve problems with current building practices it can also be argued that refining the initial design process should lead to improvements in the building detail and thus these remedial sealing options should not be required. The original design specification should be robust enough that subsequent sealing is not required or only needed in minor areas.

A significant problem at Ancion Court was the lack of understanding of the operation and maintenance of the heat pump system by Connect Housing’s maintenance team and the users at the development. This will inevitably lead to problems when using and repairing the system in the future. Before undertaking a new development particularly when considering new technologies, such as heat pumps, it is essential that the correct contractors are selected based on their knowledge and experience of the required systems. This may mean using multiple contractors to complete the development and if so there should be very clear and transparent lines of communication between these companies to ensure the needs of each party is met. If difficult/complex technologies are being implemented, as is likely as the housing industry strives to meet tighter energy requirements, it is essential that the correct operating and installation practices are carried out to ensure optimum performance. It is very important that the installers understand the technology and communicate specific requirements to other contractors within the build process. An example of this may be the need for low operating temperatures to optimise the performance of a heat pump system thus ensuring the demands of hot water requirements can be achieved using supporting technologies. It is also important that contractual documentation between client and sub-contractors outlines the need for a ‘competent’ person to be appointed to oversee the development of future projects, including system design, installation and commissioning. This may highlight the need for future industry-wide training if skills gaps are evident.

10.3 Human Factors

Since occupation, Connect Housing have held regular dissemination meetings with the residents association at Ancion Court ensuring a good flow of information is maintained between the occupants of the development and Connect Housing staff. This has been very useful in identifying problems within the development such as difficulties with heating controls and poor levels of natural light. This was also supported by a specific Energy Day held within the development which provided information to the householders as to the heating system installed and its operation, as well as providing a feedback mechanism to decide on replacement heating controls; now to be implemented in future developments. This interaction has, on the whole, worked well and should be continued at this development and future developments.

However, it is has also been identified that there was a lack of information particularly regarding some of the design aspects during the development stage of the project. This has brought to light the need for a 'Soft Landings' approach for future projects. Whereby information is disseminated throughout the design, construction, commissioning, and user groups, to ensure full understanding of the development throughout the process. This is particularly important at the design stage.

Relating to transfer of knowledge throughout the design and development team is the necessity to fully understand the needs of the end users before design and construction takes place. It was discussed within this project that some of the fixtures and fittings such as the kitchen storage, stairs and height of the toilet were not suitable for elderly individuals. Of particular importance was the location of windows and window vents which were difficult to reach particularly in the kitchen and especially for those with mobility problems. These should have been considered and altered when designing for this tenure of occupant; what works for one group is not necessarily suitable for all tenure types and it is important that this is considered through detailed review of the designs before construction takes place.

Consideration must also be given to the level and structure of information given to the end user on completion and occupation. Connect Housing have already considered this and are opting for a far more user friendly handover pack for future developments. This is an important aspect when considering the ease of handover and occupation as most residents do not want large and highly detailed instruction manuals to understand how to 'live' in their properties. Short, concise and informative documents should be sufficient for any new occupant entering a new development, with a clear line of enquiry for further information and to answer any questions the new user may have.

11 Appendices

Technology Strategy Board guidance on section requirements:	The appendices are likely to include the following documents: • Details on commissioning of systems and technologies through appending of the document *BPE_Domestic_commissioning sheets.doc* • Initial energy consumption data and analysis (including demand profiles where available) • Further detail or attachment of anonymised documents • Additional photographs, drawings, and relevant schematics • Background relevant papers

Appendix A

In-*situ* U-Value Measurement Report

In-*situ* U-Value Measurement

Exterior Kitchen Wall, Flat 4, Ancion Court
Clough Lea, Marsden, HD7 6BA

Ref: MC 05-12-28525 4AC U1
Issue Date: 8th April 2013

Prepared for:
Georgina Orr
Kiwa GASTEC at CRE

Prepared by:
Marc Cowlin
Stroma Technology

Stroma Technology, Unit 4, Pioneer Way, Whitwood, Castleford, WF10 5QU.
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Contents

U-Value Measurement Report

Introduction

Stroma Technology has been commissioned by Kiwa GASTEC at CRE to conduct an in-*situ* measurement of U-Value of the exterior Kitchen wall of the communal Kitchen located within Flat 4, Ancion Court, Clough Lea, Marsden.

The heat-flux measurements were recorded over a period of 4+ weeks, with the sensors located on Southern Wall, to the left of the westernmost window.

The purpose of the exercise was to determine the as-built U-Value.

Details of Equipment

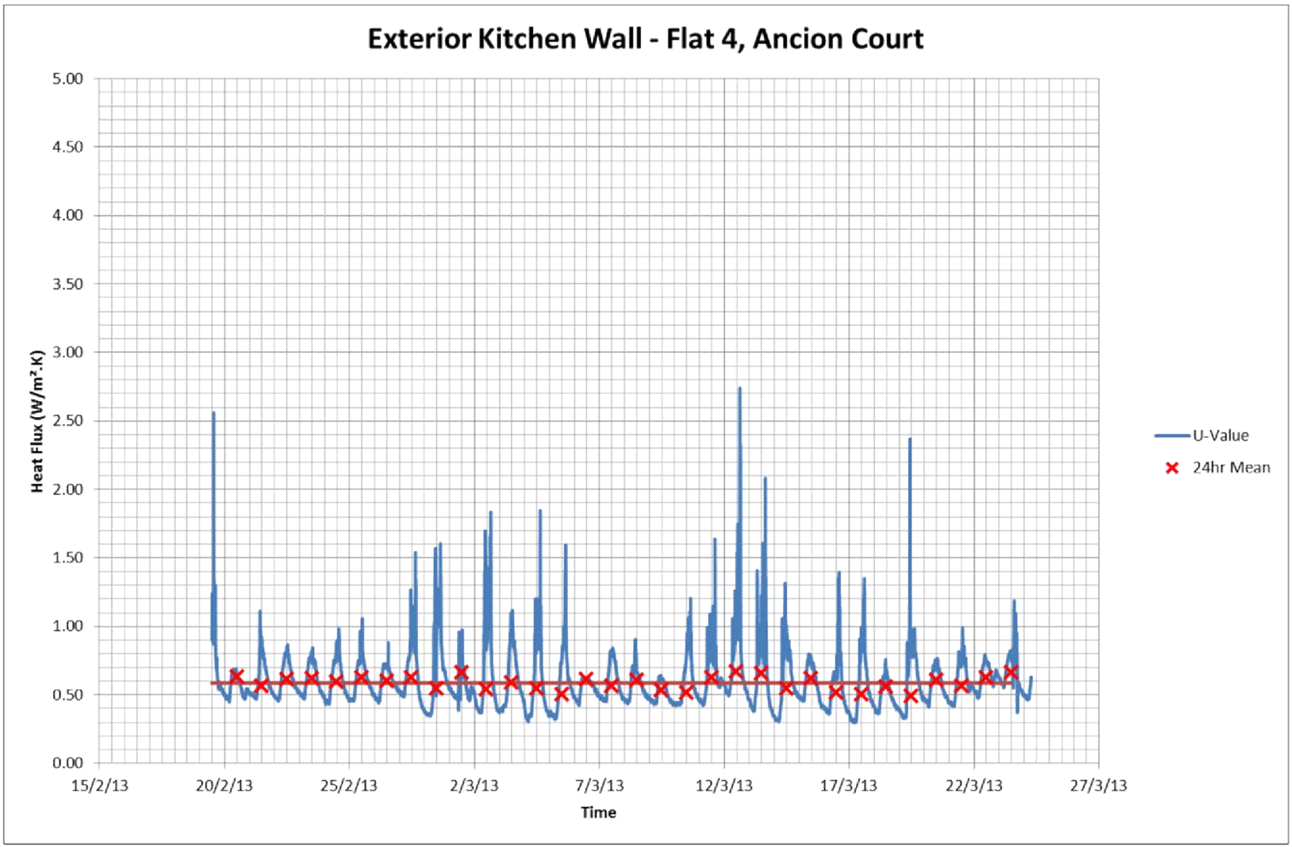
Hukseflux Heat Flux plate HFP01 - serves to measure the heat that flows through the object in which it is incorporated or on which it is mounted.

The actual sensor in HFP01 is a thermopile. This thermopile measures the differential temperature across the ceramics plastic composite body of HFP01. Working completely passively, HFP01 generates a small output voltage proportional to the local heat flux. In addition the local internal and external air temperature is also recorded, which allows the U-Value to be calculated.

Heat flux Data

The following graph plots the heat flow (including the 24hr averages) through the wall against time. The variations in heat flow are due to varying internal and external conditions. The period of logging undertaken was from 19th February 2013 through to 24th March 2013.

During this period 3 separate U-values were calculated with the overall average plotted below.



U-Value Results

Period	U-Value [W/(m².K)]	Variance [%]
19th February to 1st March	0.61	0.8
1st March to 9th March	0.56	3.7
9th March to 24th March	0.58	4.5
Average	***0.58***	***4.5***

Summary

The objective was to measure the U-values of representative sections of wall to a good level of accuracy using purpose-designed “Hukseflux” equipment. These readings were taken over a period of 4+ weeks as the element being reviewed was southern facing. It was found, that the low lying winter Sun in combination with shading by trees, the local topography (hill to the south of the development), and the element under test being located on the ground floor, allowed a quite rapid data convergence.

This in turn made it possible to undertake 3 separate periods of analysis, the overall average value obtained was 0.58 W/(m².K).

Appendix B

Air Leakage Audit Report

STROMA TECHNOLOGY

Air Leakage Audit Report

Flats 2 & 15 Ancion Court,
Clough Lea
Marsden HD7 6BA

Ref: 05-12-28525
Issue Date: 23/06/2012

Prepared for:
Ms Laura Storey
Kiwa Limited

Prepared by:
David J Tetchner

Air Tightness Inspection Report

Index

Introduction

This report relates to the recent air-tightness site inspection, the details of which are below. Its purpose was to identify as many potential air-leakage sites and areas or details requiring further consideration or works as possible within the limits of available time and site access/visibility.

Scope and Limitation

It should be noted that the observations and comments in this report are given in good faith and should not be construed as anything other than general advice. Stroma does not accept any form of liability for this advice. As visiting Stroma consultants may not always be fully aware of the designed air-barrier strategy or details, we may include observations relating to visible details that are not actually pertinent to the air-barrier strategy. The comments and observations below should therefore be interpreted and acted on as the Project Team see fit, within the context of their air-barrier strategy.

Extent of Survey	
Areas Surveyed	Flats 2 and 15
Areas Omitted	Areas where furniture and stored items were blocking access.
Reason for Omission	See above.
Hidden air barrier details (that cannot be checked)	Not know at time of inspection
Inaccessible air barrier details	N/A

Air Barrier Overview	
Primary Wall Air-Barrier Layers	Dot and dab walls with block work structural walls.
Primary Roof Air-Barrier Layer	Solid ceiling with coving.
Areas/Rooms taken to be outside of the Air-Barrier	Adjacent flats.

Summary Comments	
Summary of primary concerns	• Sealing between floor and skirting inconsistence around various the rooms. • Flat 15 which was adjacent to cold roof space was unsealed in a number of areas causing cold air ingress. • Unsealed penetrations in both flats, more marked in flat 15 allowing ingress of air to the properties. • Air movement behind dry lining (air barrier), particularly prevalent in flat 15 due to the proximity of the cold roof space, was apparent and any penetration or compromise of the dry lining air leakage was apparent. Flat 2, due to it's location showed much less of this leakage as the flat above server as a barrier. However, the soli and vent penetration appeared to leak, so an fair assumption would be that this is not sealed as it penetrates the outer shell of the property. • Some very minor settlement/drying out cracks within the dry lining were noted of particular note were window cills, where underneath these the wall cavity would be open, thus allowing air to ingress via the wall weep holes.
Summary of general remedial or additional work recommended	• A flexible robust silicone seal should be applied to the floor junction with the skirting. • Under-floor heating manifold pipes in cupboard not sealed at boxing. • Mains water pipe not sealed to floor slab. • Toilet boxing left open, requires boxing in to prevent air ingress from ceiling void. • Check and seal where necessary, all cracks, particularly under window boards.

Picture Number	Flat affected.
1	15
2	15
3	15
4	15
5	15
6	15
7	2 & 15
8	2 & 15
9	2 & 15
10	2 & 15
11	15

Audit Images

Boxing at under-floor heating manifold not sealed in flat 15 at head of stair cupboard.

Cable penetrations into dry-lining unsealed. Flat 15 in head of stairs cupboard.

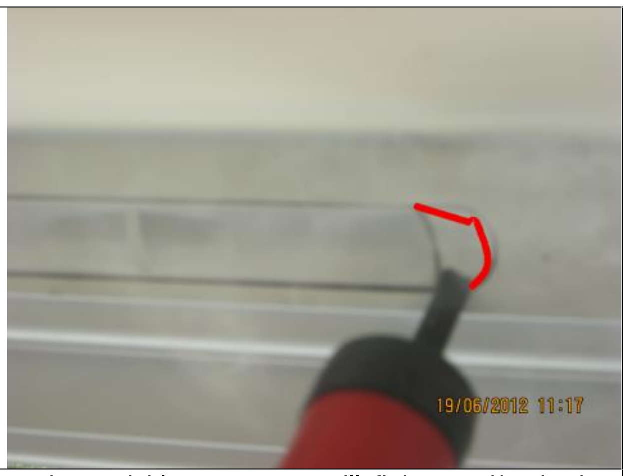
Cold water pipe from loft space penetration unsealed. Flat 15 in head of stairs cupboard.

Unsealed boxing at foot of stairs distribution cupboard. Flat 15

Foot of dry-lining unsealed at foot of stairs distribution cupboard. Flat 15

Breaks in the dry lining at foot of stairs cupboard. Flat 15

Leakage at various points within both flats at the junction of skirting and floor. This had been sealed but mastic sealant was not consistent throughout.



Various trickle vents were ill fitting and/or broken causing the ingress of air. In both flats.

Toilet boxing in both flats were left unsealed allowing air ingress from ceiling void and loft space.

Toilet waste boxing unsealed again, in both flats allowing ingress.

Loft hatches not sealing effectively allow flow of air into property from the cold roof space. Flat 15

Appendix C

Air Test Report – Flat A - (21/06/2012)

STROMA TECHNOLOGY

Air Test Report

2, Ancion Court, Clough Lea
Marsden, HD7 6BA

Ref: DT 05-12-28525 P2 T1
Issue Date: 21st June 2012

Prepared for:
Laura Storey
Kiwa Limited

Prepared by:
David Tetchner

Checked by:
Marc Cowlin

STROMA TECHNOLOGY

Contents

Details of Tested Building

Dwelling Tested:	2, Ancion Court, Clough Lea, Marsden, HD7 6BA	Nett Floor Area, A_F:	63.70 m^2
		Envelope Area, A_E:	202.90 m^2
		Geometry Prepared By:	Jonathan Teale of Stroma
Est. Year Built:	2012	Geometry Verified By:	Laura Storey of Kiwa Limited
Test Date:	19th June 2012		
Building Heating:	Underfloor heating	Test Engineer:	David Tetchner
Building Ventilation:	Natural ventilation		

Interpretation of Results

The airflow rate through the envelope of the building/zone was determined at a pressure differential of 50 Pa; this result is expressed as an airflow rate per m² of building envelope. For more information on the calculations used to determine the air permeability or the air leakage index please visit *www.stroma.com/downloads/air_permeability_calculation.pdf.*

Result & Summary

The dwelling's air permeability was determined by means of two depressurisation tests (with and without the ventilation sealed). The initial normalised air flow at a pressure differential of 50 Pascals (Q_{50}) was established in accordance with the required test methodology of ATTMA TS1. The result attained from these tests were:-

Type A Test (Vents Unsealed): **Air Permeability, AP_{50}: 4.77 m^3.h^{-1}.m^{-2} @ 50 Pa**

Type B Test (Vents Sealed): **Air Permeability, AP_{50}: 4.72 m^3.h^{-1}.m^{-2} @ 50 Pa**

This is below the target level of 5.0 m^3.h^{-1}.m^{-2} at 50 Pa specified.

Attached is the test data and graph generated from our test software, together with a certificate of compliance.

Test Date: 19 June 2012
Test Time: 13:14

Engineer Controlling Test: DT

Test No: 1

Type of Test Undertaken: Depressurisation

Engineer Locations: Inside the building under test.

Pre Test Conditions

Atmospheric Conditions

Windspeed: 0.8 m/s

	Value	Unit	Location of Reading
Internal Temperature #1:	21.7	°C	Kitchen area
Internal Temperature #2:		°C	
Internal Temperature #3:		°C	
Internal Temperature #4:		°C	
Internal Temperature #5:		°C	

External Temperature: 18.8 °C

Barometric Pressure: 995 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	0.3				
	0.1				
	0.0				
	0.0				
	0.1				

	Corrected Values
Average Positive Values, $Dp_{0,1+}$	0.2 Pa
Average Negative Values, $Dp_{0,1-}$	Pa
Total Average Values, $Dp_{0,1}$	0.1 Pa

Post Test Conditions

Atmospheric Conditions

Windspeed: 0.4 m/s

	Value	Unit	Location of Reading
Internal Temperature #1:	20.2	°C	Kitchen area
Internal Temperature #2:		°C	
Internal Temperature #3:		°C	
Internal Temperature #4:		°C	
Internal Temperature #5:		°C	

External Temperature: 18.9 °C

Barometric Pressure: 994 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-0.3				
	-0.5				
	-0.1				
	0.0				
	0.0				

	Corrected Values
Average Positive Values, $Dp_{0,2+}$	Pa
Average Negative Values, $Dp_{0,2-}$	-0.3 Pa
Total Average Values, $Dp_{0,2}$	-0.2 Pa

Average Test Conditions

Corrected Average Internal Temperature: 20.9 °C
Corrected Average External Temperature: 18.8 °C

Corrected Average Barometric Pressure: 996.8 mbar

Internal Air Density, r_i: 1.18 $kg.m^{-3}$
External Air Density, r_e: 1.18 $kg.m^{-3}$

Assumed Relative Humidity: 50%

Summary of Building Test Results

Permeability @ 50 Pa, AP_{50} $m^3.h^{-1}.m^{-2}$	Flow @ 50Pa, Q_{50} $m^3.h^{-1}$	Effective Leakage Area, A m^2	Flow Exponent, n	Flow Coeff, C_{env} $m^3.h^{-1}.Pa^{-n}$	Air Leakage Coeff, C_L $m^3.h^{-1}.Pa^{-n}$	Correlation r^2
4.77	968.2	0.048	0.65	77.15	76.83	0.9992

Calibration Information for Equipment Used

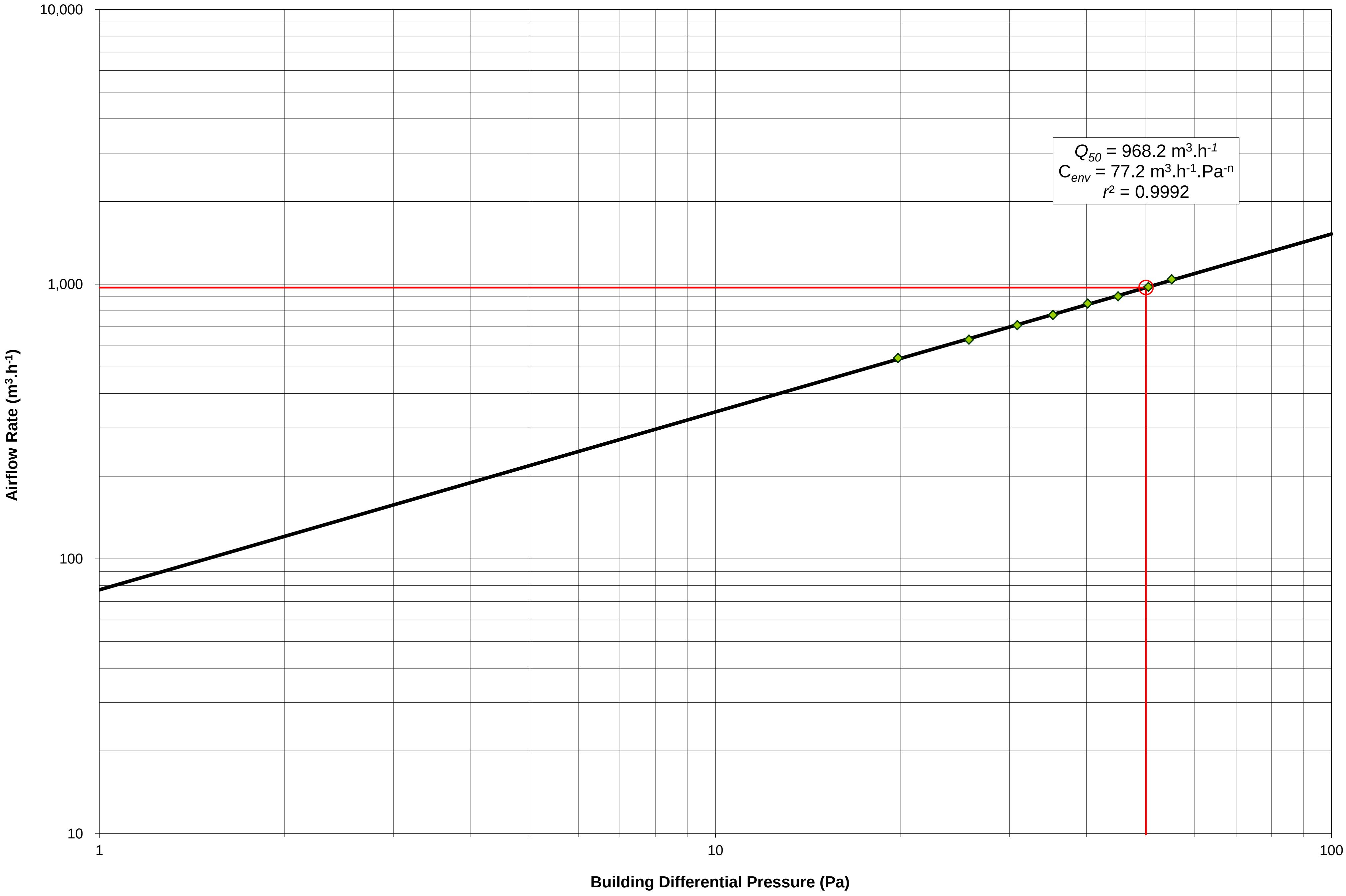
Serial Number	Equipment Type	Calib. Expiry Date
0703-90703-3	Anemometer	14 June 2013
GPB0030	Barometer	14 June 2013
703710	Thermometer	14 June 2013
831207A	Manometer (Build)	14 June 2013
831207B	Manometer (Fan)	14 June 2013
H01143	Fan	14 June 2013

Differential Building Pressures

			$Dp_{0,1}$	Dp_m										$Dp_{0,2}$
Gauge #1:	831207A	Room Pressure	0.1	-19.8	-25.8	-30.9	-35.3	-40.2	-45.0	-50.4	-55.0			-0.2
		Corrected (Pa)	0.1	-19.8	-25.8	-30.9	-35.4	-40.3	-45.1	-50.5	-55.1			-0.2
		Avg Corrected, Dp (Pa):		-19.8	-25.8	-30.9	-35.3	-40.2	-45.0	-50.4	-55.0			

Fan Flow Pressures and Volume Flow Rates

Type	Serial No.	Range	Gauge Ref													
T_5	H01143	Ring C4	831207B	Flow Pressure	Intial Static Pressure Fan Blanked Off	54.3	73.5	93.2	110.3	132.9	149.6	174.7	197.7			Final Static Pressure Fan Blanked Off
				Corrected (Pa)		54.4	73.6	93.3	110.5	133.1	149.8	174.9	198.0			
				Flow, Q_{c1} (m³/s)		0.15	0.17	0.19	0.21	0.23	0.25	0.27	0.29			
				Total Flow, Q_{env} (m³/hr)		538	628	709	773	850	903	978	1,041			
				Error (%)		0.9%	-0.8%	-0.4%	-0.4%	0.7%	-0.6%	0.0%	0.6%			


10,000
1,000
100
10
1
10
100
Q_{50} = 968.2 $m^3.h^{-1}$
C_{env} = 77.2 $m^3.h^{-1}.Pa^{-n}$
r^2 = 0.9992
Airflow Rate ($m^3.h^{-1}$)
Building Differential Pressure (Pa)

Test Date: 19 June 2012
Test Time: 13:14

Engineer Controlling Test: DT

Test No: 1

Type of Test Undertaken: Depressurisation

Engineer Locations: Inside the building under test.

Pre Test Conditions

Atmospheric Conditions

Windspeed: 0.8 m/s

	Value	Unit	Location of Reading
Internal Temperature #1:	21.7	°C	Kitchen area
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Internal Temperature #3:		°C	
Internal Temperature #4:		°C	
Internal Temperature #5:		°C	

External Temperature: 18.8 °C

Barometric Pressure: 995 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	0.3				
	0.5				
	0.2				
	0.6				
	0.4				

	Corrected Values
Average Positive Values, $Dp_{0,1+}$	0.4 Pa
Average Negative Values, $Dp_{0,1-}$	Pa
Total Average Values, $Dp_{0,1}$	0.4 Pa

Post Test Conditions

Atmospheric Conditions

Windspeed: 0.4 m/s

	Value	Unit	Location of Reading
Internal Temperature #1:	20.2	°C	Kitchen area
Internal Temperature #2:		°C	
Internal Temperature #3:		°C	
Internal Temperature #4:		°C	
Internal Temperature #5:		°C	

External Temperature: 18.9 °C

Barometric Pressure: 994 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	0.4				
	0.9				
	1.0				
	0.4				
	-0.2				

	Corrected Values
Average Positive Values, $Dp_{0,2+}$	0.7 Pa
Average Negative Values, $Dp_{0,2-}$	-0.2 Pa
Total Average Values, $Dp_{0,2}$	0.5 Pa

Average Test Conditions

Corrected Average Internal Temperature: 20.9 °C

Corrected Average External Temperature: 18.8 °C

Corrected Average Barometric Pressure: 996.8 mbar

Internal Air Density, r_i: 1.18 $kg.m^{-3}$

External Air Density, r_e: 1.18 $kg.m^{-3}$

Assumed Relative Humidity: 50%

Summary of Building Test Results

Permeability @ 50 Pa, AP_{50} $m^3.h^{-1}.m^{-2}$	Flow @ 50Pa, Q_{50} $m^3.h^{-1}$	Effective Leakage Area, A m^2	Flow Exponent, n	Flow Coeff, C_{env} $m^3.h^{-1}.Pa^{-n}$	Air Leakage Coeff, C_L $m^3.h^{-1}.Pa^{-n}$	Correlation r^2
4.72	957.6	0.048	0.66	72.97	72.67	0.9992

Calibration Information for Equipment Used

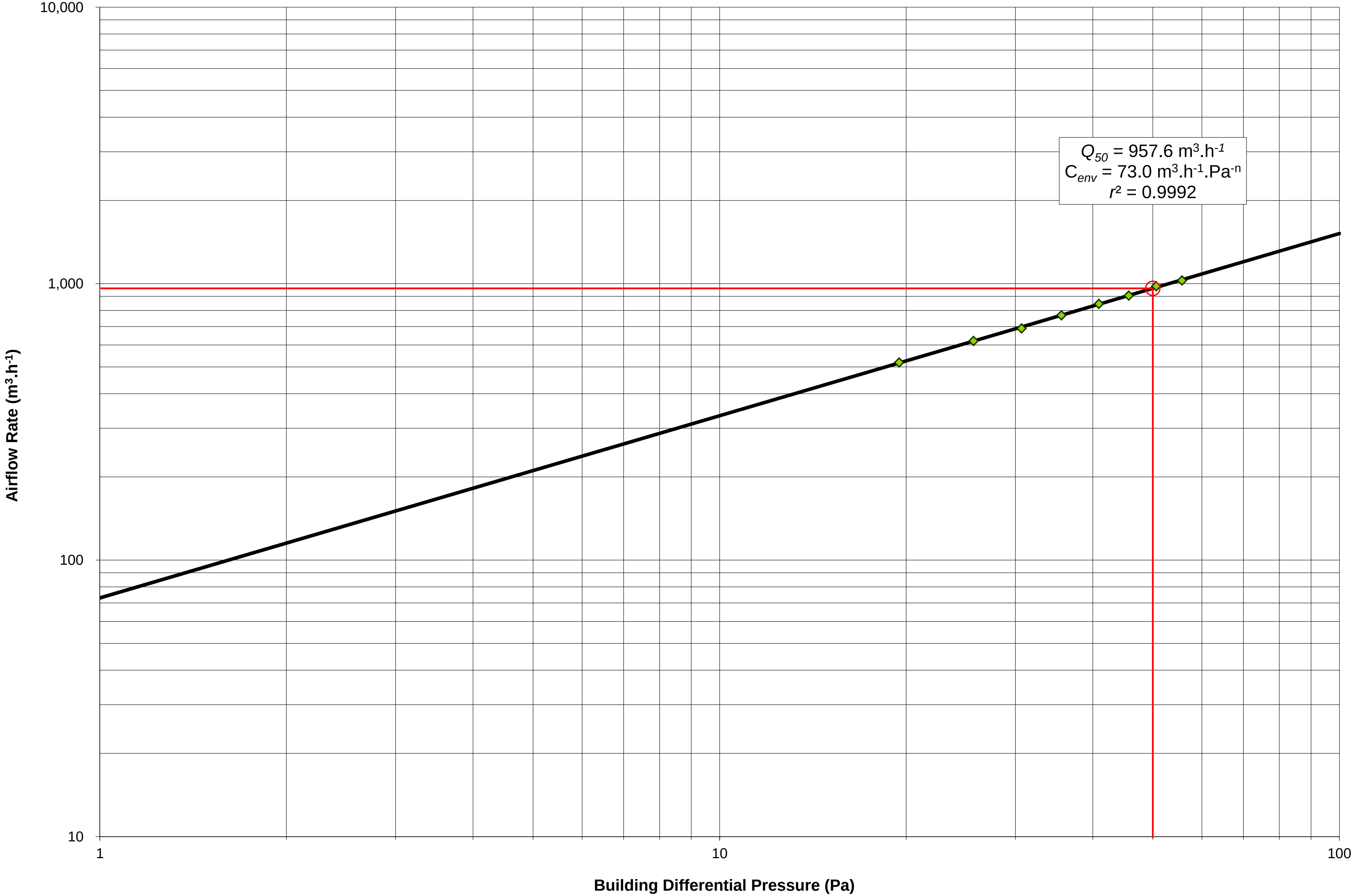
Serial Number	Equipment Type	Calib. Expiry Date
0703-90703-3	Anemometer	14 June 2013
GPB0030	Barometer	14 June 2013
703710	Thermometer	14 June 2013
831207A	Manometer (Build)	14 June 2013
831207B	Manometer (Fan)	14 June 2013
H01143	Fan	14 June 2013

Differential Building Pressures

			$Dp_{0,1}$	Dp_m										$Dp_{0,2}$
Gauge #1:	831207A	Room Pressure	0.4	-19.0	-25.2	-30.2	-35.1	-40.4	-45.2	-50.1	-55.2			0.5
		Corrected (Pa)	0.4	-19.0	-25.2	-30.2	-35.2	-40.5	-45.3	-50.2	-55.3			0.5
		Avg Corrected, Dp (Pa):		-19.5	-25.7	-30.7	-35.6	-40.9	-45.7	-50.6	-55.7			

Fan Flow Pressures and Volume Flow Rates

Type	Serial No.	Range	Gauge Ref													
T_5	H01143	Ring C4	831207B	Flow Pressure	Intial Static Pressure Fan Blanked Off	50.5	71.8	88.1	108.9	131.5	150.4	175.4	192.3			Final Static Pressure Fan Blanked Off
				Corrected (Pa)		50.6	71.9	88.2	109.1	131.7	150.6	175.6	192.6			
				Flow, Q_{c1} (m^3/s)		0.14	0.17	0.19	0.21	0.23	0.25	0.27	0.28			
				Total Flow, Q_{env} (m^3/hr)		519	621	689	768	846	906	980	1,027			
				Error (%)		0.4%	0.1%	-1.2%	-0.1%	0.4%	-0.1%	1.0%	-0.6%			


Q_{50} = 957.6 $m^3.h^{-1}$
C_{env} = 73.0 $m^3.h^{-1}.Pa^{-n}$
r^2 = 0.9992
10,000
1,000
100
10
1
10
100
Airflow Rate ($m^3.h^{-1}$)
Building Differential Pressure (Pa)

Certificate of Air Permeability Test

Issued By Stroma Technology Ltd

UKAS TESTING
2731

Details of Test

Dwelling tested:	2, Ancion Court, Clough Lea, Marsden, HD7 6BA	Nett Floor Area, A_F:	63.70 m^2
		Envelope Area, A_E:	202.90 m^2
On behalf of:	Kiwa Limited	Geometry Prepared by:	Jonathan Teale of Stroma
Test Date:	19th June 2012	Geometry Verified by:	Laura Storey of Kiwa Limited
Certificate Date:	21st June 2012	Certificate No.:	DT 05-12-28525 P2 T1

Test Conditions and Temporary Sealing at the Time of both Tests

	Type A Response	*Type B Response*
All external doors and windows closed?	Yes	Yes
All internal doors open?	Yes	Yes
All extracts sealed? Inc. kitchen and bathroom(s) extracts and the oven hood.	Yes	No
Temporary seals to drains, plugs, or overflows?	No	Yes
Combustion appliances turned off, and sealed? If located in the conditioned space of the dwelling and it is not a balanced?	Yes	Yes
Trickle vents and/or passive ventilation temporary sealed?	No	No
Fireplace temporary sealed?	N/A	N/A
All building works completed to the air boundary envelope?	Yes	Yes

Deviation(s) from ATTMA TS1

None

Test Results and Performance Characteristics

This is to certify that the above named building has been tested for air permeability in accordance with ATTMA TS1 undertaken with the conditions stated above.

The Key Leakage Characteristics of the dwelling are:

	Type A Test (Vents Unsealed)	*Type B Test (Vents Sealed)*
Air Permeability, AP_{50}:	**4.77 $m^3.h^{-1}.m^{-2}$ @ 50 Pa**	**4.72 $m^3.h^{-1}.m^{-2}$ @ 50 Pa**
Effective Leakage Area:	0.048 m² @ 50 Pa	0.048 m² @ 50 Pa
Correlation of results, r^2:	0.9992	0.9992
Slope, n:	0.65	0.66
Air Flow Coefficient, C_{env}:	77.15 $m^3.h^{-1}.Pa^{-n}$	72.97 $m^3.h^{-1}.Pa^{-n}$
Intercept, C_L:	76.83 $m^3.h^{-1}.Pa^{-n}$	72.67 $m^3.h^{-1}.Pa^{-n}$

Signed: D Tetchner   Name: David Tetchner   Position: Engineer

On Behalf of Stroma Technology Ltd.

Appendix D

Air Test Report – Flat A - (11/09/2014)

Air Test Report

2, Ancion Court, Clough Lea
Marsden, HD7 6BA

Ref: DT 05-12-28525 P2 T2
Issue Date: 11th September 2014

Prepared for:
Mrs Doreen Kelly
Kiwa Limited

Prepared by:
David Tetchner

Checked by:
Jon Robinson

Stroma Technology, 6 Silkwood Business Park, Fryers Way, Wakefield, West Yorkshire, WF5 9TJ.
t: 0845 621 2222   f: 0845 621 1112   e: info@stroma.com   w: stroma.com

STROMA TECHNOLOGY

Contents

Details of Tested Building

Dwelling Tested:	2, Ancion Court, Clough Lea, Marsden, HD7 6BA	Nett Floor Area, A_F:	63.70 m^2
		Envelope Area, A_E:	202.90 m^2
		Geometry Prepared By:	Jonathan Teale of Stroma
Est. Year Built:	2014	Geometry Verified By:	Laura Storey
Test Date:	8th September 2014		of Kiwa Limited
Building Heating:	Underfloor heating	Test Method:	B (Building envelope)
Building Ventilation:	Natural ventilation	Test Engineer:	David Tetchner

Interpretation of Results

The airflow rate through the envelope of the building/zone was determined at a pressure differential of 50 Pa; this result is expressed as an airflow rate per m² of building envelope. For more information on the calculations used to determine the air permeability or the air leakage index please visit *www.stroma.com/downloads/air_permeability_calculation.pdf.*

Result & Summary

The dwelling's air permeability was determined by means of two depressurisation tests (with and without the ventilation sealed). The initial normalised air flow at a pressure differential of 50 Pascals (*Q*) was established in accordance with the required test methodology of ATTMA TS1. The result attained from these tests were:-

Type A Test (Vents Unsealed): **Air Permeability, AP_{50}:** ***4.83 $m^3.h^{-1}.m^{-2}$ @ 50 Pa***
Type B Test (Vents Sealed): **Air Permeability, AP_{50}** **4.77 $m^3.h^{-1}.m^{-2}$ @ 50 Pa**

This is below the target level of 5.0 $m^3.h^{-1}.m^{-2}$ at 50 Pa specified. Thus the building complies with this part of the requirements.

Attached is the test data and graph generated from our test software, together with a certificate of compliance.

Test Date: 8 September 2014
Test Time: 16:47

Engineer Controlling Test: DT

Test No: 2

Type of Test Undertaken: Depressurisation

Engineer Locations: Inside the building under test.

Pre Test Conditions

Atmospheric Conditions

	Value	Unit	Location of Reading
Internal Temperature #1:	22.9	°C	Kitchen area
Internal Temperature #2:		°C	
Internal Temperature #3:		°C	
Internal Temperature #4:		°C	
Internal Temperature #5:		°C	

External Temperature: 16.7 °C

Barometric Pressure: 997 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-0.2				
	-0.3				
	-0.3				
	-0.4				
	-0.3				

Corrected Values

Average Positive Values, $\Delta p_{0,1+}$		Pa
Average Negative Values, $\Delta p_{0,1-}$	-0.3	Pa
Total Average Values, $\Delta p_{0,1}$	-0.3	Pa

Post Test Conditions

Atmospheric Conditions

	Value	Unit	Location of Reading
Internal Temperature #1:	22.7	°C	Kitchen area
Internal Temperature #2:		°C	
Internal Temperature #3:		°C	
Internal Temperature #4:		°C	
Internal Temperature #5:		°C	

External Temperature: 16.5 °C

Barometric Pressure: 997 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	0.0				
	0.1				
	0.1				
	-0.1				
	-0.2				

Corrected Values

Average Positive Values, $\Delta p_{0,2+}$	0.1	Pa
Average Negative Values, $\Delta p_{0,2-}$	-0.1	Pa
Total Average Values, $\Delta p_{0,2}$	0.0	Pa

Average Test Conditions

Corrected Average Internal Temperature: 22.7 °C

Corrected Average External Temperature: 16.4 °C

Corrected Average Barometric Pressure: 1,000.5 mbar

Internal Air Density, ρ_i: 1.17 $kg.m^{-3}$

External Air Density, ρ_e: 1.20 $kg.m^{-3}$

Assumed Relative Humidity: 50%

Summary of Building Test Results

Permeability @ 50 Pa, AP_{50} $m^3.h^{-1}.m^{-2}$	Flow @ 50Pa, Q_{50} $m^3.h^{-1}$	Effective Leakage Area, A m^2	Flow Exponent, n	Flow Coeff, C_{env} $m^3.h^{-1}.Pa^{-n}$	Air Leakage Coeff, C_L $m^3.h^{-1}.Pa^{-n}$	Correlation r^2
4.83	980.1	0.049	0.65	76.48	76.49	0.9999

Calibration Information for Equipment Used

Serial Number	Equipment Type	Calib. Expiry Date
0703-90703-3	Anemometer	5 June 2015
GPB0030	Barometer	5 June 2015
627846	Thermometer	5 June 2015
831207A	Manometer (Build)	5 June 2015
831207B	Manometer (Fan)	5 June 2015
H01143	Fan	5 June 2015

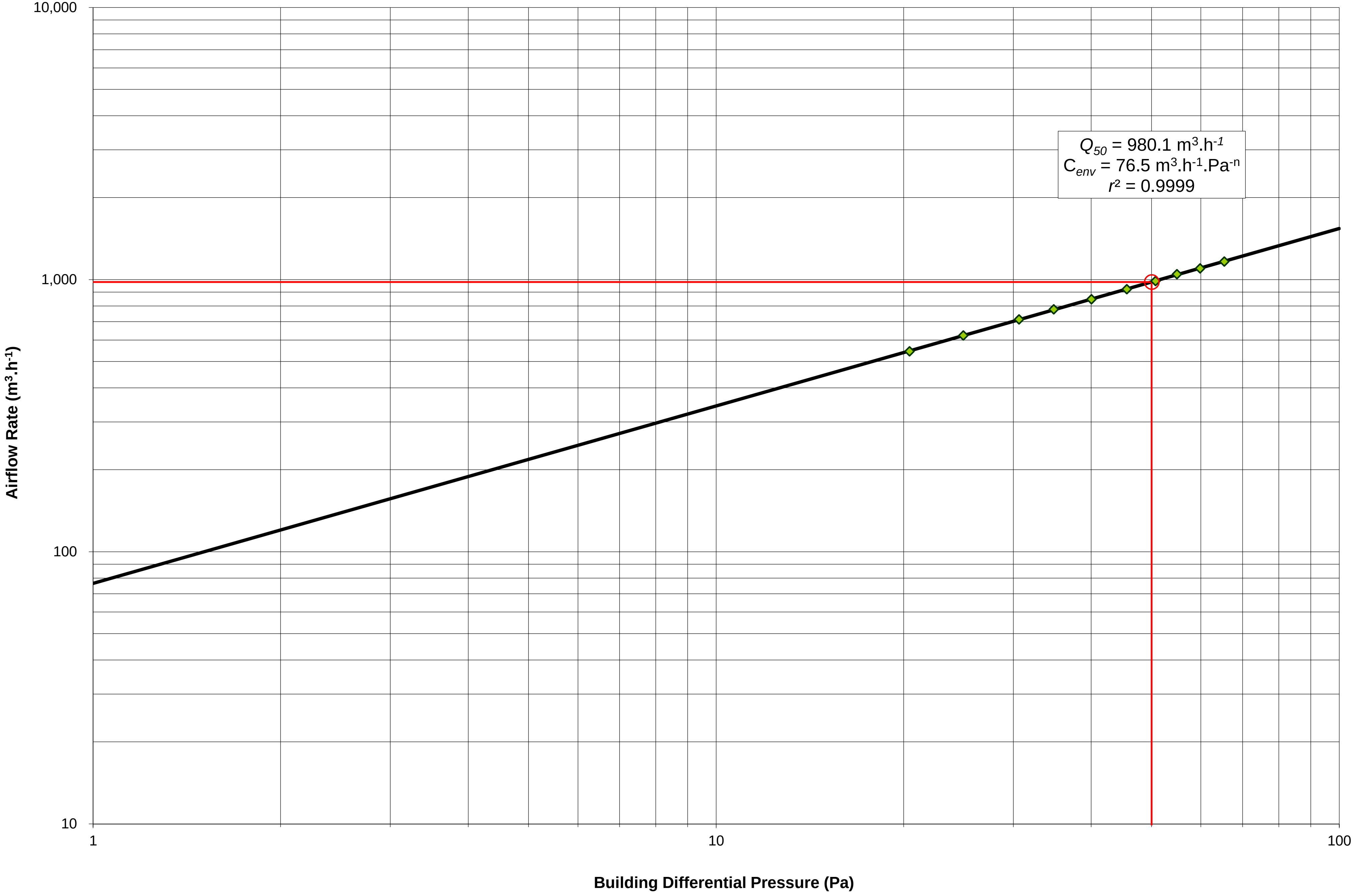
Differential Building Pressures

			$\Delta p_{0,1}$	Δp_m										$\Delta p_{0,2}$
Gauge #1:	831207A	Room Pressure	-0.3	-20.6	-25.1	-30.8	-35.0	-40.2	-45.8	-50.9	-55.1	-60.0	-65.6	0.0
		Corrected (Pa)	-0.3	-20.6	-25.1	-30.8	-35.0	-40.2	-45.8	-50.9	-55.1	-60.0	-65.6	0.0
		Avg Corrected, Δp (Pa):		-20.4	-24.9	-30.6	-34.8	-40.0	-45.6	-50.7	-54.9	-59.8	-65.4	

Fan Flow Pressures and Volume Flow Rates

Type	Serial No.	Range	Gauge Ref
T_5	H01143	Ring C4	831207B

	Intial Static Pressure Fan Blanked Off											Final Static Pressure Fan Blanked Off
Flow Pressure		55.4	72.1	94.0	111.1	131.7	155.3	177.6	198.9	219.5	245.8	
Corrected (Pa)		55.6	72.4	94.3	111.5	132.2	155.8	178.2	199.6	220.3	246.7	
Flow, Q_{c1} (m³/s)		0.15	0.17	0.20	0.22	0.24	0.26	0.27	0.29	0.31	0.32	
Total Flow, Q_{env} (m³/hr)		545	623	714	777	848	922	987	1,046	1,100	1,165	
Error (%)		-0.4%	0.1%	0.2%	0.4%	0.0%	-0.1%	-0.2%	0.4%	-0.1%	-0.2%	


10,000
1,000
100
10
Airflow Rate (m3.h-1)
1
10
100
Building Differential Pressure (Pa)
Q50 = 980.1 m3.h-1
Cenv = 76.5 m3.h-1.Pa-n
r² = 0.9999

Test Date: 8 September 2014
Test Time: 16:47

Engineer Controlling Test: DT

Test No: 2

Type of Test Undertaken: Depressurisation

Engineer Locations: Inside the building under test.

Pre Test Conditions

Atmospheric Conditions

	Value	Unit	Location of Reading
Internal Temperature #1:	22.8	°C	Kitchen area
Internal Temperature #2:		°C	
Internal Temperature #3:		°C	
Internal Temperature #4:		°C	
Internal Temperature #5:		°C	

External Temperature: 16.8 °C

Barometric Pressure: 997 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-0.1				
	0.0				
	0.0				
	-0.1				
	-0.1				

	Corrected Values
Average Positive Values, $\Delta p_{0,1+}$	Pa
Average Negative Values, $\Delta p_{0,1-}$	-0.1 Pa
Total Average Values, $\Delta p_{0,1}$	-0.1 Pa

Post Test Conditions

Atmospheric Conditions

	Value	Unit	Location of Reading
Internal Temperature #1:	22.7	°C	Kitchen area
Internal Temperature #2:		°C	
Internal Temperature #3:		°C	
Internal Temperature #4:		°C	
Internal Temperature #5:		°C	

External Temperature: 16.6 °C

Barometric Pressure: 997 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	0.4				
	-0.1				
	0.0				
	0.0				
	-0.1				

	Corrected Values
Average Positive Values, $\Delta p_{0,2+}$	0.4 Pa
Average Negative Values, $\Delta p_{0,2-}$	-0.1 Pa
Total Average Values, $\Delta p_{0,2}$	0.0 Pa

Average Test Conditions

Corrected Average Internal Temperature: 22.6 °C

Corrected Average External Temperature: 16.5 °C

Corrected Average Barometric Pressure: 1,000.5 mbar

Internal Air Density, ρ_i: 1.17 $kg.m^{-3}$

External Air Density, ρ_e: 1.20 $kg.m^{-3}$

Assumed Relative Humidity: 50%

Summary of Building Test Results

Permeability @ 50 Pa, AP_{50} $m^3.h^{-1}.m^{-2}$	Flow @ 50Pa, Q_{50} $m^3.h^{-1}$	Effective Leakage Area, A m^2	Flow Exponent, n	Flow Coeff, C_{env} $m^3.h^{-1}.Pa^{-n}$	Air Leakage Coeff, C_L $m^3.h^{-1}.Pa^{-n}$	Correlation r^2
4.77	966.9	0.048	0.63	82.17	82.17	0.9993

Calibration Information for Equipment Used

Serial Number	Equipment Type	Calib. Expiry Date
0703-90703-3	Anemometer	5 June 2015
GPB0030	Barometer	5 June 2015
627846	Thermometer	5 June 2015
831207A	Manometer (Build)	5 June 2015
831207B	Manometer (Fan)	5 June 2015
H01143	Fan	5 June 2015

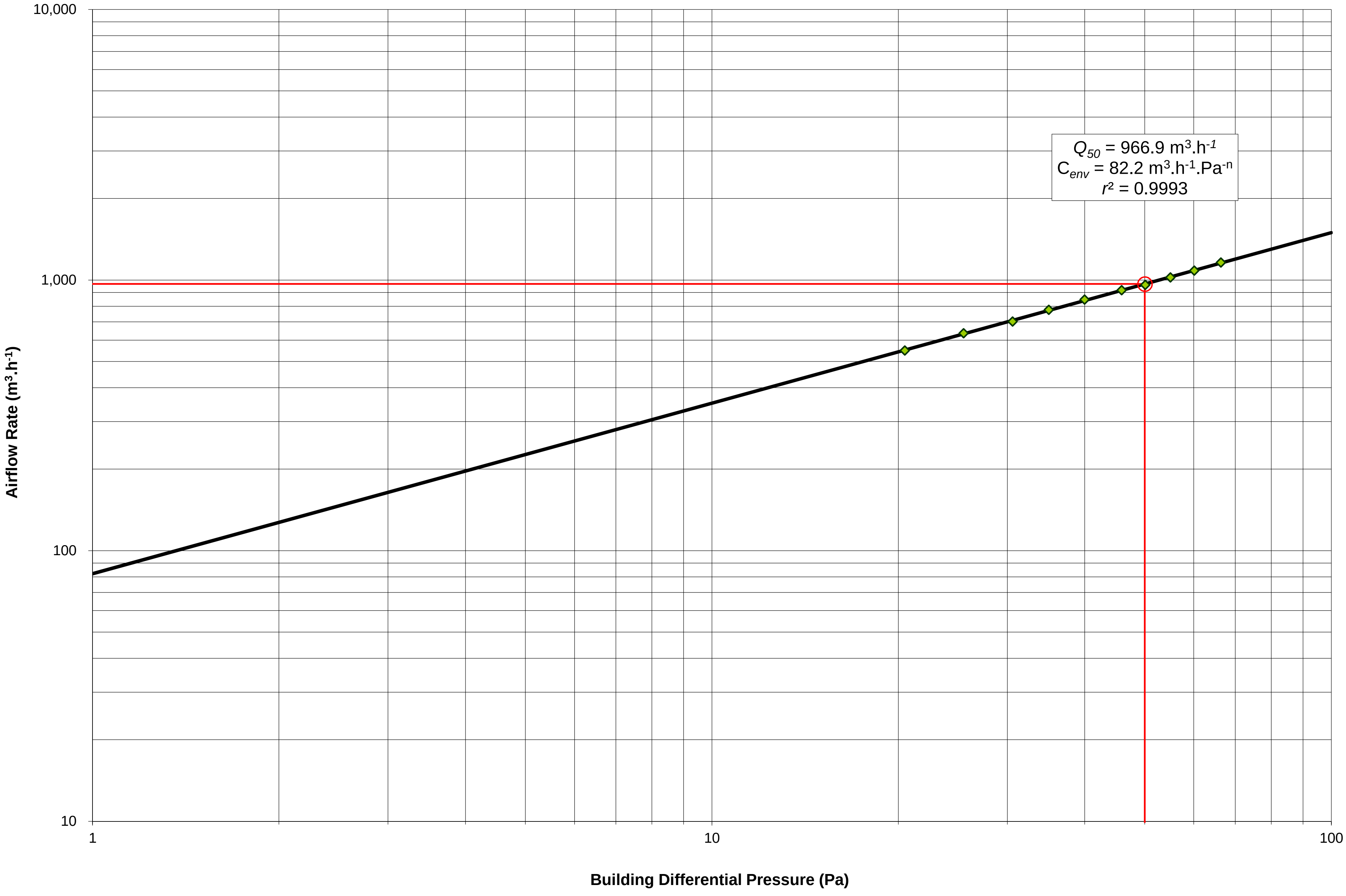
Differential Building Pressures

		$\Delta p_{0,1}$	Δp_m										$\Delta p_{0,2}$
Gauge #1: 831207A	Room Pressure	-0.1	-66.4	-60.1	-55.0	-50.1	-45.9	-40.0	-35.0	-30.6	-25.5	-20.5	0.0
	Corrected (Pa)	-0.1	-66.4	-60.1	-55.0	-50.1	-45.9	-40.0	-35.0	-30.6	-25.5	-20.5	0.0
	Avg Corrected, Δp (Pa):		-66.4	-60.1	-55.0	-50.1	-45.9	-40.0	-35.0	-30.6	-25.5	-20.5	

Fan Flow Pressures and Volume Flow Rates

Type	Serial No.	Range	Gauge Ref
T_5	H01143	Ring C4	831207B

	Intial Static Pressure Fan Blanked Off											Final Static Pressure Fan Blanked Off
Flow Pressure		244.1	213.1	189.9	168.0	153.7	131.6	110.7	91.1	75.0	56.3	
Corrected (Pa)		245.0	213.8	190.6	168.6	154.2	132.1	111.1	91.4	75.3	56.5	
Flow, Q_{c1} (m^3/s)		0.32	0.30	0.28	0.27	0.25	0.24	0.22	0.19	0.18	0.15	
Total Flow, Q_{env} (m^3/hr)		1,162	1,084	1,022	960	917	847	776	702	636	549	
Error (%)		0.5%	-0.2%	-0.4%	-0.8%	0.2%	0.9%	0.5%	-1.0%	0.6%	-0.3%	


Q_{50} = 966.9 $m^3.h^{-1}$
C_{env} = 82.2 $m^3.h^{-1}.Pa^{-n}$
r^2 = 0.9993
10,000
1,000
100
10
1
10
100
Airflow Rate ($m^3.h^{-1}$)
Building Differential Pressure (Pa)

Certificate of Air Permeability Test

Issued By Stroma Technology Ltd

Details of Test

Dwelling tested:	2, Ancion Court, Clough Lea, Marsden, HD7 6BA	Nett Floor Area, A_F:	63.70 m^2
		Envelope Area, A_E:	202.90 m^2
On behalf of:	Kiwa Limited	Geometry Prepared by:	Jonathan Teale of Stroma
Test Date:	8th September 2014	Geometry Verified by:	Laura Storey of Kiwa Limited
Certificate Date:	11th September 2014	Certificate No.:	DT 05-12-28525 P2 T2

Test Conditions and Temporary Sealing at the Time of Test

	Type A Response	*Type B Response*
All external doors and windows closed?	Yes	Yes
All internal doors open?	Yes	Yes
All extracts sealed? Inc. kitchen and bathroom(s) extracts and the oven hood.	No	Yes
Temporary seals to drains, plugs, or overflows?	No	No
Combustion appliances turned off, and sealed? If located in the conditioned space of the dwelling and it is not a balanced?	Yes	Yes
Trickle vents and/or passive ventilation temporary sealed?	No	No
Fireplace temporary sealed?	N/A	N/A
All building works completed to the air boundary envelope?	Yes	Yes

Deviation(s) from ATTMA TSL1

None

Test Result and Performance Characteristics

This is to certify that the above named building has been tested for air permeability in accordance with ATTMA TSL1 undertaken with the conditions stated above, with the exception of the deviation(s) stated above.

The Key Leakage Characteristics of the dwelling are:

	Type A test (vents unsealed)	Type B Test (vents sealed)
Air Permeability, AP_{50}:	**4.83 $m^3.h^{-1}.m^{-2}$ @ 50 Pa**	**4.77 $m^3.h^{-1}.m^{-2}$ @ 50 Pa**
Effective Leakage Area:	0.049 m^2 @ 50 Pa	0.048 m^2 @ 50 Pa
Correlation of results, r^2:	0.9999	0.9993
Slope, n:	0.65	0.63
Air Flow Coefficient, C_{env}:	76.48 $m^3.h^{-1}.Pa^{-n}$	82.17 $m^3.h^{-1}.Pa^{-n}$
Intercept, C_L:	76.49 $m^3.h^{-1}.Pa^{-n}$	82.17 $m^3.h^{-1}.Pa^{-n}$

Signed: David J Tetchner Name: David Tetchner Position: Engineer

On Behalf of Stroma Technology Ltd.

Appendix E

Air Test Report – Flat B - (21/06/2012)

Air Test Report

15, Ancion Court, Clough Lea
Marsden, HD7 6BA

Ref: DT 05-12-28525 P15 T1
Issue Date: 21st June 2012

Prepared for:
Laura Storey
Kiwa Limited

Prepared by:
David Tetchner

Checked by:
Marc Cowlin

Stroma Technology, Unit 4, Pioneer Way, Pioneer Business Park, Castleford, WF10 5QU.
t: 0845 621 1111   f: 0845 621 1112   e: info@stroma.com   w: stroma.com

STROMA TECHNOLOGY

Contents

Details of Tested Building

Dwelling Tested:	15, Ancion Court, Clough Lea, Marsden, HD7 6BA	Nett Floor Area, A_F:	55.50 m^2
		Envelope Area, A_E:	181.60 m^2
		Geometry Prepared By:	Jonathan Teale of Stroma
Est. Year Built:	2012	Geometry Verified By:	Laura Storey
Test Date:	19th June 2012		of Kiwa Limited
Building Heating:	Underfloor heating	Test Engineer:	David Tetchner
Building Ventilation:	Natural ventilation		

Interpretation of Results

The airflow rate through the envelope of the building/zone was determined at a pressure differential of 50 Pa; this result is expressed as an airflow rate per m² of building envelope. For more information on the calculations used to determine the air permeability or the air leakage index please visit *www.stroma.com/downloads/air_permeability_calculation.pdf.*

Result & Summary

The dwelling's air permeability was determined by means of two depressurisation tests (with and without the ventilation sealed). The initial normalised air flow at a pressure differential of 50 Pascals (Q_{50}) was established in accordance with the required test methodology of ATTMA TS1. The result attained from these tests were:-

Type A Test (Vents Unsealed): **Air Permeability, AP_{50}: 7.70 m^3.h^{-1}.m^{-2} @ 50 Pa**

Type B Test (Vents Sealed): **Air Permeability, AP_{50}: 7.66 m^3.h^{-1}.m^{-2} @ 50 Pa**

This is above the target level of 5.0 m^3.h^{-1}.m^{-2} at 50 Pa specified.

Attached is the test data and graph generated from our test software.

Test Date: 19 June 2012
Test Time: 11:29

Engineer Controlling Test: DT

Test No: 1

Type of Test Undertaken: Depressurisation

Engineer Locations: Inside the building under test.

Pre Test Conditions

Atmospheric Conditions

Windspeed: 1.3 m/s

	Value	Location of Reading
Internal Temperature #1:	21.3 °C	Kitchen Area
Internal Temperature #2:	°C	
Internal Temperature #3:	°C	
Internal Temperature #4:	°C	
Internal Temperature #5:	°C	

External Temperature: 16.8 °C

Barometric Pressure: 994 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-0.9				
	-1.2				
	-1.7				
	-1.9				
	-1.2				

	Corrected Values
Average Positive Values, $Dp_{0,1+}$	Pa
Average Negative Values, $Dp_{0,1-}$	-1.4 Pa
Total Average Values, $Dp_{0,1}$	-1.4 Pa

Post Test Conditions

Atmospheric Conditions

Windspeed: 1.5 m/s

	Value	Location of Reading
Internal Temperature #1:	22.5 °C	Kitchen Area
Internal Temperature #2:	°C	
Internal Temperature #3:	°C	
Internal Temperature #4:	°C	
Internal Temperature #5:	°C	

External Temperature: 16.9 °C

Barometric Pressure: 994 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-1.7				
	-1.1				
	-2.5				
	-1.1				
	-1.1				

	Corrected Values
Average Positive Values, $Dp_{0,2+}$	Pa
Average Negative Values, $Dp_{0,2-}$	-1.5 Pa
Total Average Values, $Dp_{0,2}$	-1.5 Pa

Average Test Conditions

Corrected Average Internal Temperature: 21.9 °C
Corrected Average External Temperature: 16.8 °C

Corrected Average Barometric Pressure: 996.7 mbar

Internal Air Density, r_i: 1.17 $kg.m^{-3}$
External Air Density, r_e: 1.19 $kg.m^{-3}$

Assumed Relative Humidity: 50%

Summary of Building Test Results

Permeability @ 50 Pa, *AP* $_{50}$ $m^3.h^{-1}.m^{-2}$	Flow @ 50Pa, *Q* $_{50}$ $m^3.h^{-1}$	Effective Leakage Area, *A* m^2	Flow Exponent, *n*	Flow Coeff, *C* $_{env}$ $m^3.h^{-1}.Pa^{-n}$	Air Leakage Coeff, *C* $_L$ $m^3.h^{-1}.Pa^{-n}$	Correlation r^2
7.70	1,398	0.070	0.64	113.9	113.7	0.9914

Calibration Information for Equipment Used

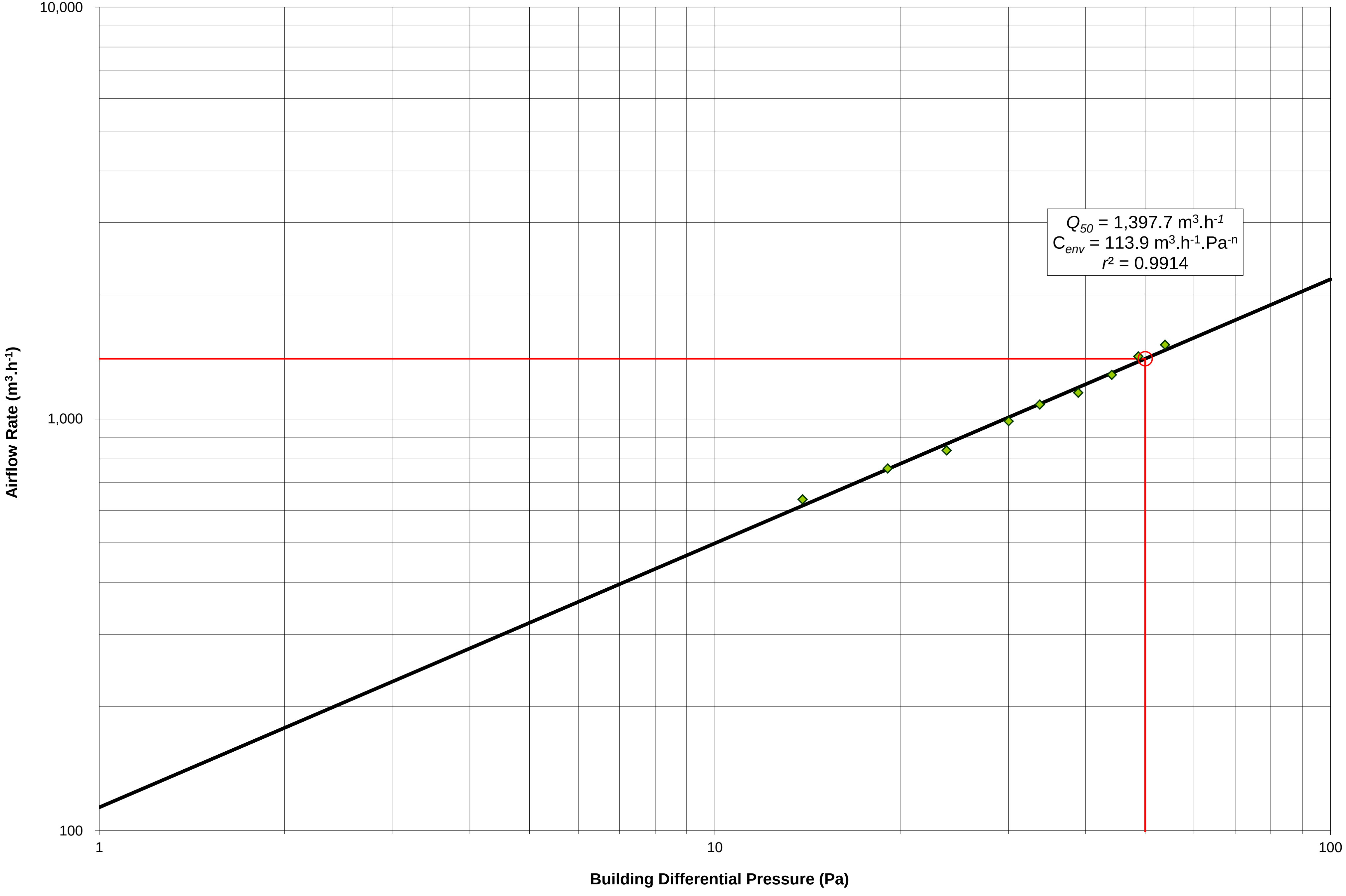
Serial Number	Equipment Type	Calib. Expiry Date
0703-90703-3	Anemometer	14 June 2013
GPB0030	Barometer	14 June 2013
703710	Thermometer	14 June 2013
831207A	Manometer (Build)	14 June 2013
831207B	Manometer (Fan)	14 June 2013
H01143	Fan	14 June 2013

Differential Building Pressures

			$Dp_{0,1}$	Dp_m										$Dp_{0,2}$
Gauge #1:	831207A	Room Pressure	-1.4	-15.3	-20.5	-25.2	-31.4	-35.1	-40.3	-45.5	-50.1	-55.2		-1.5
		Corrected (Pa)	-1.4	-15.3	-20.5	-25.2	-31.4	-35.2	-40.4	-45.6	-50.2	-55.3		-1.5
		Avg Corrected, Dp (Pa):		-13.9	-19.1	-23.8	-30.0	-33.7	-38.9	-44.1	-48.7	-53.8		

Fan Flow Pressures and Volume Flow Rates

Type	Serial No.	Range	Gauge Ref													
T_5	H01143	Ring C4	831207B	Flow Pressure	Intial Static Pressure Fan Blanked Off	76.8	107.6	131.2	180.9	216.9	246.9	300.1	367.3	417.6		Final Static Pressure Fan Blanked Off
				Corrected (Pa)		76.9	107.8	131.4	181.2	217.2	247.2	300.5	367.8	418.2		
				Flow, Q_{c1} (m³/s)		0.18	0.21	0.23	0.27	0.30	0.32	0.35	0.39	0.42		
				Total Flow, Q_{env} (m³/hr)		638	758	839	988	1,084	1,158	1,279	1,418	1,515		
				Error (%)		3.5%	0.4%	-3.7%	-2.1%	-0.3%	-3.0%	-1.0%	2.9%	3.1%		


10,000
1,000
100
Airflow Rate (m³.h⁻¹)
1
10
100
Building Differential Pressure (Pa)
Q50 = 1,397.7 m³.h⁻¹
Cenv = 113.9 m³.h⁻¹.Pa⁻ⁿ
r² = 0.9914

Test Date: 19 June 2012
Test Time: 12:33

Engineer Controlling Test: DT

Test No: 1

Type of Test Undertaken: Depressurisation

Engineer Locations: Inside the building under test.

Pre Test Conditions

Atmospheric Conditions

Windspeed: 1.6 m/s

		Location of Reading
Internal Temperature #1:	22.5 °C	Kitchen area
Internal Temperature #2:	°C	
Internal Temperature #3:	°C	
Internal Temperature #4:	°C	
Internal Temperature #5:	°C	

External Temperature: 17.2 °C

Barometric Pressure: 994 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-1.9				
	-1.7				
	-1.5				
	-1.1				
	-1.3				

	Corrected Values
Average Positive Values, $Dp_{0,1+}$	Pa
Average Negative Values, $Dp_{0,1-}$	-1.5 Pa
Total Average Values, $Dp_{0,1}$	-1.5 Pa

Post Test Conditions

Atmospheric Conditions

Windspeed: 1.4 m/s

		Location of Reading
Internal Temperature #1:	22.9 °C	Kitchen area
Internal Temperature #2:	°C	
Internal Temperature #3:	°C	
Internal Temperature #4:	°C	
Internal Temperature #5:	°C	

External Temperature: 17.0 °C

Barometric Pressure: 994 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-1.7				
	-1.6				
	-2.0				
	-1.8				
	-1.9				

	Corrected Values
Average Positive Values, $Dp_{0,2+}$	Pa
Average Negative Values, $Dp_{0,2-}$	-1.8 Pa
Total Average Values, $Dp_{0,2}$	-1.8 Pa

Average Test Conditions

Corrected Average Internal Temperature: 22.7 °C

Corrected Average External Temperature: 17.1 °C

Corrected Average Barometric Pressure: 996.7 mbar

Internal Air Density, r_i: 1.17 $kg.m^{-3}$

External Air Density, r_e: 1.19 $kg.m^{-3}$

Assumed Relative Humidity: 50%

Summary of Building Test Results

Permeability @ 50 Pa, AP_{50} $m^3.h^{-1}.m^{-2}$	Flow @ 50Pa, Q_{50} $m^3.h^{-1}$	Effective Leakage Area, *A* m^2	Flow Exponent, *n*	Flow Coeff, C_{env} $m^3.h^{-1}.Pa^{-n}$	Air Leakage Coeff, C_L $m^3.h^{-1}.Pa^{-n}$	Correlation r^2
7.66	1,391	0.069	0.64	114.3	114.0	0.9994

Calibration Information for Equipment Used

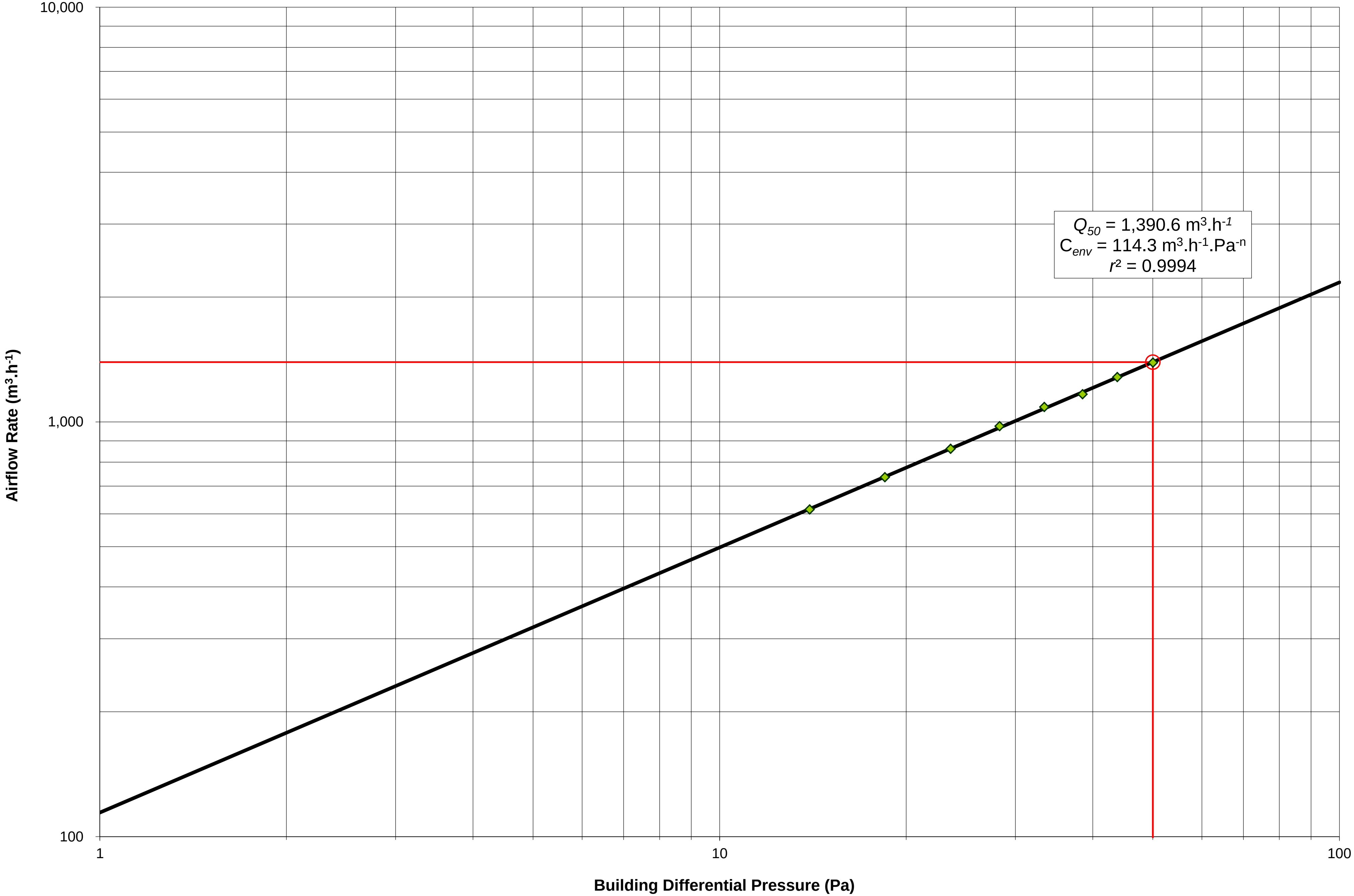
Serial Number	Equipment Type	Calib. Expiry Date
0703-90703-3	Anemometer	14 June 2013
GPB0030	Barometer	14 June 2013
703710	Thermometer	14 June 2013
831207A	Manometer (Build)	14 June 2013
831207B	Manometer (Fan)	14 June 2013
H01143	Fan	14 June 2013

Differential Building Pressures

			$Dp_{0,1}$	Dp_m										$Dp_{0,2}$
Gauge #1:	831207A	Room Pressure	-1.5	-15.6	-20.1	-25.2	-29.9	-35.0	-40.1	-45.4	-51.6			-1.8
		Corrected (Pa)	-1.5	-15.6	-20.1	-25.2	-29.9	-35.1	-40.2	-45.5	-51.7			-1.8
		Avg Corrected, Dp (Pa):		-14.0	-18.5	-23.6	-28.3	-33.4	-38.5	-43.8	-50.0			

Fan Flow Pressures and Volume Flow Rates

Type	Serial No.	Range	Gauge Ref													
T_5	H01143	Ring C4	831207B	Flow Pressure	Intial Static Pressure Fan Blanked Off	71.4	101.4	138.0	176.6	217.6	249.8	301.0	352.4			Final Static Pressure Fan Blanked Off
				Corrected (Pa)		71.5	101.5	138.2	176.8	217.9	250.2	301.4	352.9			
				Flow, Q_{c1} (m^3/s)		0.17	0.20	0.24	0.27	0.30	0.32	0.35	0.38			
				Total Flow, Q_{env} (m^3/hr)		615	736	861	977	1,087	1,166	1,283	1,390			
				Error (%)		-0.3%	-0.2%	-0.1%	0.9%	0.9%	-1.1%	0.1%	-0.3%			


10,000
1,000
100
Airflow Rate (m3.h-1)
1
10
100
Building Differential Pressure (Pa)
Q50 = 1,390.6 m3.h-1
Cenv = 114.3 m3.h-1.Pa-n
r² = 0.9994

Certificate of Air Permeability Test

Issued By Stroma Technology Ltd

UKAS TESTING 2731

Details of Test

Dwelling tested:	15, Ancion Court, Clough Lea, Marsden, HD7 6BA	Nett Floor Area, A_F:	55.50 m^2
		Envelope Area, A_E:	181.60 m^2
On behalf of:	Kiwa Limited	Geometry Prepared by:	Jonathan Teale of Stroma
Test Date:	19th June 2012	Geometry Verified by:	Laura Storey of Kiwa Limited
Certificate Date:	21st June 2012	Certificate No.:	DT 05-12-28525 P15 T1

Test Conditions and Temporary Sealing at the Time of both Tests

	Type A Response	***Type B Response***
All external doors and windows closed?	Yes	Yes
All internal doors open?	Yes	Yes
All extracts sealed? Inc. kitchen and bathroom(s) extracts and the oven hood.	Yes	No
Temporary seals to drains, plugs, or overflows?	No	Yes
Combustion appliances turned off, and sealed? If located in the conditioned space of the dwelling and it is not a balanced?	Yes	Yes
Trickle vents and/or passive ventilation temporary sealed?	No	No
Fireplace temporary sealed?	N/A	N/A
All building works completed to the air boundary envelope?	Yes	Yes

Deviation(s) from ATTMA TS1

None

Test Result and Performance Characteristics

This is to certify that the above named building has been tested for air permeability in accordance with ATTMA TS1 undertaken with the conditions stated above.

The Key Leakage Characteristics of the dwelling are:

	Type A Test (Vents Unsealed)	*Type B Test (Vents Sealed)*
Air Permeability, AP_{50}:	**7.70 $m^3.h^{-1}.m^{-2}$ @ 50 Pa**	**7.66 $m^3.h^{-1}.m^{-2}$ @ 50 Pa**
Effective Leakage Area:	0.070 m^2 @ 50 Pa	0.069 m^2 @ 50 Pa
Correlation of results, r^2:	0.9914	0.9994
Slope, n:	0.64	0.64
Air Flow Coefficient, C_{env}:	113.9 $m^3.h^{-1}.Pa^{-n}$	114.3 $m^3.h^{-1}.Pa^{-n}$
Intercept, C_L:	113.7 $m^3.h^{-1}.Pa^{-n}$	114.0 $m^3.h^{-1}.Pa^{-n}$

Signed: D Tetchner   Name: David Tetchner   Position: Engineer

On Behalf of Stroma Technology Ltd.

Appendix F

Air Test Report – Flat B - (11/09/2014)

Air Test Report

15 Ancion Court, Clough Lea,
Marsden, HD7 6BA

Ref: DT 05-12-28525 P15 T2
Issue Date: 11th September 2014

Prepared for:
Mrs C Hanson
Kiwa Limited

Prepared by:
David Tetchner

Checked by:
Jon Robinson

Stroma Technology, 6 Silkwood Business Park, Fryers Way, Wakefield, West Yorkshire, WF5 9TJ.
t: 0845 621 2222 f: 0845 621 1112 e: info@stroma.com w: stroma.com

Contents

Details of Tested Building

Dwelling Tested:	15, Ancion Court, Clough Lea, Marsden, HD7 6BA	Nett Floor Area, A_F:	55.50 m^2
		Envelope Area, A_E:	181.60 m^2
		Geometry Prepared By:	Jonathan Teale of Stroma
Est. Year Built:	2014	Geometry Verified By:	Laura Stone of Kiwa Limited
Test Date:	8th September 2014		
Building Heating:	Underfloor heating	Test Method:	B (Building envelope)
Building Ventilation:	Natural ventilation	Test Engineer:	David Tetchner

Interpretation of Results

The airflow rate through the envelope of the building/zone was determined at a pressure differential of 50 Pa; this result is expressed as an airflow rate per m² of building envelope. For more information on the calculations used to determine the air permeability or the air leakage index please visit *www.stroma.com/downloads/air_permeability_calculation.pdf.*

Result & Summary

The dwelling's air permeability was determined by means of two depressurisation tests (with and without the ventilation sealed). The initial normalised air flow at a pressure differential of 50 Pascals (*Q*) was established in accordance with the required test methodology of ATTMA TS1. The result attained from these tests were:-

Type A Test (Vents Unsealed): **Air Permeability, AP_{50}:** ***8.12 $m^3.h^{-1}.m^{-2}$ @ 50 Pa***
Type B Test (Vents Sealed): **Air Permeability, AP_{50}** **7.97 $m^3.h^{-1}.m^{-2}$ @ 50 Pa**

This is above the target level of 5.0 $m^3.h^{-1}.m^{-2}$ at 50 Pa specified.

Attached is the test data and graph generated from our test software.

Test Date: 8 September 2014
Test Time: 17:54

Engineer Controlling Test: DT

Test No: 2

Type of Test Undertaken: Depressurisation

Engineer Locations: Inside the building under test.

Pre Test Conditions

Atmospheric Conditions

	Value	Location of Reading
Internal Temperature #1:	22.3 °C	Kitchen area
Internal Temperature #2:	°C	
Internal Temperature #3:	°C	
Internal Temperature #4:	°C	
Internal Temperature #5:	°C	

External Temperature: 15.9 °C

Barometric Pressure: 997 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-1.0				
	-1.2				
	-1.3				
	-1.0				
	-0.9				

	Corrected Values
Average Positive Values, $\Delta p_{0,1+}$	Pa
Average Negative Values, $\Delta p_{0,1-}$	-1.1 Pa
Total Average Values, $\Delta p_{0,1}$	-1.1 Pa

Post Test Conditions

Atmospheric Conditions

	Value	Location of Reading
Internal Temperature #1:	22.8 °C	Kitchen area
Internal Temperature #2:	°C	
Internal Temperature #3:	°C	
Internal Temperature #4:	°C	
Internal Temperature #5:	°C	

External Temperature: 15.7 °C

Barometric Pressure: 997 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-0.8				
	-0.6				
	-0.6				
	-0.5				
	-0.5				

	Corrected Values
Average Positive Values, $\Delta p_{0,2+}$	Pa
Average Negative Values, $\Delta p_{0,2-}$	-0.6 Pa
Total Average Values, $\Delta p_{0,2}$	-0.6 Pa

Average Test Conditions

Corrected Average Internal Temperature: 22.4 °C

Corrected Average External Temperature: 15.6 °C

Corrected Average Barometric Pressure: 1,000.4 mbar

Internal Air Density, ρ_i: 1.17 $kg.m^{-3}$

External Air Density, ρ_e: 1.20 $kg.m^{-3}$

Assumed Relative Humidity: 50%

Summary of Building Test Results

Permeability @ 50 Pa, AP_{50} $m^3.h^{-1}.m^{-2}$	Flow @ 50Pa, Q_{50} $m^3.h^{-1}$	Effective Leakage Area, A m^2	Flow Exponent, n	Flow Coeff, C_{env} $m^3.h^{-1}.Pa^{-n}$	Air Leakage Coeff, C_L $m^3.h^{-1}.Pa^{-n}$	Correlation r^2
8.12	1,474	0.073	0.64	121.7	121.8	0.9999

Calibration Information for Equipment Used

Serial Number	Equipment Type	Calib. Expiry Date
0703-90703-3	Anemometer	5 June 2015
GPB0030	Barometer	5 June 2015
627846	Thermometer	5 June 2015
831207A	Manometer (Build)	5 June 2015
831207B	Manometer (Fan)	5 June 2015
H01143	Fan	5 June 2015

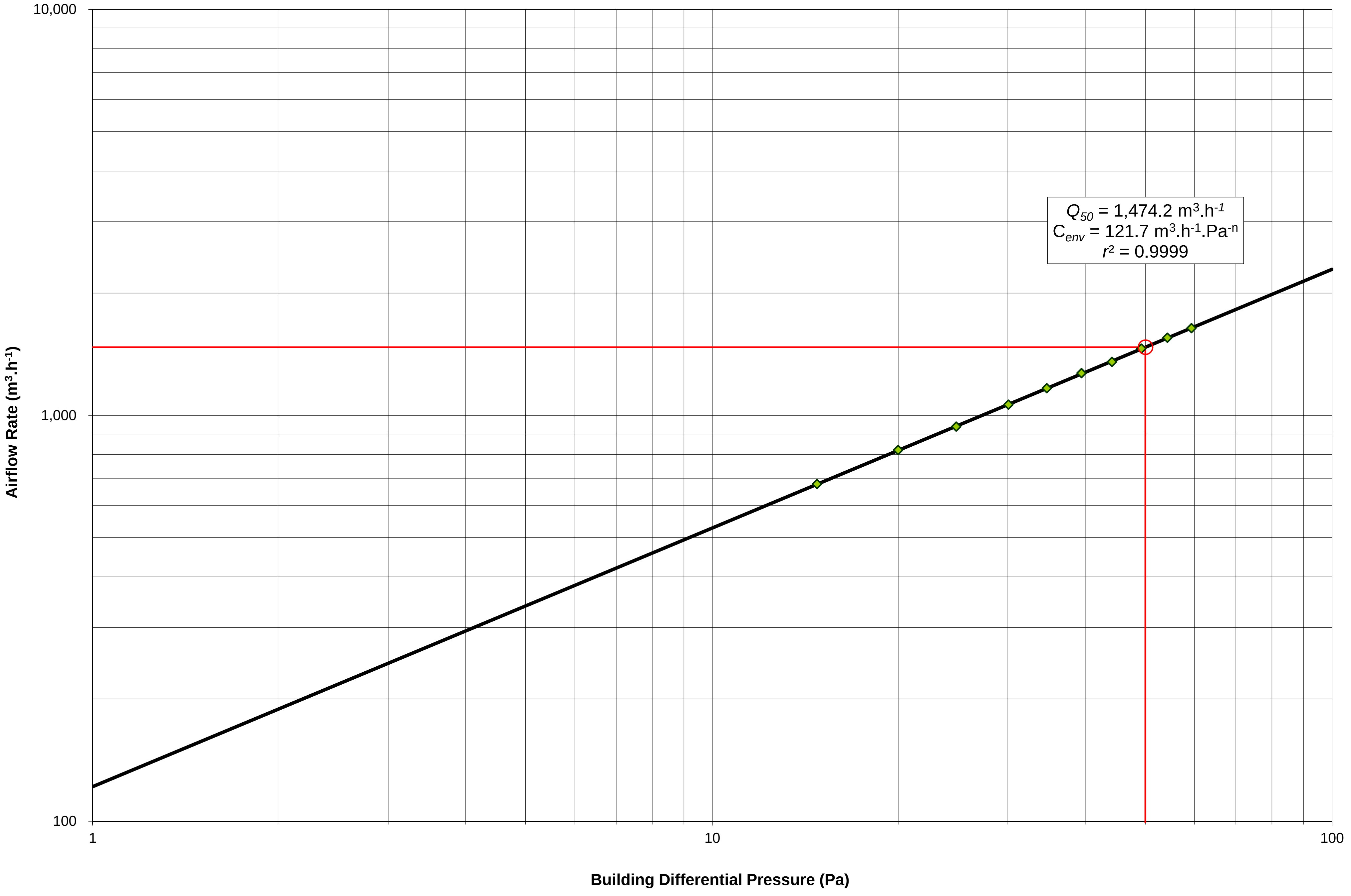
Differential Building Pressures

			$\Delta p_{0,1}$	Δp_m										$\Delta p_{0,2}$
Gauge #1:	831207A	Room Pressure	-1.1	-60.2	-55.1	-50.1	-45.0	-40.3	-35.5	-30.9	-25.6	-20.8	-15.6	-0.6
		Corrected (Pa)	-1.1	-60.2	-55.1	-50.1	-45.0	-40.3	-35.5	-30.9	-25.6	-20.8	-15.6	-0.6
		Avg Corrected, Δp (Pa):		-59.3	-54.2	-49.2	-44.1	-39.4	-34.6	-30.1	-24.8	-20.0	-14.8	

Fan Flow Pressures and Volume Flow Rates

Type	Serial No.	Range	Gauge Ref
T_5	H01143	Ring C4	831207B

	Intial Static Pressure Fan Blanked Off											Final Static Pressure Fan Blanked Off
Flow Pressure		483.3	434.2	385.0	331.8	292.8	247.4	206.5	161.8	124.6	85.2	
Corrected (Pa)		485.0	435.7	386.3	333.0	293.8	248.3	207.2	162.4	125.0	85.5	
Flow, Q_{c1} (m³/s)		0.46	0.43	0.41	0.38	0.35	0.32	0.30	0.26	0.23	0.19	
Total Flow, Q_{env} (m³/hr)		1,641	1,553	1,461	1,354	1,270	1,166	1,063	939	821	677	
Error (%)		-0.1%	0.2%	0.2%	-0.4%	0.3%	0.0%	-0.1%	-0.2%	0.2%	0.0%	


10,000
1,000
100
Airflow Rate (m³.h⁻¹)
1
10
100
Building Differential Pressure (Pa)
Q_{50} = 1,474.2 $m^3.h^{-1}$
C_{env} = 121.7 $m^3.h^{-1}.Pa^{-n}$
r^2 = 0.9999

Test Date: 8 September 2014
Test Time: 17:54

Engineer Controlling Test: DT

Test No: 2

Type of Test Undertaken: Depressurisation

Engineer Locations: Inside the building under test.

Pre Test Conditions

Atmospheric Conditions

	Value	Unit	Location of Reading
Internal Temperature #1:	20.5	°C	Kitchen area
Internal Temperature #2:		°C	
Internal Temperature #3:		°C	
Internal Temperature #4:		°C	
Internal Temperature #5:		°C	

External Temperature: 16.2 °C

Barometric Pressure: 997 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-0.1				
	-0.2				
	-0.1				
	-0.1				
	0.0				

	Corrected Values
Average Positive Values, $\Delta p_{0,1+}$	Pa
Average Negative Values, $\Delta p_{0,1-}$	-0.1 Pa
Total Average Values, $\Delta p_{0,1}$	-0.1 Pa

Post Test Conditions

Atmospheric Conditions

	Value	Unit	Location of Reading
Internal Temperature #1:	22.2	°C	Kitchen area
Internal Temperature #2:		°C	
Internal Temperature #3:		°C	
Internal Temperature #4:		°C	
Internal Temperature #5:		°C	

External Temperature: 15.9 °C

Barometric Pressure: 997 mbar

Fan Off Pressures

Manometer Number	#1	#2	#3	#4	#5
Gauge Serial Number	831207A				
Readings (Pa)	-0.4				
	-0.5				
	-0.4				
	-0.6				
	-0.7				

	Corrected Values
Average Positive Values, $\Delta p_{0,2+}$	Pa
Average Negative Values, $\Delta p_{0,2-}$	-0.5 Pa
Total Average Values, $\Delta p_{0,2}$	-0.5 Pa

Average Test Conditions

Corrected Average Internal Temperature: 21.2 °C
Corrected Average External Temperature: 15.9 °C
Corrected Average Barometric Pressure: 1,000.4 mbar

Internal Air Density, ρ_i: 1.18 kg.m^{-3}
External Air Density, ρ_e: 1.20 kg.m^{-3}
Assumed Relative Humidity: 50%

Summary of Building Test Results

Permeability @ 50 Pa, *AP* $_{50}$ m^3.h^{-1}.m^{-2}	Flow @ 50Pa, Q_{50} m^3.h^{-1}	Effective Leakage Area, *A* m^2	Flow Exponent, *n*	Flow Coeff, C_{env} m^3.h^{-1}.Pa^{-n}	Air Leakage Coeff, C_L m^3.h^{-1}.Pa^{-n}	Correlation r^2
7.97	1,447	0.072	0.63	123.9	124.1	0.9998

Calibration Information for Equipment Used

Serial Number	Equipment Type	Calib. Expiry Date
0703-90703-3	Anemometer	5 June 2015
GPB0030	Barometer	5 June 2015
627846	Thermometer	5 June 2015
831207A	Manometer (Build)	5 June 2015
831207B	Manometer (Fan)	5 June 2015
H01143	Fan	5 June 2015

Differential Building Pressures

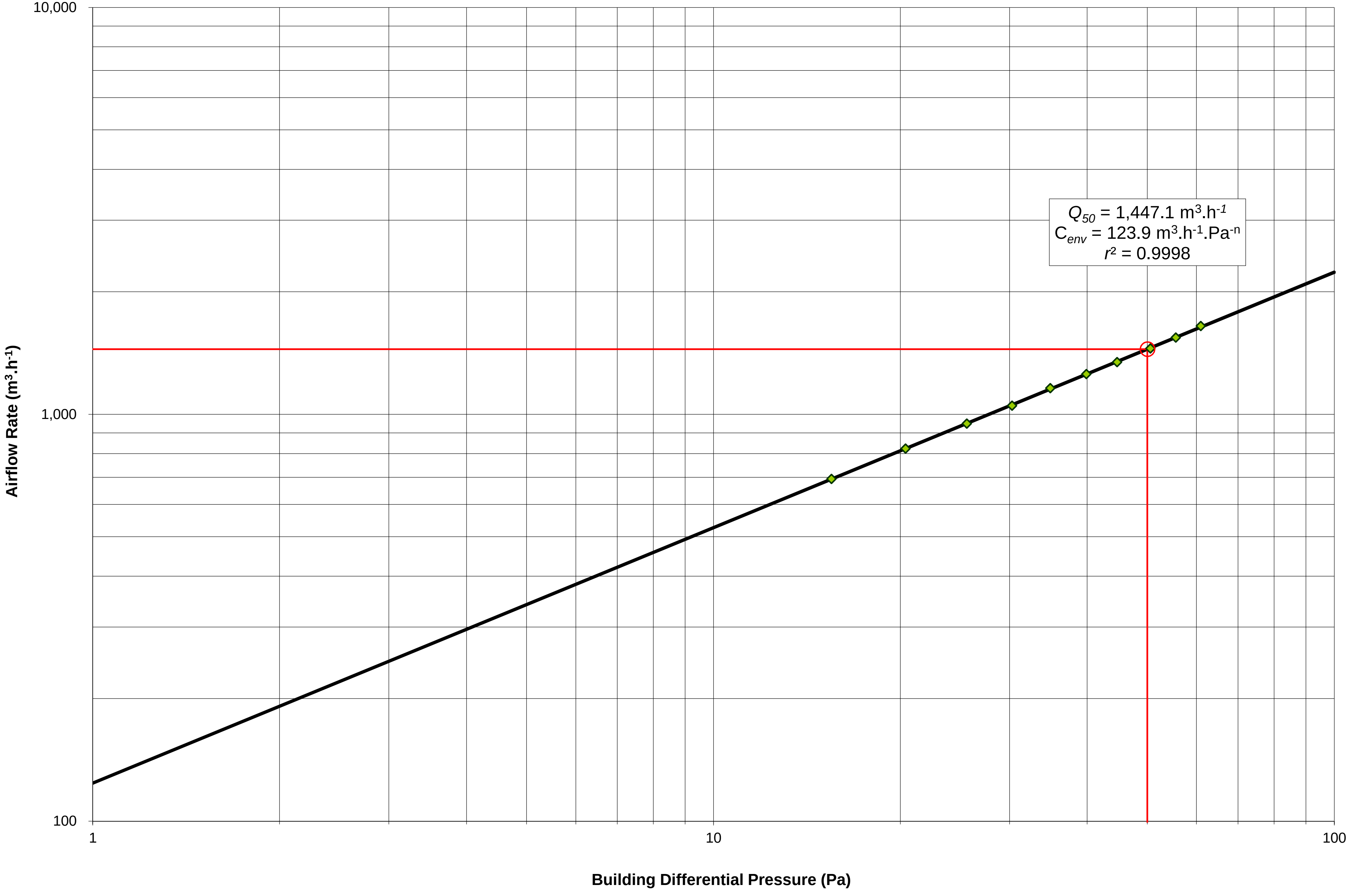
Gauge #1: 831207A

	$\Delta p_{0,1}$	Δp_m										$\Delta p_{0,2}$
Room Pressure	-0.1	-61.3	-55.9	-50.9	-45.0	-40.2	-35.2	-30.6	-25.9	-20.7	-15.8	-0.5
Corrected (Pa)	-0.1	-61.3	-55.9	-50.9	-45.0	-40.2	-35.2	-30.6	-25.9	-20.7	-15.8	-0.5
Avg Corrected, Δp (Pa):		-61.0	-55.6	-50.6	-44.7	-39.9	-34.9	-30.3	-25.6	-20.4	-15.5	

Fan Flow Pressures and Volume Flow Rates

Type	Serial No.	Range	Gauge Ref
T_5	H01143	Ring C4	831207B

	Intial Static Pressure Fan Blanked Off											Final Static Pressure Fan Blanked Off
Flow Pressure		486.4	427.7	379.0	325.7	285.5	244.3	201.2	164.9	124.9	89.3	
Corrected (Pa)		488.1	429.2	380.3	326.8	286.5	245.2	201.9	165.5	125.3	89.6	
Flow, Q_{c1} (m³/s)		0.46	0.43	0.40	0.37	0.35	0.32	0.29	0.26	0.23	0.19	
Total Flow, Q_{env} (m³/hr)		1,648	1,543	1,451	1,343	1,255	1,159	1,050	949	823	694	
Error (%)		0.6%	-0.1%	-0.4%	-0.3%	0.1%	0.5%	-0.5%	-0.1%	0.0%	0.2%	


10,000
1,000
100
Airflow Rate ($m^3.h^{-1}$)
1
10
100
Building Differential Pressure (Pa)
Q_{50} = 1,447.1 $m^3.h^{-1}$
C_{env} = 123.9 $m^3.h^{-1}.Pa^{-n}$
r^2 = 0.9998

Certificate of Air Permeability Test

Issued By Stroma Technology Ltd

Details of Test

Dwelling tested:	15, Ancion Court, Clough Lea, Marsden, HD7 6BA	Nett Floor Area, A_F:	55.50 m^2
		Envelope Area, A_E:	181.60 m^2
On behalf of:	Kiwa Limited	Geometry Prepared by:	Jonathan Teale of Stroma
Test Date:	8th September 2014	Geometry Verified by:	Laura Stone of Kiwa Limited
Certificate Date:	11th September 2014	Certificate No.:	DT 05-12-28525 P15 T2

Test Conditions and Temporary Sealing at the Time of Test

	Type A Response	*Type B Response*
All external doors and windows closed?	Yes	Yes
All internal doors open?	Yes	Yes
All extracts sealed? Inc. kitchen and bathroom(s) extracts and the oven hood.	No	Yes
Temporary seals to drains, plugs, or overflows?	No	No
Combustion appliances turned off, and sealed? If located in the conditioned space of the dwelling and it is not a balanced?	Yes	Yes
Trickle vents and/or passive ventilation temporary sealed?	No	No
Fireplace temporary sealed?	N/A	N/A
All building works completed to the air boundary envelope?	Yes	Yes

Deviation(s) from ATTMA TSL1

None

Test Result and Performance Characteristics

This is to certify that the above named building has been tested for air permeability in accordance with ATTMA TSL1 undertaken with the conditions stated above, with the exception of the deviation(s) stated above.

The Key Leakage Characteristics of the dwelling are:

	Type A test (vents unsealed)	Type B Test (vents sealed)
Air Permeability, AP_{50}:	**8.12 $m^3.h^{-1}.m^{-2}$ @ 50 Pa**	**7.97 $m^3.h^{-1}.m^{-2}$ @ 50 Pa**
Effective Leakage Area:	0.073 m^2 @ 50 Pa	0.072 m^2 @ 50 Pa
Correlation of results, r^2:	0.9999	0.9998
Slope, n:	0.64	0.63
Air Flow Coefficient, C_{env}:	121.7 $m^3.h^{-1}.Pa^{-n}$	123.9 $m^3.h^{-1}.Pa^{-n}$
Intercept, C_L:	121.9 $m^3.h^{-1}.Pa^{-n}$	124.1 $m^3.h^{-1}.Pa^{-n}$

Signed: David J Tetchner Name: David Tetchner Position: Engineer

On Behalf of Stroma Technology Ltd.

Appendix G

Thermal Imaging Survey

TSB
File Ref: 450083
Application ref: 17929-111174

Table of Contents

Kiwa GASTEC at CRE

Kiwa Ltd
The Orchard Business Centre
Stoke Orchard
Cheltenham
GL52 7RZ
UK

Telephone: +44 (0)1242 677877
Fax: +44 (0)1242 676506
E-mail: enquries@kiwa.co.uk
Web: www.kiwa.co.uk

1 Introduction

A thermal imaging survey was carried out as supporting evidence for the building performance evaluation project at the Connect Housing Development of Ancion Court in Marsden.

The development was photographed externally and internally in each of the monitored properties (Flat A and B). The whole development was photographed externally to identify area of particular heat loss or interest. Some internal images were also taken in the communal flat to identify the impact of the plant room on this area.

This document details the findings of the thermal imaging survey, split into 4 main sections:

- External Envelope
- Communal flat and plant room
- Flat A
- Flat B

2 External Envelope

The following images show the external envelope of the Ancion Court development. The images were taken on a cold evening in November with external temperatures averaging approximately 2°C and the heating system fully operational.

The development is a horseshoe shape and thus images were taken from the NE corner across the building to the NW corner. Where possible a comparative image has also been included.

Figure 1: NE Corner Front

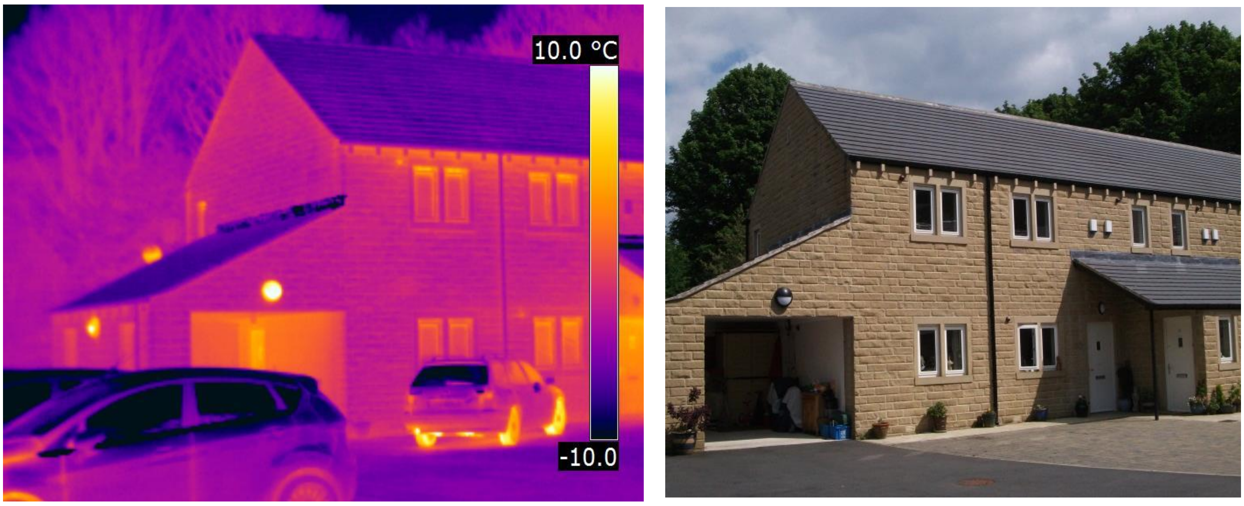


Figure 2: NE Front

Figure 3: Centre Front

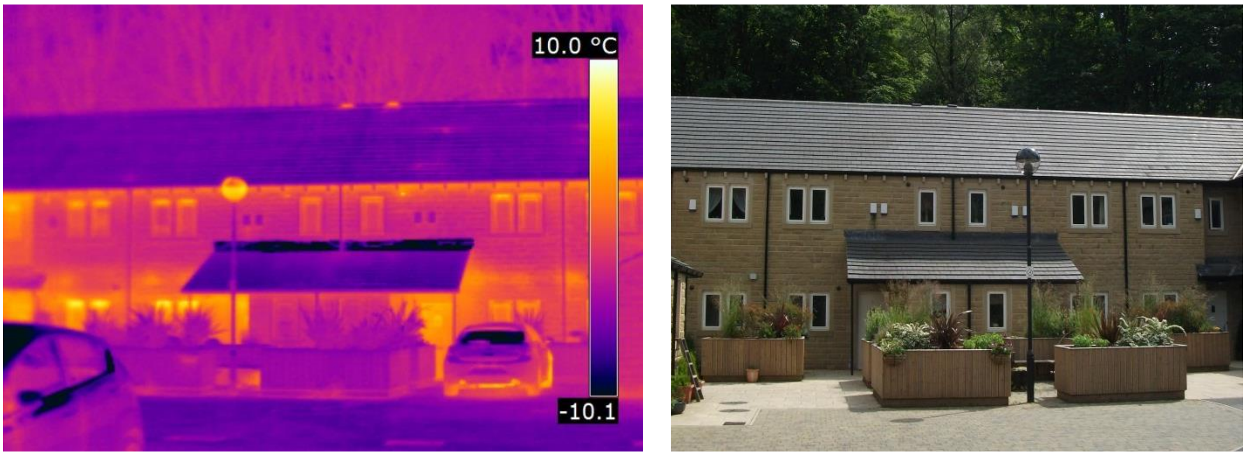


Figure 4: NW Front

Figure 5: NW Corner Front

There are several areas identifiable around the development where the structure is warmer than the majority of the building fabric and thus it can be suggested that heat is being lost from the dwelling at these points. Most significant of these are the trickle vents at the top of each window as shown in Figure 6. Also visible in this image is the heat lost at the bridge of the wall and roof and under the window sill. Small vents in the brickwork are also shown as losing heat compared to the wall fabric.

The boundary between the ground and building and the boundary between porches, garages and extensions are also areas where the fabric has been identified as warmer than the rest of the structure, indicating a possible area of heat loss.

It must be noted however that the upper limit of the scale on the thermal images is approximately 10°C, suggesting that the actual heat loss from this building is minimal.

Figure 6: Ventilation losses and fabric junctions

The following two images were taken on the rear NE corner of the development.

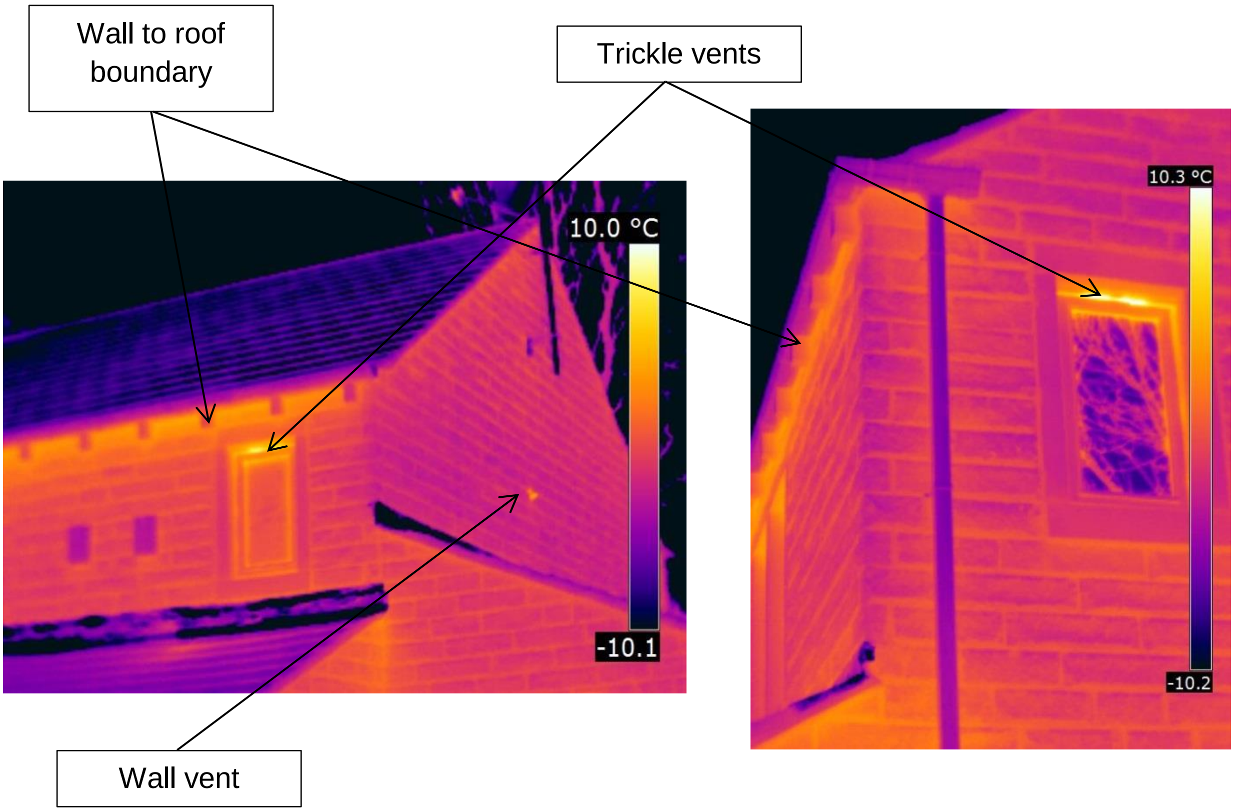
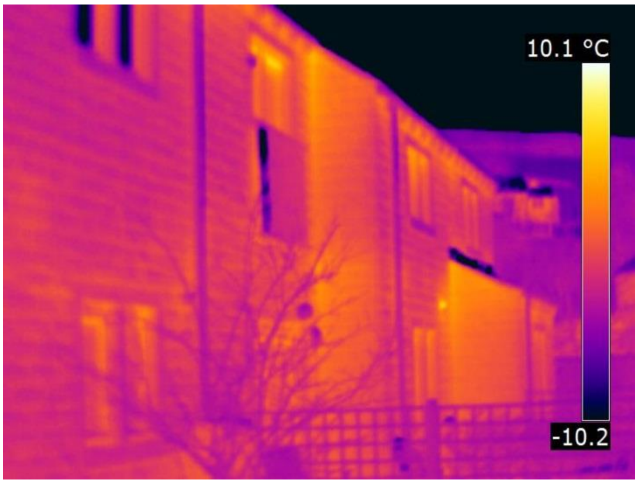


Figure 7: Heat losses through fabric joins

Rear NE elevation



Rear NW corner

Front NW corner

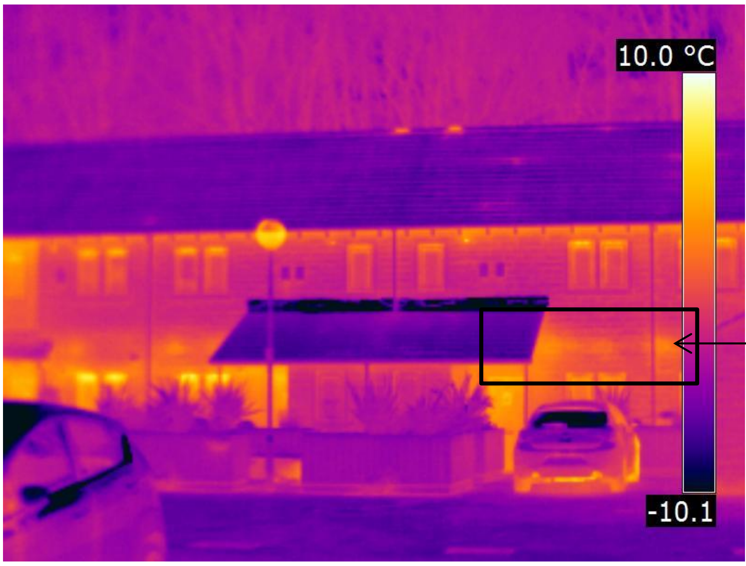
Heat is lost through structural joints such as those shown in Figure 7 as a result of thermal bridging. Where different structures and materials join, such as window sills and wall boundaries, there is a direct route for heat to travel from internal (warmer) spaces to the external air. This is also the case in corners where two walls meet, as insulation rarely meets exactly at these joints and thus heat can transfer more easily through the building fabric. Although there is evidence of this at Ancion Court the losses from this development are low and the building fabric is uniform in its thermal performance.

The properties at Ancion Court are heated on a district heating main fed from two heat pumps. The district heat main feeds underfloor heating in each of the properties, which is then zoned into individual rooms and thermostatically controlled. The following images show a distinct line running across the wall of the development which may indicate the location of the underfloor heating.

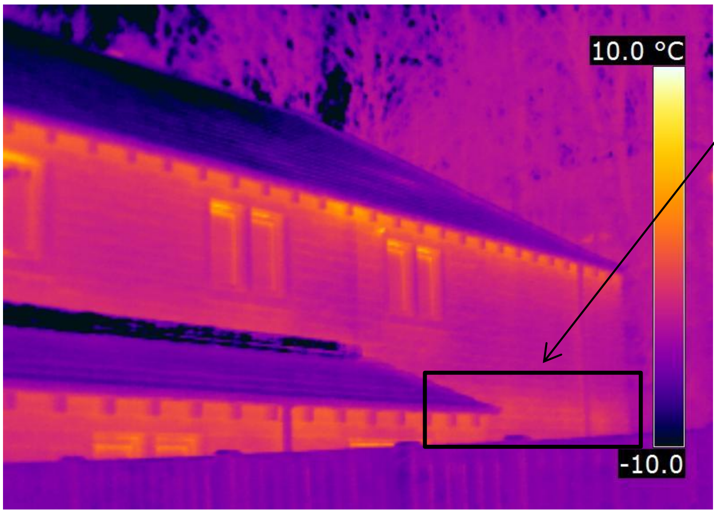
The heat from the underfloor heating will be distributed laterally as well as vertically through the floor of the properties. The delivery temperature of the central heating in the properties averages 36°C and this means the building fabric in which the pipework sits is also maintained at a higher than ambient temperature. The lateral transfer of heat results in a band of warmer material at the location of the heating distribution pipework.

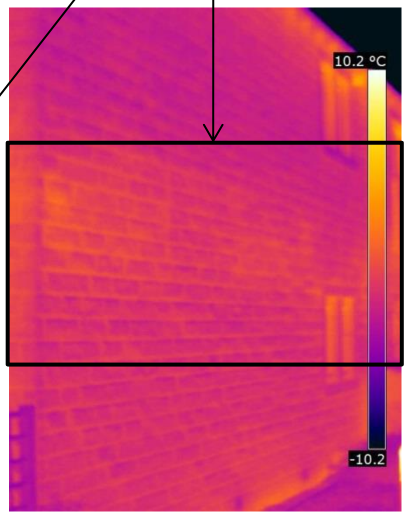
Figure 8: Underfloor heating

Front elevation



Rear NE side of Ancion Court



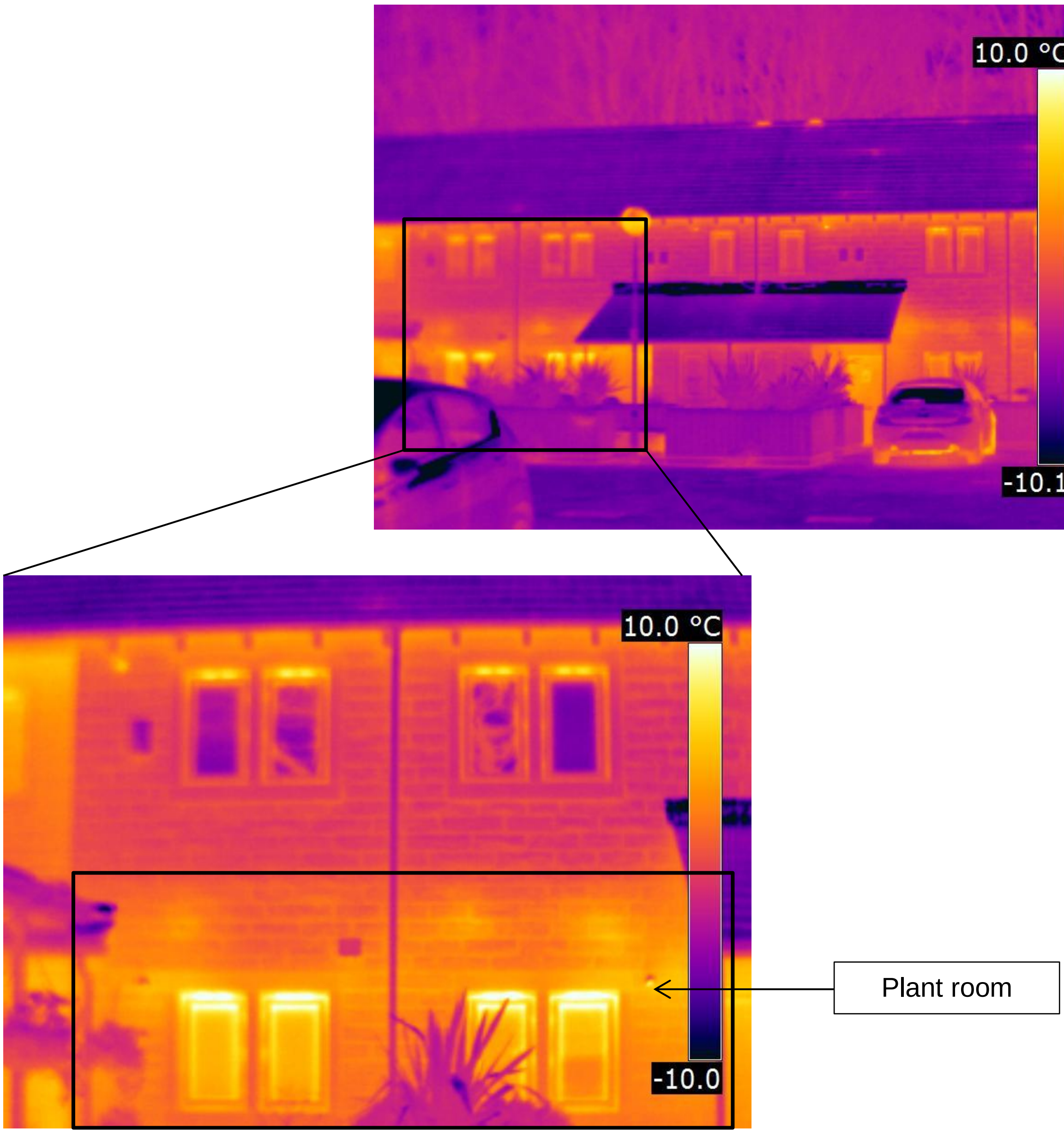


Rear NW side of Ancion Court

3 Communal Flat and Plant Room

The properties at Ancion Court are heated on a district heating main fed from two heat pumps and back up electric boiler situated in a plant room within the development. The internal temperature of this plant room is significant with monitored data showing average operational temperatures of 35°C. The thermal images below clearly show the plant room as an area of significantly warmer building fabric compared to the rest of the development.

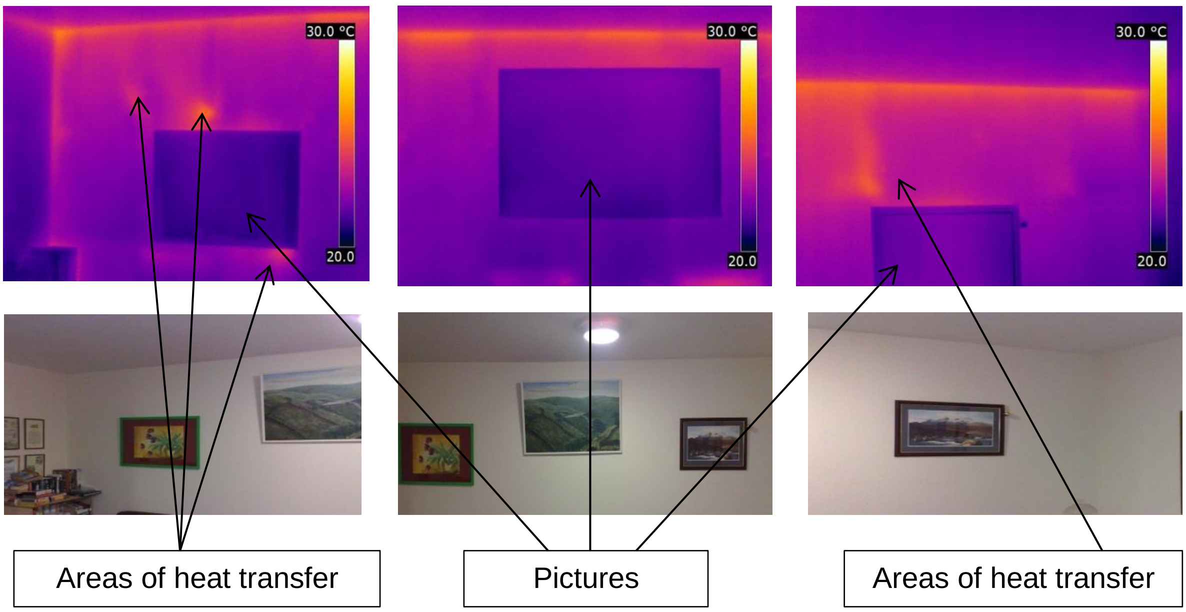
Figure 9: Location of plant room – Front of property



It is suggested that these high internal temperatures are as a result of the actual heat pump operation with each of the units venting considerable warm air when running. The plant room also contains a significant number of un-insulated valves and pumps and a very large volume of stored water which will all contribute to the internal temperature of the room. The latter however to a lesser extent due to good quality insulated cylinders. As the external building fabric is very well insulated the heat within the plant room is maintained thus resulting in the high temperatures.

This significant internal temperature of the plant room also has an impact of the communal room which is adjacent to the plant room. The following images were taken of the internal wall between the plant room and communal space.

Figure 10: Internal wall between the plant room and communal room taken from the communal space



In these images the heat transfer between the plant room and communal space is clear particularly between the wall and ceiling and to a lesser extent through patches in the wall (indicated as areas of heat transfer in the image above).

4 Flat A

The following images were taken inside Flat A. Overall the property showed very little cold air ingress, with the walls, ceiling and floor remarkably consistent. Even the joints between different structures e.g. the wall and ceiling and wall and floor did not show significant alterations in temperature.

There were however some areas where temperature gradients were observed and these are shown in the images below. Perhaps the most significant area where temperatures were notably lower than the internal ambient was around the front door and to a lesser extent around the bedroom window. There was also evidence of thermal bridging on the rear external wall.

Figure 11: Rear Wall Flat A

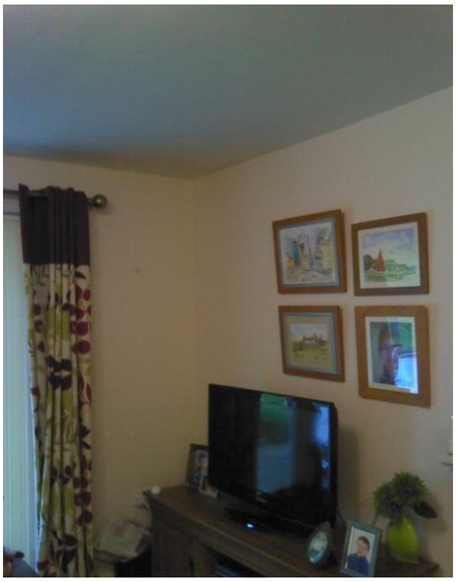
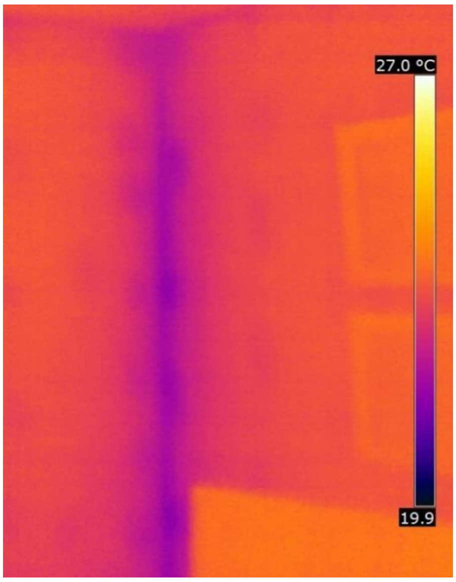
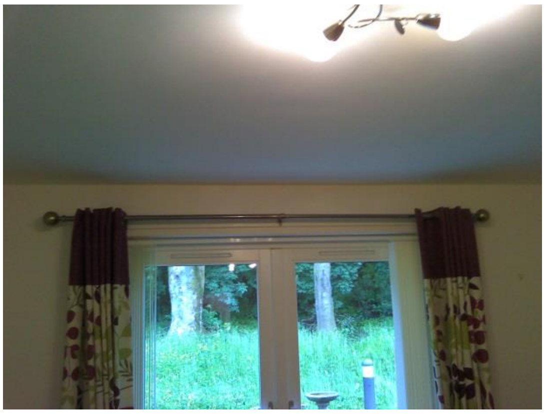
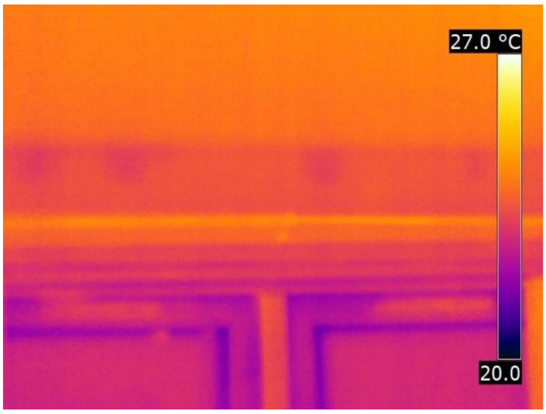



Figure 12: Rear Windows Flat A

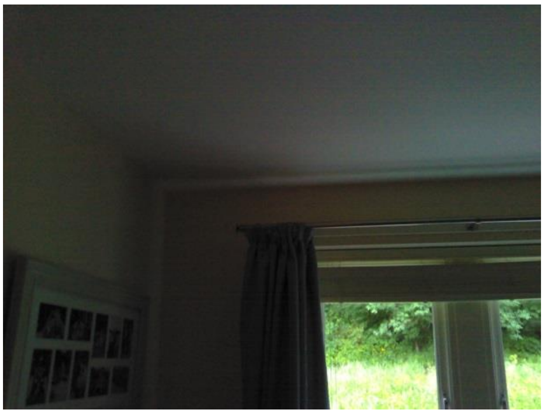
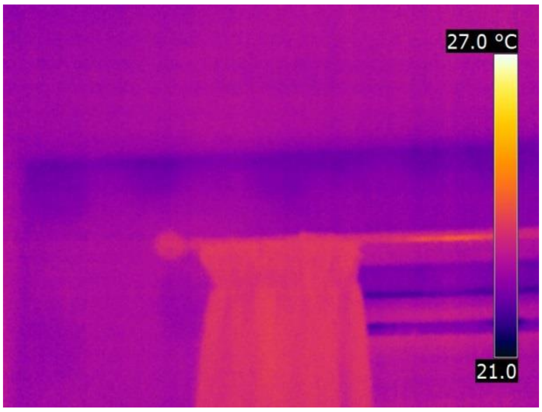
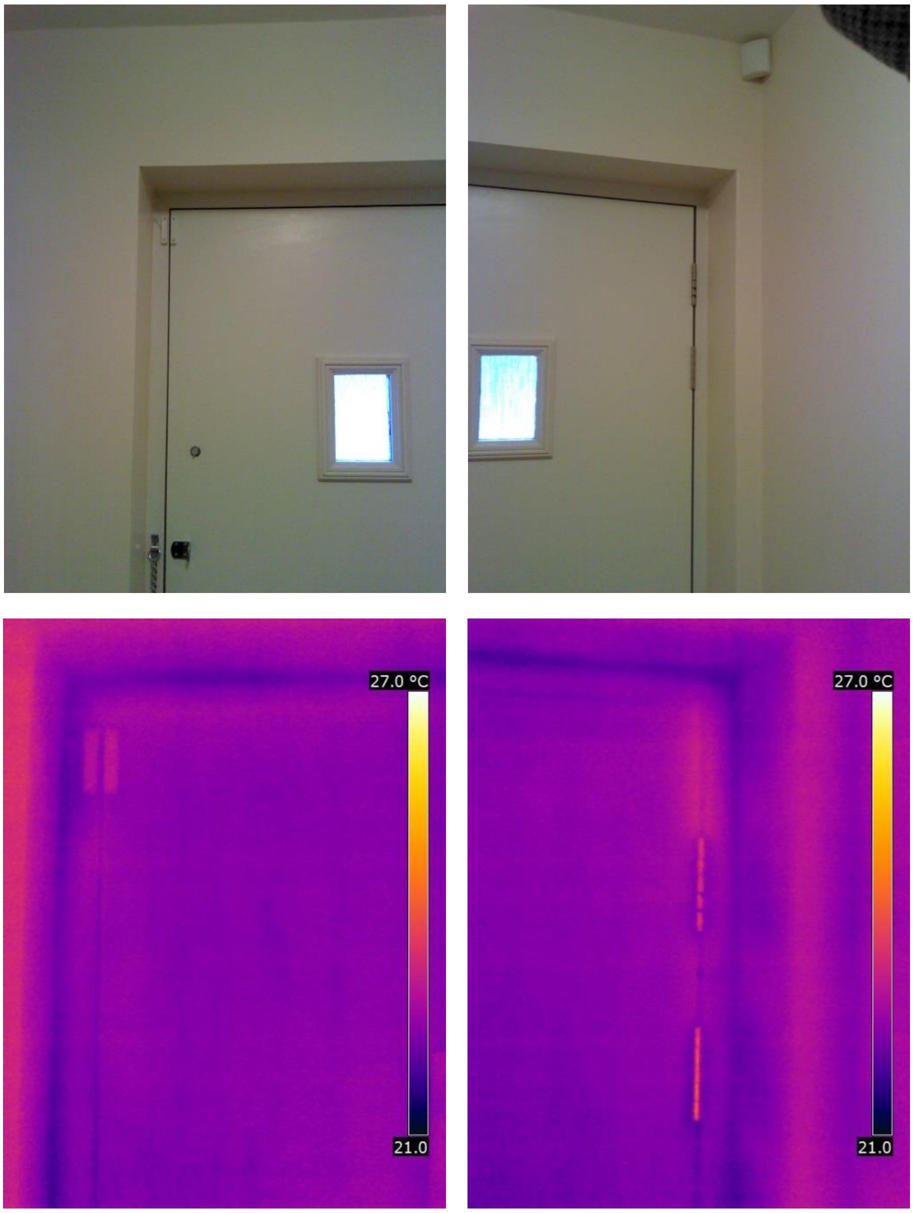



Figure 13: Front Door

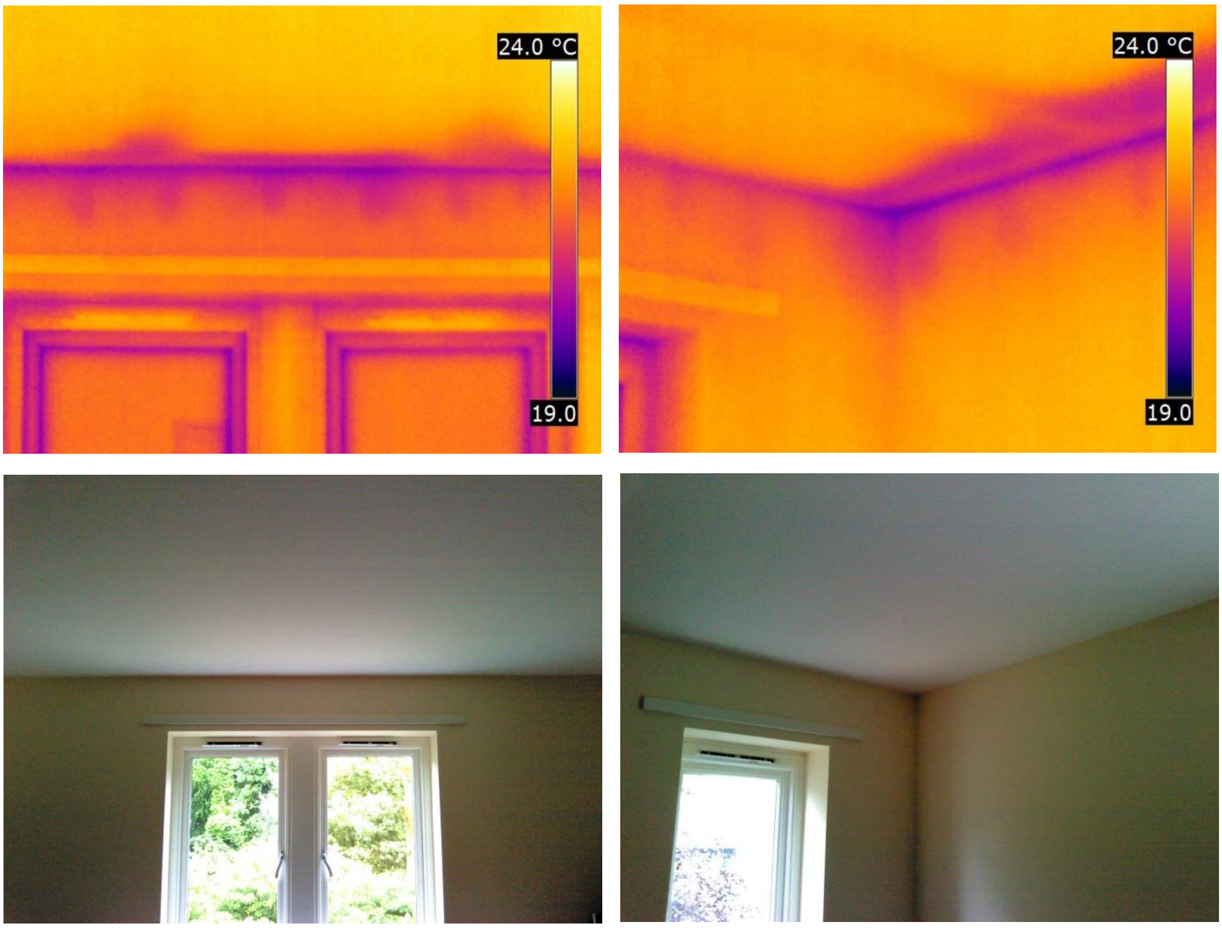


Flat A is a ground floor corner flat, with only two external walls. All the images above, apart from the front door were taken of these external walls. As expected and in support of the external images shown above, thermal bridging was seen at structural joints, where different building materials join, e.g. wall and ceiling or corner of two external walls. The remaining fabric was very uniform suggesting good levels and construction of insulation. This is supported by the construction audit and SAP surveys showing low heat losses and low space heating requirements, as well as warm internal temperatures.

5 Flat B

In contrast to Flat A above, Flat B is a 1st floor corner flat with 3 external walls and a roof. The following images show a selection of the images taken in this property.

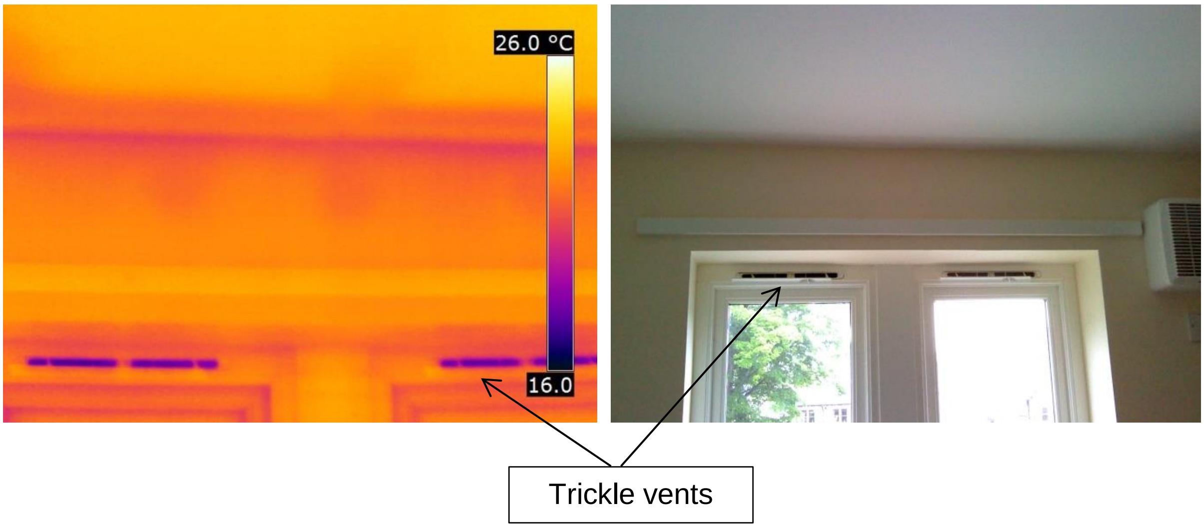
Figure 14: Flat B Rear Wall



As with Flat A the most significant areas of temperature change are where the varying structures join. The vertical corner sections did not show the same variances as in Flat A, however the ceiling to wall joint showed noticeably cooler temperatures that the majority of the wall fabric; more so than in Flat A, likely to be due to the fact that this is a first floor flat and thus the space above the flat is open loft space.

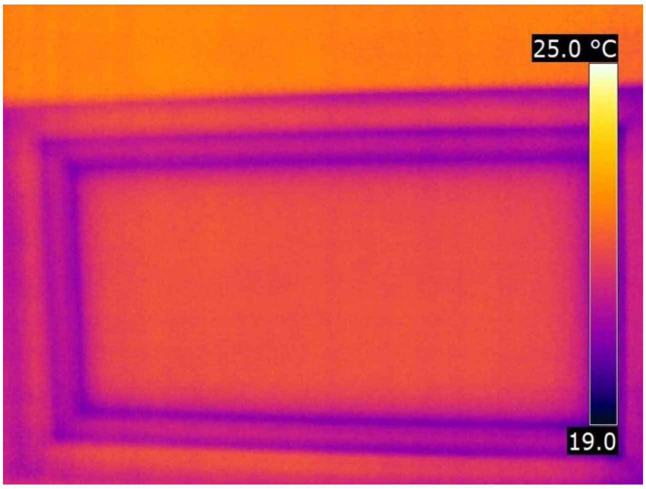
The window frames were also identified as an area where temperatures varied compared to the surrounding fabric. As identified in the external thermal imaging survey, the window vents (Figure 15) were identified in the internal survey as an area of cold air ingress, however these are essential for keeping the flats ventilated and are also regularly used by the residents.

Figure 15: Window Vents Flat B



As well as temperature variations between the walls and ceiling this flat also contained a loft hatch. Similarly to the window frames, heat loss or cold air ingress was found around the hatch.

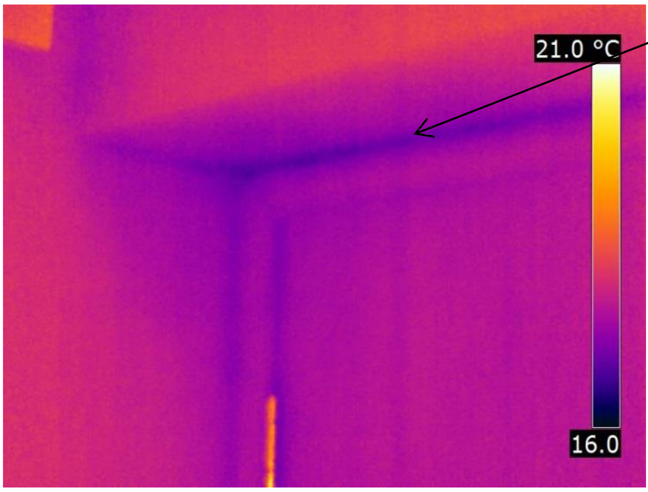
Figure 16: Loft Hatch Flat B



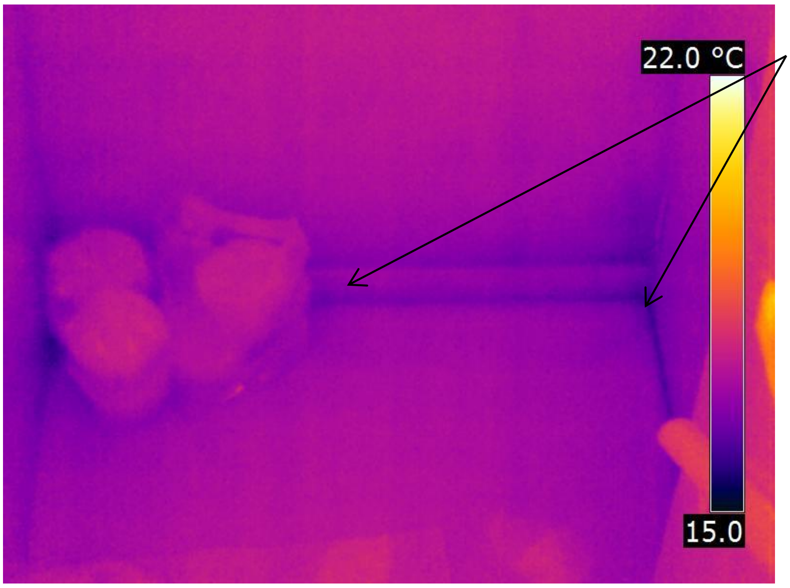
The resident in Flat B often complains that the stairwell is cold. Thermal images were taken at the foot of the stairs and it was shown that there is significant cold air ingress surrounding the door, and from the floor to wall joint at the bottom of the staircase (shown below

It should be stressed that the pattern and location of the areas of heat loss are very much what would be predicted in a modern build, and are not a cause of concern for Connect Housing or the residents.

Figure 17: Entrance hall and lower stairwell – Flat B



Top corner of front door (hinge side)



Base of stairwell showing cold sections at the floor to wall joints.

Interestingly, the resident in Flat B also mentioned a faulty thermostat in the spare bedroom suggesting the temperature was hard to control and often too warm. The images below clearly show the underfloor heating was operational during the visit, even though internal temperatures were recorded as 23.7°C and the thermostat is set to 23°C

None of the other zones within the property were operational during the visit.

Figure 18: Evidence of underfloor heating

6 Conclusions

Overall the images taken both internally and externally have shown Ancion Court to be very well insulated with only minor areas of heat loss and cold air ingress, which are very challenging to avoid with current building methods. The only notable areas are where structures are joining or changing, and in these locations it is very difficult to ensure insulation meets entirely.

The most obvious area of heat loss is through the trickle vents at the top of each window. However with the very low air permeability in the properties it is essential these are maintained to keep the environment comfortable to occupy.

Appendix H

Design and Construction Audit

TSB
File Ref: 450083
Application ref: 17929-111174

Table of Contents

Kiwa GASTEC at CRE

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1 Introduction

An audit was carried out on the construction details and design of the Ancion Court development in Marsden. The aim was to assess the building materials and construction plans and compare with the actual built structure including any deviations from the original designs. These details were then compared to the SAP assessments also carried out at the properties and the energy consumption data collected during the trial.

2 Construction Quality

Ancion Court was designed as a sustainable homes code 4 development meaning the energy use and emissions on site should show a 25% improvement on the target emission rate as stated in standard building regulations. It means all fixtures and fittings should be energy efficient and that consideration has been made to the environmental and ecological impact of the development on the surrounding area, including the use of water within the dwellings. It also means that building materials have been sustainably sourced and all waste materials are suitably contained and disposed of, particularly the provision of recycling facilities.

The building is constructed of block and brick with a Yorkshire stone outer leaf. The wall cavity is insulated with 80mm to 100mm of rigid thermal board (Kingspan Thermawall TW50) giving a design U-value of 0.20W / m^2K. The building is damp proofed with Permabit bitumen polymer.

Floors are constructed of sand and cement screed with 55mm Kingspan insulation on concrete slabs, with suspended floors also constructed of suspended concrete beam and block. Ground floors also consist of a radon barrier and void space. Each flat is heated by underfloor heating as discussed in section 3.

Ceilings are constructed of plasterboard suspended off a grid system and roof spaces are insulated with 300mm of mineral wool or fibreglass. The plasterboard ceiling is foil backed and designed to achieve a U-value of 0.16W/m^2K. The domestic hot water distribution loop is also present in the roof space with individual DHW supplies teeing off the main pump around loop.

Window and door frames are wooden and all are double glazed sealed units using Pilkington K glass. All doors also contain safety glass. Windows are rated at a U-value of 1.8W/m^2K .

Ventilation in the properties is largely provided by natural means however extract fans are also available in the bathrooms and kitchens. In the bathroom these extract vents are linked to lighting, thus when the light is on, so is the extract fan; the fan has an over-run of 15 minutes. On the design specifications, extraction vents in the bathroom are rated to achieve 3 air changes per hour. In kitchen areas extract fans are rated at 60litres/second.

Drainage, sanitation and flashing are designed to the relevant building standards.

2.1 Deviations from Design

As the project at Ancion Court was a design and build contract the final constructed building is very much in line with the final building design. Any variations to the project were discussed within the design and construction team as and when they arose and necessary alterations were made.

One of the alterations that were made was the location and layout of the communal flat in relationship to the heating plant room. Originally the communal room was designed to contain a laundry however the final heating system design was considerably larger than originally expected. As a result the laundry was removed from the plans and the plant room located in its place. This was confirmed by Connect Housing as all tenants would have their own washing machines.

The design and building contractors ordinarily work on Code 3 properties and this development had to take into consideration the additional draught sealing and ventilation aspects that Code 4 requires. A major difference in the design for this development was the use of mechanical extract fans in the bathroom and kitchen instead of cooker hoods in the kitchen.

There was a comment from the design and delivery team that the extra finance required to meet Level 4 is not necessarily good value for money.

No major problems were encountered during the completion of the project and it was delivered on time. If the team were to repeat this project they would not make any major changes.

2.2 Air Tightness

Air tightness tests to ATTMA TS1 were carried out as part of the monitoring project. This measures the amount of air that will inadvertently leak in and out of a building as a result of the construction. It is measured in $m^3\ h^{-1}\ m^{-2}$ at 50Pa. The lower the number, the better the air tightness of the building.

To comply with Building Regulations Approved Document L1A, air permeability must not exceed $10m^3\ /h\ m^2$. Ancion Court was designed with a target air permeability of $5m^3\ /h\ m^2$.

Two tests were carried out in each monitored flat: a sealed test (as per Part L1A of the Building Regulations) and an unsealed test. The results are shown below:

Table 1: Air tightness test results 19/06/2012

Flat	Sealed result $m^3\ /h\ m^2$	Unsealed result $m^3\ /h\ m^2$
A	4.72	4.77
B	7.66	7.70

It is apparent that Flat A fulfils the design specification of 5 $m^3\ h^{-1}\ m^{-2}$; however Flat B is above this target, (although still considerably lower than the building regulations). In support of this, a smoke test was used to identify areas of leakage in each of the dwellings.

Overall both properties suffered from air leakage at points between the floor and skirting; although mastic sealant was present, it was not always consistent and thus gaps were present. Trickle vents were also identified as a significant area of air permeability which was also identified on the thermal imaging survey (as reported in a separate document). Some of the air vents were ill fitting, also supported by comments from the householders that they are difficult to use as seem ‘flimsy’. Finally the toilet and plumbing boxes within the bathrooms in each dwelling were not sealed, thus air could travel through the boxing to either the loft space or external wall cavity.

In Flat B several other areas of air ingress were identified, these included:

- Unsealed cable penetrations into dry lining
- Unsealed pipe runs from the loft space into the heated envelope
- Unsealed boxing at base of stairs
- Breaks evident in dry lining at foot of stairs
- Ineffectively sealed loft hatch

These additional areas are likely to cause the higher air permeability seen in pressurisation tests and are also likely to result in a higher heat use in Flat B than in Flat A. This will be further investigated as the project continues and more data collected.

3 Heating System

Heating and hot water is supplied by two DeLonghi ground source heat pumps rated at 33.3kW and 7.5kW. The source boreholes are located in the adjoining car park feeding the plant room through 40 and 63mm pipework.

The heating system was sized based on the initial SAP surveys carried out during the design and construction phase using a supply temperature of 40°C delivered to under-floor heating in each of the dwellings.

The choice of heating system was discussed with Connect Housing during the design phases. Various options were discussed including wind, solar and biomass.

Solar was discounted as a result of significant shading from trees around the south of the development. These trees could not be removed because the development is in a conservation area and some have Tree Preservation Orders (TPOs) on them. Wind was also discounted because the location of the site within a steep valley.

Biomass was a viable alternative, however due to a lack of resources for maintenance and fuel management this option was considered too expensive. Fuel deliveries could also have proved problematic due to the location and access difficulties in poor weather. Space for fuel storage would have been difficult as there is little space to extend the site; (protected trees to the South and a Listed Building (church) within close proximity).

Individual air source heat pumps were also considered, but the view was taken that it would be more difficult to obtain planning permission for air source heat pumps as they would have been visible on the outside of each individual flat. Therefore it was decided to use ground source heat pumps combined with under-floor heating on a district heating scheme in order to provide heating and hot water to each flat.

The performance of this heating system will be analysed in detail as the project progresses.

4 SAP assessments

SAP assessments were carried out for each of the monitored dwellings. The following table shows the results of these assessments. As the project progresses and at least a year of data have been collected, the results from the data monitoring will be compared to the SAP figures.

Stroma carried out the original SAP surveys and air permeability tests discussed above on the dwellings when they were in the design and build phase. As part of the TSB project Kiwa then carried out a second SAP assessment at the start of the project phase. The results from these assessments are shown below. Interestingly the SAP assessments carried out by Kiwa suggest a higher heat demand than those by Stroma.

Table 2: SAP Summary

	Property Ref	Average Internal Temp	Space heating requirements kWh/yr.	Space heating fuel requirements kWh/yr.	Water heating requirements kWh/yr.	Water heating fuel requirements kWh/yr.	Elec for lighting kWh/yr.	CO2 heat	CO2 Water	CO2 Lighting	**Total CO2**	**Sap Band**	**SAP rating**
Stroma	Flat A	18.3	2633	823	2942	1314	388	347	554	164	**1120**	**B**	**84**
Stroma	Flat B	18.5	1941	607	2751	1228	306	256	518	129	**958**	**B**	**85**
Kiwa	Flat A	17.6	4437	1165	3138	784	698	491	331	295	**1117**	**C**	**80**
Kiwa	Flat B	17.6	4486	1178	2826	706	201	497	298	201	**996**	**C**	**79**

5 On-going Aspects

Overall the development has been built to a good standard with very positive feedback received from the residents.

There have been some issues with cool Domestic Hot Water (DHW) delivery at one of the dwellings furthest from the plant room and these are being monitored as the trial progresses. It is thought likely that this cooler delivery temperature may be the result of a mixing valve or low flow rate in this property.

The residents have also expressed concern over the controls within the flats for the underfloor heating. This has been noted and Connect Housing are considering the possibility of replacing these controls in the future. It has been difficult for some of the residents to adjust to underfloor heating when moving from a standard radiator heating system and this may require further consideration by Connect Housing as the best way to operate and control this type of system. This has been suggested as a change to the resident user guide offered to new tenants.

There have also been comments from the residents regarding the trees at the back of the site and the amount of shading which is being experienced, especially in the ground floor flats. This has been quite well demonstrated in the lighting estimations shown in the SAP assessment above, with Flat A (ground floor) having a much higher estimated lighting use than Flat B. This will be monitored as the trial progresses.

No other significant maintenance issues or problems have arisen so far.

Appendix I

User Guide Evaluation

TSB
File Ref: 450083
Application ref: 17929-111174

Table of Contents

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1 Introduction

An evaluation was carried out on the Home User Guide to assess its effectiveness in providing useful and informative advice to new householders in Ancion Court, Marsden. The aim of the document is to provide information to new residents concerning the various fixtures and fittings within the property as well as useful local information such as contact numbers, transport links and local amenities. This review assesses how user friendly and useful the current version of the document is, with the aim of recommending improvements to the document for future tenants and developments.

This review starts with an overview of the User Guide and then comments are made on each section in turn with recommendations for improvements.

2 Overview of User Guide

Each section of the user guide was assessed and the resulting comments and suggestions of this review are detailed below. Each section is addressed with the corresponding heading number and title as displayed in the user guide.

Overall the document has been designed to be informative for the tenants and contains useful and important information. However, the document is considerable in size and some aspects are repeated. The tone of the document can also be a little patronising in some areas such as the phrase “what to touch and what not to touch” and there are ways in which it could be improved to provide the tenants with a user friendly but informative guide.

One of the main recommendations is to re-order the document to avoid numerous sections covering the same aspect. It is suggested that the document is divided into the following headings:

- Introduction & Contact details (including emergency contact details within Connect Housing)
- Stop Taps/Emergency shut-offs
- Emergency services
- Environmental considerations
- Electricity
- Cold Water
- Hot Water
- Central Heating
- Gas (In developments where gas is not present this can be stated clearly on this page)
- Fixtures and Fittings (to include ventilation, door entry, drainage, TV)
- Local amenities and transport

Although there is a section entitled ‘stop taps/Emergency shut-offs’, it is recommended that there is a statement and clearly labelled photograph / diagram regarding the location of the emergency shut off taps/valves at the beginning of each of the utility (electricity, water, heating etc.) sections. Images should not be hand drawn or labelled in hand writing as this can be difficult to read, particularly for residents with visual problems. All images should be annotated/labelled electronically and sized to fit the page in which they are located. Images should not be skewed or squashed to fit.

The guide also refers to websites throughout; this is good as a point of reference but as many of the tenants may not have internet access or not wish to use the internet, particularly if they are elderly, the important aspects should be listed in the guide. This also encourages regular reviews to be carried out to ensure the information is up to date.

3 Detailed Review (Including Recommendations)

3.1 Section 1.2 Stop taps/shut offs

Cold Water – This section starts with the comment 'sure stop' located … but no indication of what a sure stop is. It may seem obvious however some residents may not realise this cuts off the water supply.

Heating – "turn off both the red and blue insulation valves" should read "…isolation…" not "…insulation…". These valves should be clearly shown in an annotated diagram as the entire underfloor manifold has red and blue valves on each circuit and without any experience of underfloor heating it could be difficult to identify which shut off valves are being referred to.

There is no attached plan in the document.

The statement regarding drilling or puncturing of underfloor heating should be at the beginning of the space heating section.

3.2 Section 1.3 Metering

Heading could be misleading; this section is really about utility provision and the position of the utility meters in the dwelling.

The notes on heating are brief, almost note form. The method and source of heating should be explained as should the fact that heat is provided by underfloor heating and not radiators. The comment that "you will be able to monitor your consumption…" shows very good intention but it is very unlikely that any householder will know how to do this, or be able to easily access the meters currently installed. If this is put forward as an option for householders to monitor their consumption, this should be explained with detailed photographs showing the meter, its location, the display and what the figures are showing. Alternatively, this could be explained during an extended householder introduction session.

3.3 Section 1.4 Fire Safety

Doors are listed as "fire rated" but this is not explained, sentence could read 'doors are fire rated which means….'

Final sentence says "In the event of a fire you should carry out the following procedures" but no procedures are listed.

3.4 Section 1.5 What to touch and what not to touch

Title should be changed.

This section seems unnecessary and not that helpful to the tenants, the tone of text is also a little unfriendly. The annotated diagrams should be re-produced electronically and then a clearly labelled and properly sized image should be included in each section as listed in section 2 above, e.g. a diagram showing the under sink area should be included in the section headed ‘Cold Water’. Similarly an annotated diagram showing the components of the heating manifold should be included in a section headed ‘Central Heating’. This reduces repetition. The hand written annotations are difficult to read in places and have corrections clearly visible

The text bubbles stating whether of not the tenants should touch anything e.g. “No need to touch anything here” should be removed. Instead a sentence above the diagram could read… ‘The following image shows the main fixtures and fittings in your property with regard the (ENTER SUBJECT e.g. central heating). The majority of these do not require any interaction, however the (ENTER OBJECT) highlighted in (ENTER COLOUR) will need to be (ENTER ACTION) if an emergency occurs’

Labels show a high level of detail but very little explanation particularly labels on the underfloor heating manifold which just state ‘isolation valves (1/4 turn)’. This does not seem relevant information for the tenants.

3.5 Section 1.6 Environmental Considerations

This section should start with an explanation as to the importance of environmental aspects such as energy saving, water conservation, pollution reduction and financial savings. It is important to explain why people should care about the items being listed to ensure greatest uptake of co-operation.

Point 1 states that the development has been built to achieve Level 4, but with no explanation as to what this means. Connect should want the tenants to be proud of this fact and thus should explain the importance of achieving this standard.

Point 3 describes that heating and hot water are provided by heat pumps. Many residents may not know what a heat pump is or how it works, so a brief explanation should be provided particularly regarding the last sentence that the heat pump does not use “free energy”.

Point 4 states that replacement lamps must be the same. Is this referring to the bulbs, or the light fittings? This point also suggests residents visit the Energy Saving Trust website for further energy saving ideas; however it is unlikely that residents will do this unless there is some explanation behind why this is important. The aims of Connect should be clearly stated with regard energy savings, as well as the ethical reasons why everyone should be concerned with saving energy, plus the financial benefits of reducing energy waste. This can then be followed by the aspects listed in point 6.

After the Environmental considerations section there is a photocopy of a government guidance document regarding rated appliances. However, the image as is stands shows no explanation. The section should start by explaining to the reader what the document is and how it should be used.

3.6 Section 8 Waste

This section should be renumbered as it does not fit with the numbering scheme.

The information provided in section 8 is good; the only comment would be to provide a list of those items that are accepted in each of the bins instead of a link to a website address. It is unlikely the websites will be viewed, however a list, or even a separate pull out page showing items that can be recycled could be useful as tenants may wish to stick this on a fridge or notice board. Pictures of the different bins available may also be helpful.

3.7 Section 1.7 Heating

First sentence is good but should be expanded to explain that underfloor heating is not the same as standard radiator systems and outline how performance and operation is different. This section should also explain the use of zones within the properties.

A lot of the detail in this section repeats what has already been discussed in 1.5. Only one section is needed for heating.

3.8 Section 1.8 Hot Water

No comment.

3.9 Section 1.9 Cold Water

No comment

3.10 Section 1.10 Electrics

Remove the word ground from the first sentence to read "…enters your flat at ~~ground~~ floor level…"

The photograph should be electronically annotated to show the switches that may need attention.

3.11 Section 1.11 Ventilation

Re-order so descriptions match listing, e.g. listed as a) then b), so descriptions should be a) then b).

Some more explanation or re-wording could be beneficial here to stress the importance of ventilation and how it should be achieved. The sentences in bold at the bottom of the page are not well worded and could be re-written.

Note regarding extract fan for battery acid is not clear. Do all flats have this function? It should be noted where these additional extract fans are located.

3.12 Section 1.12 TV

Overall this section needs attention and re-wording to clarify.

3.13 Section 1.13 Door Entry

Check wording is sufficient to understand how to use the door entry system and the options the user has with regard security.

3.14 Section 1.14 Drainage

Check wording. Sentences are over complicated perhaps containing more information than a standard tenant would require.

3.15 Section 1.15 Amenities

Very informative and useful for the reader.

3.16 Section 1.16 Transport

Again this section provides useful and informative information however the map is difficult to read. The fact that Ancion Court is hand written as ‘site’ is impersonal and the diagram should be replaced with a clearly annotated electronic map showing ‘Ancion Court’ and surrounding road network.

3.17 Section 1.17 Emergency Services

Very useful but could be moved to a more prominent position nearer the front of the guidance for easy access should an emergency occur. Telephone number for Marsden Health Centre is missing a ‘0’.

3.18 Section 2 Operating Instructions

This section contains a lot of information and is not easy for the reader to navigate. There is also significant repetition from previous sections. For each object there should be a one or two page quick start guide included in the user manual. This should be within the named section for the object, e.g. the guide to the thermostats should be within the central heating section of the guidance.

As support to the quick start guide the full instruction manuals should be included in a separate pack, to which the tenant can refer if the quick guide is not sufficient, or to which the tenant can refer an engineer to if there is a problem within the property.

By separating the documents it makes the welcome guide much smaller and less daunting to the tenant and much easier to follow and refer to should they need to. The full instructions are very complicated and not necessary in everyday operation of the fittings and appliances in the flat.

4 Further Recommendations

It is suggested that Connect Housing carry out a witnessed hand over process, at Ancion Court to assess how effective the process is and if all aspects are fully covered. This will enable Connect Housing to ensure their staff are fully informed and adequately trained, as well as ensuring any new tenants fully understand their new home and can live comfortably in the property. This could form part of an on-going staff training programme.

The user guide should also be regularly reviewed to ensure the information is up to date and contact numbers are still relevant.

Appendix I

User Guide Evaluation

Ancion Court, Marsden

Evaluation of handover process and guidance provided to occupants.

Meeting 22 September 2014 at Connect Housing

Michael Rose - Lettings & Leasehold Manager
Joanne Wilson - Senior Customer & Service Improvement Officer
Jenny Brierley - Chief Executive

Information given to new tenant	Comment
Welcome Pack – as for all new Connect tenants	
Home User Guide	See 4.3 User Guide Review. Quantity and complexity of information in HUG makes this of limited value to tenants at moving-in stage. Useful as reference manual but clear concise operating instructions close to equipment with annotated photos, would be more helpful (e.g. as produced by bere:architects for Ranulph Road Passivhaus, Camden).
Brief explanation given of how GSHP, underfloor heating and controls work.	Needs more emphasis on setting-and-leaving controls to provide consistent temperatures on day-time/night-time settings.
Advice given if extra heat needed – use boost setting, but allow 2 hours to reach temperature. Use of extra heaters discouraged.	From experience, advice should be to use additional heaters, supplied by Connect and leave controls as set.

Help to operate controls - visit by Energy Efficiency Officer offered. Phone number for heating breakdown given.	As this may be 1-2 weeks into tenancy, heating to be set on standard settings at handover. Check correct number given as this scheme requires specialist heating contractor.
Need for carpet/underlay suitable for underfloor heating explained.	
EPC provided to tenant with brief explanation.	Opportunity to explain energy ratings on domestic appliances and energy efficient lighting (appliances and light bulbs are tenants responsibility).
Payment for heating and hot water through service charge explained, calibrated according to usage.	
	Explain trickle vents and importance of using these.
	Explain high level of insulation means heating system is economic, even if left on continuously. This is counter-intuitive for occupants used to conventional heating system and keen to save energy costs.
	Explain best way to get natural light through the flat, especially flats shaded by trees.
	Reinforce messages about heating controls at initial visit (1-2 weeks after handover) and starter visit (6-8 weeks after handover). Involve Energy Efficiency Officer for advice if occupant still has problems with heating system.

Appendix J

BUS Surveys – Interim report

TSB
File Ref: 450083
Application ref: 17929-111174

Table of Contents

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1 Introduction

A BUS study was carried out at the Connect Housing Development of Ancion Court in Marsden. Each resident was asked to answer the questionnaire truthfully and openly with all of the residents willingly completing the survey.

This document details the findings of the BUS, identifying the salient points from which developers of future projects can consider. The document is split into five main sections detailing:

- Air quality
- Controllability
- Design Aspects
- User Needs
- User Feedback

The results from each aspect are compared with benchmarks and scale limits. The benchmark value is shown on the top of the slider bars displayed below and relates the project data to previously collected information. Each benchmark has an average (mean) figure as well as an upper and lower limit. The scale value is displayed on the bottom of the slider and shows the mid, upper and lower ranges of the scale for the aspect in question (usually a score of 1 to 7). The data collected during the survey can be related to these values as a way to compare the results with other developments.

The colours relate to whether the aspect is good, bad or average. If the colour is orange then the result is close or within the upper and lower limits of the benchmark and scale value. If the colour is red then the result is outside of the upper or lower limit and results in a negative impact to the resident, e.g. greater than average noise is present in the development. If the colour is green then the result is also outside of the upper or lower limit but the impact of this on the resident is positive, e.g. better than average or acceptable air quality is felt by the residents.

2 Air Quality

Residents were asked to comment on the air quality of the development during summer and winter periods. The following diagrams show the results of the first questionnaire.

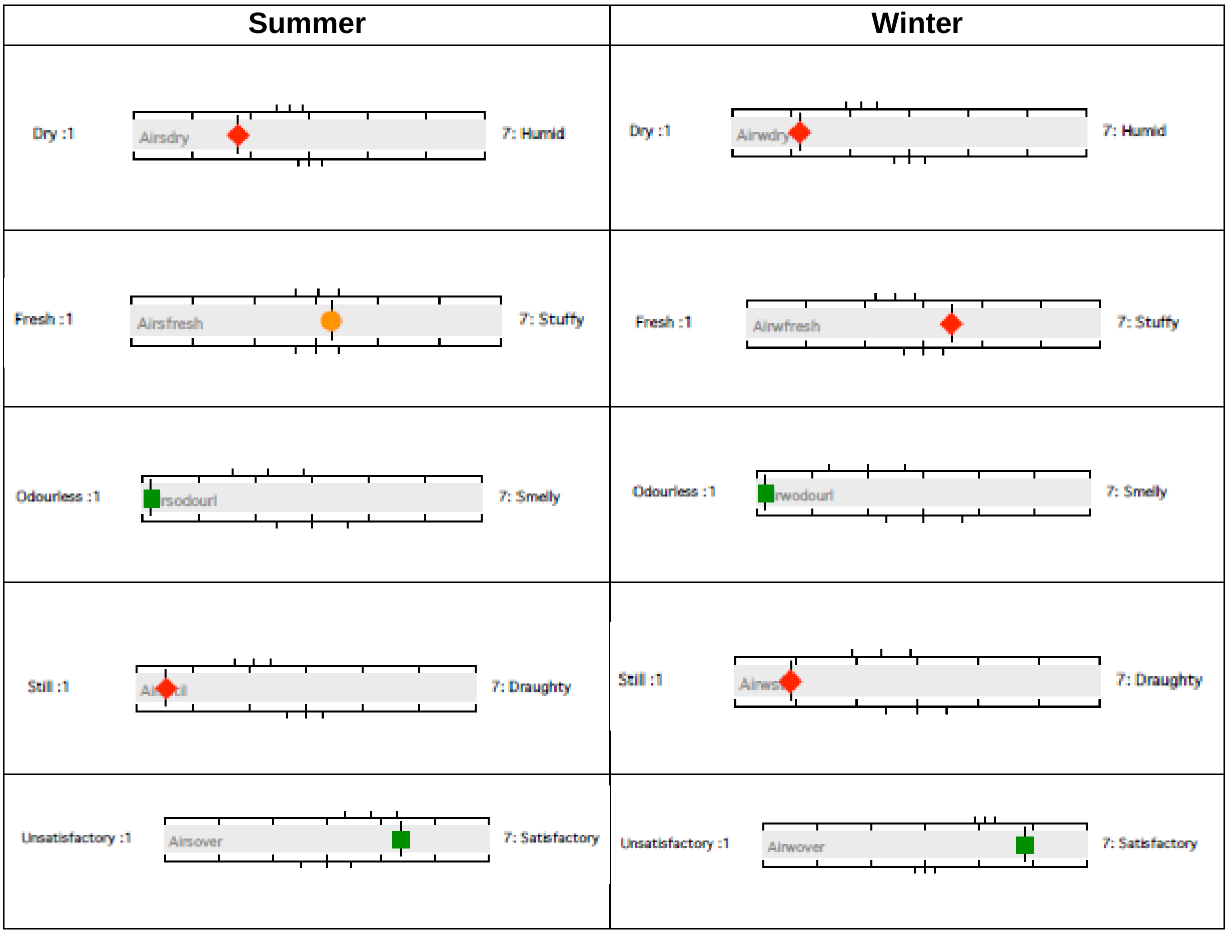
During both winter and summer the air was considered dry, and below both the lower benchmark figure and the lower scale limit. Over 50% of the residents consider the air to be dry, and 75% of those questioned feel the air quality is average to stuffy within the flats. This Indicates the air is perceived as dryer than considered acceptable in this development than in other projects. Similarly the stillness of the air in both winter and summer was also considered below the lower benchmark and scale values, suggesting a sheltered location and minimal draughts. This may also suggest limited ventilation, and comments from the residents included:

- *Air flow in summer by opening doors and windows. There's no on/off button on the heating so cannot be sure it is off (particularly at night).*
- *Bedroom is hot and we don't want to open windows because it is a ground floor flat.*
- *Black flies from trees if I open windows.*
- *The doors are opened more in summer.*
- *Electric fan needed because it is too still.*
- *You can open the door, but you do not know if the heating is on or off.*

The odour of the air falls below the lower limit of the benchmark and scale limit, meaning the air is odourless, which is very positive for the residents. However, the results also indicate that the air freshness falls towards the upper range for both the benchmark figures and scale figures, meaning that the air can be stuffier than considered acceptable.

Overall satisfaction falls above the upper range for both the benchmark and scale figures showing a better than average satisfaction in air quality in the development.

Figure 1: Air Quality



3 Controllability

Control was considered with regard heating and cooling of the properties. This was by far the most verbally criticised aspect of the development, particularly with regard the heating system; however the slider results do not show a significantly worse than average result. Heating control is within the scale limits and only marginally below the benchmark lower limit.

Overall 61% of the residents thought they had full control when cooling the property, with only one resident saying they had no control. Similarly 69% of those questioned thought they had full control on the level of ventilation within their property. This is supported in Figure 2 below with results for both of these aspects above the upper benchmark and scale limit.

In contrast only 30% of the residents (4 individuals) thought they had full control of their heating system with another 30% stating they had no control. The remaining residents tended to provide scores of 4 or below when considering the heating system, suggesting a feeling of a lack of control. The numerical result for heating control is only marginally below the lower limits of the benchmark and scale limits; however some of the comments are shown below:

- *Controls are in a bad position and angle is poor.*
- *Controls are difficult to use.*
- *Draught from the stairs. Controller complicated, with the underfloor the feet are hot all the time, have to use a foot stall.*
- *The controls are hard to use, so don't mess with it.*
- *The controls are too complicated.*
- *If there is a sudden temperature drop, there is a lag in re-heating. The system is unresponsive.*
- *Response of underfloor system is slow, it takes a couple of hours to heat or cool. The controller is hard to set up.*
- *Temperature is up and down, takes 2 hours to cool the underfloor. The controls are hard to use and the position is bad. The flat is both too hot and too cold.*

Lighting control was also an interesting aspect with 23% of the residents suggesting they had no control over the levels of lighting and 31% suggesting full control. In this category 9 of the residents suggested scores of 4 or above for lighting controls. It is likely that lack of control observed by some of the residents is a result of trees against the back of the property. Many of the residents comment that the trees make natural light very dark and thus artificial lighting is required all day. Comments have also suggested that the lighting within the development as a whole is quite dim, with many residents adding additional lamps to compensate.

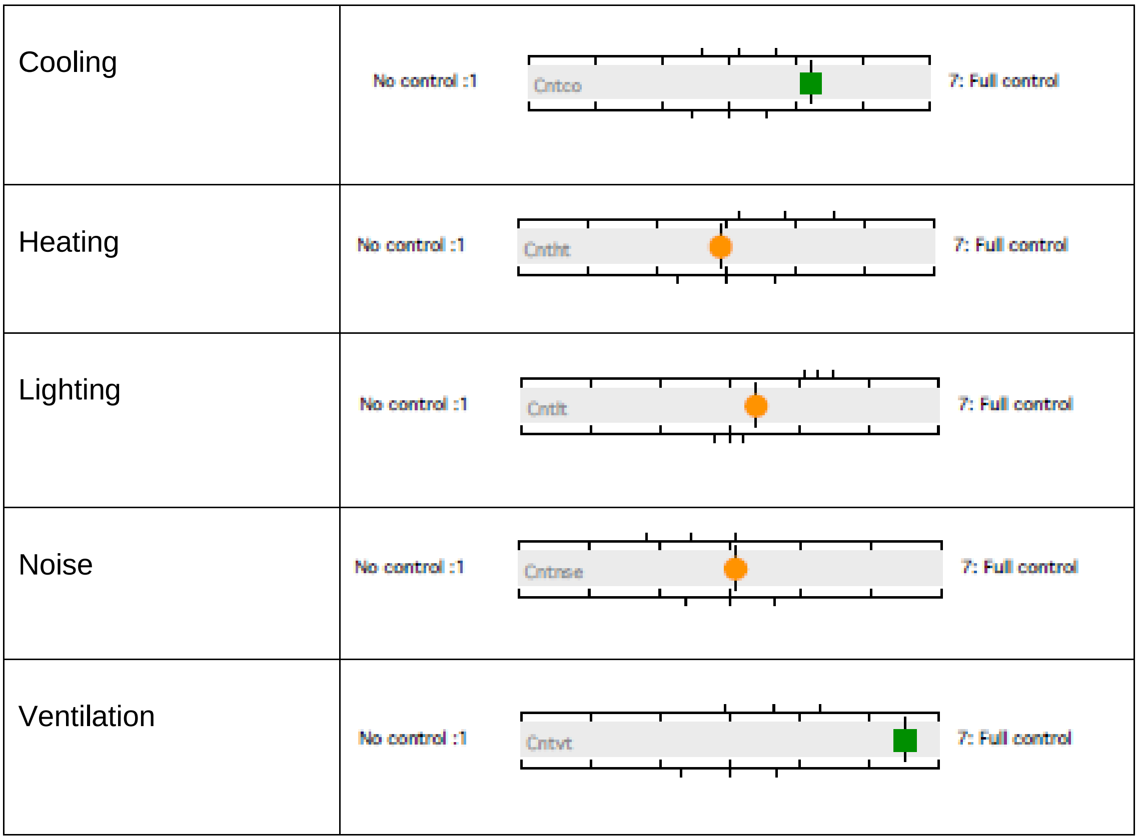
- *All lights on at once in the lounge, no way to just have one light on. The hall and lounge lights are on all day.*
- *The trees block out all the natural light.*

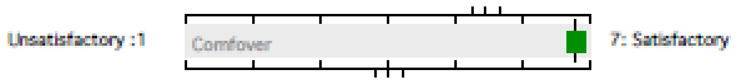
- *Bulbs are not strong enough. The lounge light bulbs go very quickly - potential wiring issue.*
- *Bulbs take too long to come on, the hallway is dark.*
- *Need a separate switch for each light and brighter bulbs. The trees block the light.*
- *Poor lighting. The low energy lights are not bright enough.*
- *Shady in the living room, it's not bright enough.*
- *Trees block all the light. Need to add lots of lamps.*

The final category with regard control is the level of noise observed within the property. This again was a very even divide between those that felt they had full control over the level of noise, compared to those that felt they had no control (31% for each). Several comments were received with regard the noise of the plant room, which is under automatic control and quite noisy day and night, as well as the road which runs along the back of the development. The amount of control felt by the resident is likely to have a direct link to the proximity of the property to the plant room and road.

Even with many of the residents showing dissatisfaction with some of the control aspects in the development, the overall perception of comfort by the residents is good. 85% of the residents claimed that comfort was satisfactory.

Figure 2: Level of Control

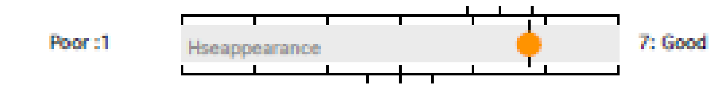
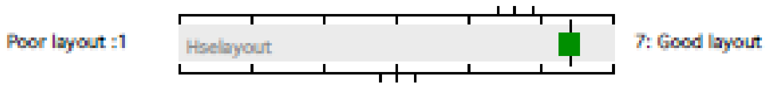
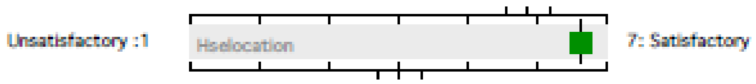
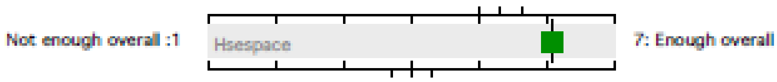
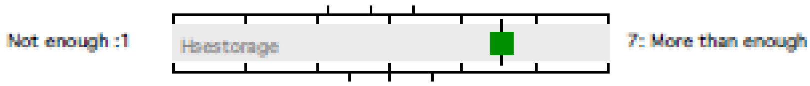
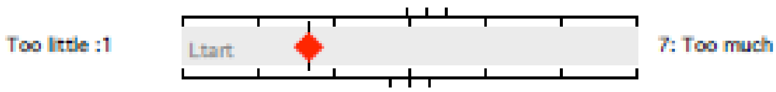
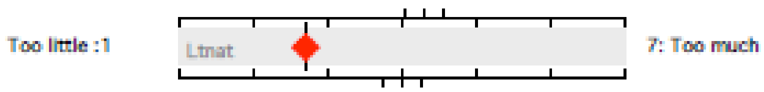
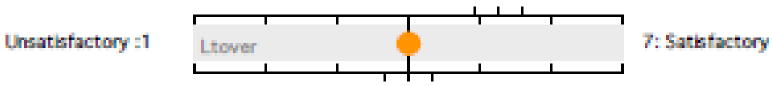
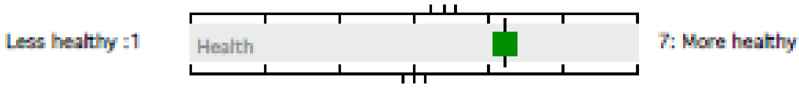
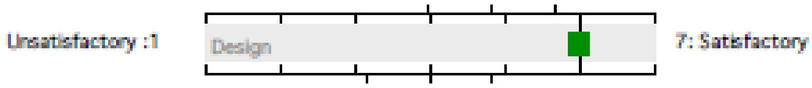


Overall Satisfaction	

4 Design Aspects

The residents were asked about the design aspects of the property, including how satisfied they were with design, whether there were any perceived health benefits and the level of light within the property. The following figure shows the results.

Figure 3: Design Aspects

Appearance	
Layout	
Location	
Space	
Storage	
Lighting – artificial	
Lighting – natural	
Lighting – overall	
Health	
Overall satisfaction	

Resident satisfaction at Ancion Court is high with the majority of results falling above the upper limits for both benchmark and scale aspects. Comments from the residents include:

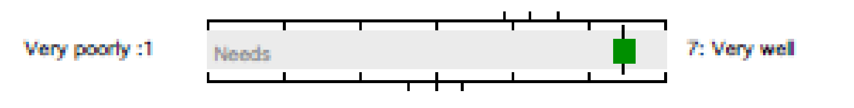
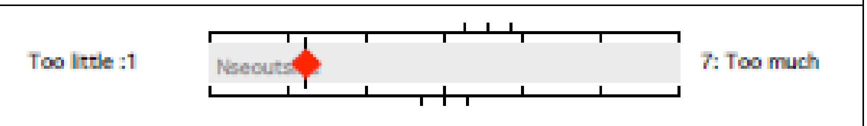
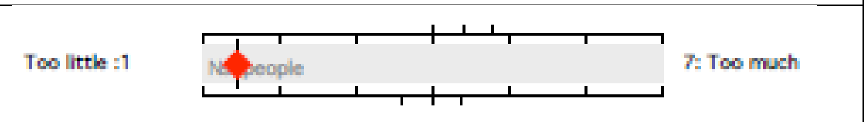
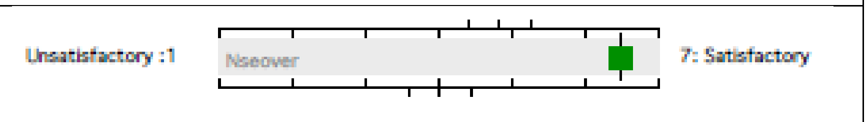
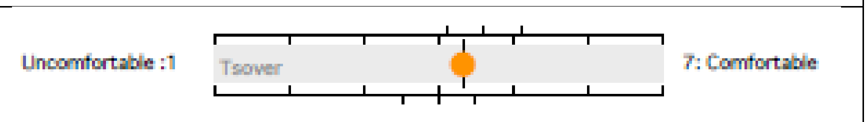
- *Beautiful location and other tenants are pleasant and sociable.*
- *Flat is level, as is the walk to the village.*
- *Involved in lots of activities, including gardening and the allotment.*
- *Library and shops nearby; could do with a swimming bath nearby. Good pubs and nice walks.*
- *Much more social and very friendly neighbours. More able to get involved in activities.*
- *Flat has given me some of my independence back as I can do more things on my own without relying on my wife as much.*
- *Healthier, more relaxed community.*

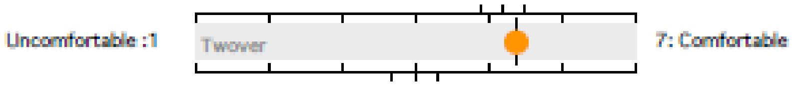
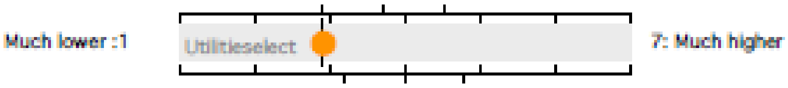
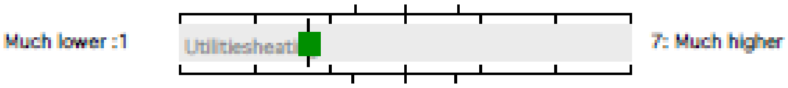
However as with the control aspects discussed above the level of light does cause problems with the results for both natural and artificial light falling below the lower limit of the benchmark and scale figures. When carrying out the resident walkthroughs there was also a comment regarding the difficulty in reaching the window vents in the kitchen, with some residents having to use step ladders to reach over the working surfaces or sinks. This may be difficult with older tenants.

5 User Needs

The final section details the success of the development for meeting the users' needs; this includes the costs of living in the building with regard heating and electricity compared to previous accommodation.

Figure 4: User needs

Property Meets Needs	
Noise from outside	
Noise from other people	
Noise overall	
Temperature – summer	

Temperature – winter	
Utility cost – electricity	
Utility cost – heating	

Overall, the residents seem very satisfied that the property meets their needs very well. Interestingly, although many of the residents comment on the lack of control and difficulty with the heating system the numerical score given to the level of comfort within the development seems to suggest a comfortable internal temperature during both winter and summer months, with a score given within the benchmark boundaries. It will be interesting to see if these scores or comments change at the end of the trial period.

There also seems to be a positive outcome with regard the cost of heating the properties and the cost of electricity usage. However some of the comments received seem to contradict the scores given. Many residents' thought that more electricity is required in this development because more artificial lighting is required. However some also commented that the properties are now smaller than previous dwellings and thus require fewer light fittings and less heating. Some were concerned that the heating is now on all the time compared to the old systems in previous dwellings, however some also suggested that secondary heating is now not required as the ambient temperature is warmer.

The residents were satisfied with the location of the development with regard local amenities and transport links, however did comment that the trees in very close proximity to the buildings caused problems with sap dripping on the flagstones and making walkways slippery. Since this has been brought to Connect Housing's attention, the flagstones are now being regularly cleaned to remove the sap.

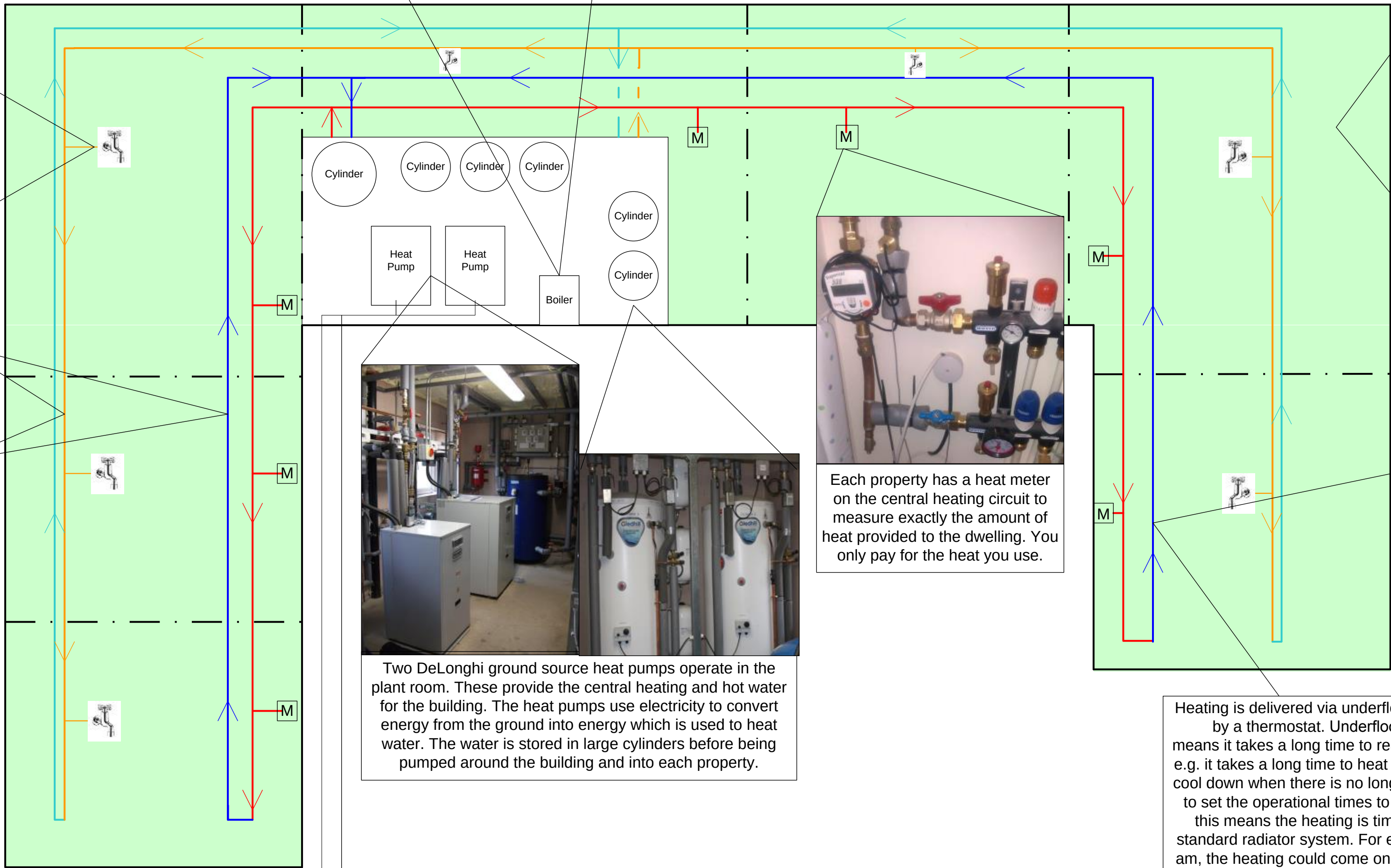
The feedback from the BUS questionnaire has, on the whole, provided very positive feedback with regard living at Ancion Court. There seems to be a good sense of community and satisfaction within the development.

Appendix K

Energy day Material

Ancion Court

A back-up electric boiler and immersion heaters are available to supply heat and hot water if necessary.



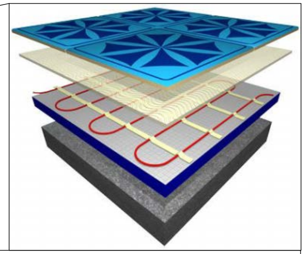
The hot water is supplied using a ‘pump around’ system meaning hot water is constantly pumped around a loop from the storage cylinders in the plant room. This ensures that every time you turn the tap on, the water is hot immediately.

The pipework for the hot water and central heating run through the roof space. Each dwelling has it’s own supply ‘leg’ from the central system

Electricity meters record the electricity supplied to each property. You are charged for the electricity you use.

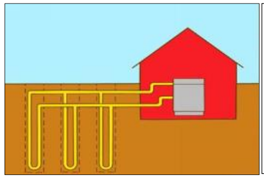
Each property has a heat meter on the central heating circuit to measure exactly the amount of heat provided to the dwelling. You only pay for the heat you use.

Two DeLonghi ground source heat pumps operate in the plant room. These provide the central heating and hot water for the building. The heat pumps use electricity to convert energy from the ground into energy which is used to heat water. The water is stored in large cylinders before being pumped around the building and into each property.



Heating is delivered via underfloor heating which is controlled in each room by a thermostat. Underfloor heating has a slow ‘response’ time, which means it takes a long time to react to a change in temperature requirement; e.g. it takes a long time to heat up when the room is cold and a long time to cool down when there is no longer a need for heat. It is therefore important to set the operational times to accommodate this delay in response. Often this means the heating is timed to come on and go off earlier than with a standard radiator system. For example, if the rooms needs to be warm at 7 am, the heating could come on at 5 am, so it is warm by 7 am. If after 9 am the room does not need to be warm as the property is empty the heating could go off at 7 am, meaning it will only start to feel cooler by 9 am.

BOREHOLES



http://www.biggsandread.co.uk

Heat from the ground is absorbed at low temperatures into a fluid inside a loop of pipe buried within a borehole. The fluid then passes through the heat pump where compression and expansion of the fluid raises it to a higher temperature, which is then used for the heating and hot water circuits. The cooled ground-loop fluid passes back into the borehole where it absorbs further energy from the ground in a continuous process as long as heating is required.

Appendix L

Occupant Interview – Flat A

Occupant Interview - Flat A

Thank you for being willing to take part in this interview. Can I assure you that no records of the interview will be kept with your name on them.

Section A: SATISFACTION
1. How satisfied were you with the induction process? Yeah it was good, they were all quite friendly. The reason we moved was very traumatic but it was OK and they didn't miss anything. We always lived in the surrounding area anyway but then my husband died and I have a disabled son. I sold the bungalow within a day of putting it on the market so had to move.
2. How satisfied were you with the home user guide? **-understandable?** **-easy to read?** Don't think I read much! It's all quite straight forward when you've lived in a house for 50 odd years. It's quite warm in here though, the house gets very warm when I'm ironing, and can get too hot, but then I can also feel cold; especially at night, there's no happy medium. I can't stand heat at night though; I don't like it too hot. My son loves it here. He's really happy. We left a lot of people when we moved, he left his day care centre, I left my friends, but no we're both happy here. It's great.
3. How easy is it to clean and maintain the house? Oh lovely, very easy. Couldn't have bought anything better. I didn't want to rent but there's just nothing available to buy round here. I've always had a bungalow, so I wasn't going from a bungalow to a house; my son is disabled and needs the flat. We rented round the corner when we first moved, but I didn't trust the landlord. We had problems with the boiler over Christmas and he didn't get it mended, he wasn't paying the right premium to get a call out. I didn't like him. This is a nice flat with nice people.
4. Is there anything you do not understand about your home? **-renewables** **-equipment** **-fixtures** **-fittings** No not really. I'm disappointed that there is only 1 switch for the two lights in the lounge. You have to have them both on at once. In my old house each light had a different switch. It doesn't seem very economical to have them both on at once. It's not a problem though, but might be useful for Connect for future.

The second bedroom could do with a bit more space. It’s long and narrow and would be nice if it was slightly bigger so you could move the furniture round. It has to stay as it is at the moment. But my son loves it, he doesn’t come out. I ask if he wants to come out and he says no thank you I like it in here! He loves it. He loves his bedroom.

I really like my room too actually. I think it’s lovely.

5. How satisfied are you generally with living in this house?
-appeal

Absolutely. Can’t fault it really, apart from the trees. Did I tell you I’m getting a new window fitted in here (*lounge area*), I’m ecstatic! I can’t wait. It’s going here behind me where this mirror is. I bought the mirror to reflect the light from the hallway but no, I can’t wait for the window.

-ease of use

Drying clothes can be difficult, I dry them in the hall on a maiden but it takes a while. In my old house I used to put them out in the morning and they’d be dry by dinner time, only took a couple of hours. But I used to hang things on the radiators, which I can’t do here and I do think it makes a difference.

The trees also make it feel damp, they really overhang and it makes things damp. The trees don’t let the sun in. It felt damp in here so I put some of those crystals under the beds and the ones in Howard’s room filled up with water. So it can be damp.

We can dry things outside, some of us have got lines, but there’s not enough for everybody. They’re talking about putting a washing line in the car park so it’s not under the trees, some of the others were talking about using it, but I’m not going to; I’m not airing my knickers in public! I don’t want everyone to see my things; my mother always used to say good neighbours are neighbours with a fence!

-family friendly

It’s very good, it’s flat which is great for Howard and my daughter and my grandchildren.

-livability

It’s great.

Section B: COMFORT AND CONTROL

6. How well does the heating system perform?
-temperatures

I'm not 100% happy but I wouldn't want to go back to radiators. Now I'm used to it I like it. My son has just converted a house to have underfloor heating and it's wonderful. He just sets it and leaves it alone, he doesn't change it and is always telling me just to leave it. Daniel's is better than this, he can switch it on, on his way home from work but I wouldn't want that, he's a real gadget man; I wouldn't want to do that.

-ease of use

Nightmare! The thermostats are awful. I can turn it up or down but I can't change the day or times and I'd like to turn it off in the day. My daughter has set it up for me several times; she comes round and sets it up and she's shown me how to do it, but I can't remember it's so difficult.

-responsiveness

When I'm busy during the day I don't notice it but at night it can feel cold, especially by the window. I wouldn't complain, but it's just niggly little things, like there feels like a draft by the window and it gets cold.

Connect have been really good, they're friendly and they do do stuff to help.

-quality of heat

It's a dry heat. We both got a dry cough last winter, for the whole winter. I think it's slightly too dry, so sometimes I might turn it down to try and help it. (*Son coughs*), see he's coughing now.

7. How effective is the day lighting in the home?
-different rooms

It's not. It's very dark, but they are putting in the new window which will help, I'm ecstatic about it. I have to have the light on in the hall all year round.

8. How effective is the artificial lighting in the home?
-different rooms

I don't like the light bulbs; I think they're awful really cold and dim. I used to have 60W candle bulbs which were spot on, they were lovely warm light. These are not good, they're ugly and the light is so dull. I'm going to change the light fittings once I've had the window and stuff. There's just a strip light in the kitchen I don't like those either. I used to have the halogen spot things, I like those, they're much better.

9. Are there any acoustic issues in the home?
-inside/outside

No I'm quite happy. I don't like it too quiet; it's nice to hear the traffic and people passing outside. I like to hear people but I don't like too much noise. I have the radio on all day.

I do hear a little bit from the neighbours but nothing bad. When I first moved in I met the lady upstairs and she warned me that they often have parties and hoped I didn't mind! I said as long as I was invited that wasn't a problem! No they said they go to bed about 11 and so do I, I love reading in bed.

I would like to have a window on the front of the house. I don't see anyone passing and if I don't go out I don't see anyone. I miss just looking out of the window and watching the world go by and just seeing what's going on. I used to see the same people walking past every day, you know, a lady used to walk her dog and if I didn't see them I would wonder what had happened to them or where they were. It's nice to know everyone is ok. I think it would bother me more if I was off my feet and couldn't get out. But I do miss it.

10. Do you ventilate the house?

Yes

-when during day

The vents in the kitchen and bedroom are open most of the time. I also open the kitchen windows if I'm in and the often bedroom windows too. In the morning I might open the patio doors and I often keep the vents open unless it's drafty.

-using what?

Mainly the vents and windows.

-any problems?

The vents are quite high up and a bit difficult to get to, but there's no other problem. There is a gap in the front door, I don't know if you saw it when you came in. But I'm going to put a curtain up there in the winter so that's ok.

-air quality

Yeah it's good.

-ease of use

Only what I said about height of vents.

-responsiveness

The heating is on all the time apart from when it drops down at night, but I would like to be able to turn it off, I don't want it on at night.

When I open the windows, especially the patio doors the red lights come on, on the heating; you know the thing in the cupboard. But I don't want the heating to come on because I've opened the doors because it's too hot. I don't understand why that happens. Surely if I've opened the doors it shouldn't come on because it's too warm. I've talked to other residents who just leave their heating alone. But I think a lot of us look at the lights, it's nice when they're all on green, then you know it's all OK.

When I had a boiler, in the old house, I used to just switch it on and off when I wanted to. So if I wanted it a bit warmer I'd just flick it on so it warmed up a bit, then if I wanted it colder I could turn it off. Now if I forget to turn the heating back up it takes ages for it to get warmer, it doesn't respond. I want to be able to switch it on and off when I need to.

Section C: FLEXIBILITY AND SPACE STANDARDS

11. How flexible is the house in accommodating your needs?

To begin with I missed radiators for hanging, but I'm used to it now and I like it. You can move the furniture where you want instead of covering radiators.

It's great.

Use of space

Good, yeah it's fine.

Workspace

I always had a bigger kitchen in the past and I had to get rid of a lot of stuff when I got here, but I'm used to it now.

You know what it's like. I'm quite arty so I've got lots of things, but now I just get rid of things instead of keeping them.

An extra 6 inches in the bedroom would be better, you know for moving stuff round.

Visitors

Oh yeah its fine. They don't sleep here but it's fine when they're here. We have granddaughters, and grandsons and my daughters for breakfast on Saturday morning. My husband used to say they had to come round for breakfast on a Saturday and we have done ever since.

I like being so close to everyone, they all live round here.

12. How satisfactory are the room sizes?

Yeah they're fine. I just don't keep so much now.

13. How satisfactory is the storage space in the house

I'm a woman! I never have enough storage space. I had a blitz the other weekend so it's quite tidy in here at the moment. But I do have to be careful about what I keep. I often throw paint testers away instead of keeping it all.

-kitchen

I manage, yeah fine. I've got rid of quite a few things but it's OK now. I've had to bring the tumble drier in now because where they were in the sheds, people were complaining that they didn't use them so shouldn't have to pay for them. I hate having it here.

-bedrooms

Smashing, I love my bedroom.

-bathroom

It's fine, adequate. I bought a cupboard to put in there but it's fine.

14. How functional are the rooms?

As I've said really. I'm quite happy with it.

15. How well do you think this house could accommodate your future needs?

-old age
-disability
-changing number of residents
-workspace

Fine, absolutely fine. My son is in a wheelchair now and it's great. It's flat and the nurse can visit. Yeah it's brilliant.

Section D: GENERAL

16. What are the best aspects of the house?

Knowing you can come home and be comfortable in your own home. I love coming home and you can write I've said that as I don't care who knows it! You know some people have a horrible time at home and don't like being at home; I wouldn't want that.

It was a massive wrench when we first came here, but we've settled down now and it's great.

17. What are the worst aspects of the house? None! Well just the trees. No complaints what-so-ever.
20. Are there any other comments you'd like to make I would like to have bought round here but I'm happy.

Occupant Walkthrough - Flat A

Outside
Front I don’t like the front; it looks like an old people’s home. Especially the windows in the doors.
Back I like the back a lot; it looks lovely when you’re walking along the top and looking down. It’s nice to have a garden.
Grounds We don’t have a very conscientious gardener; a lot of the plants have died around here which is a shame. Everyone here does quite a bit outside; there’s a plot round the corner but I don’t use that, it’s too much commitment, but a lot of people do.
Other Comments No
Inside
Hallway & Stairs The lights have to be on all year in the hallway and I know a lot of the residents think the stairs are drafty. They feel cold on the stairs. The doors for the storage cupboard in the lounge and the hall in the hallway hit when they are both open. It’s such a silly design. It doesn’t really matter but it’s just daft.
Storage Fine, I like the storage, like I said the door is daft.
Bedroom 1 I like the bedroom, I can see a bit of the garden outside which is lovely. Do you like my new plants?! I put them in recently, the purple one is lovely.
Bedroom 2 Just the space really, like I said it would be nice to be able to move the furniture round so a few more inches. But no changes really needed. Howard likes it.

Bathroom I’m quite happy, it’s fine.
Lounge I love it; I can’t wait to get the new window. It’s quite dark that’s my main complaint, and the switches.
Kitchen The drier is the most annoying thing, I really don’t like having the drier in here.
Other Comments You get some lovely birds out here (looking out rear patio doors). Come and have a look at this bird. It’s great, we’ve had some nesting; we get lots round here. Connect have put up all the boxes, we had some using this one this year.

Appendix M

Occupant Interview – Flat B

Occupant Interview - Flat B

Section A: SATISFACTION
1. How satisfied were you with the induction process? Fine, yeah fine, although once we were in, the attitude from Connect Housing became different. Now we were just tenants, the friendliness had gone. People were polite but not friendly. I did actually speak to Connect about the change in attitude and with one person it did get better. The other person it didn't make any difference. I think it's a generational thing, age is just a number, we may be old but we're not stupid.
2. How satisfied were you with the home user guide? **-understandable?** **-easy to read?** It was very large, only really go to it when needed, like the heating and stuff. Although heating is still not clear. Thermostats need to be higher, head height, except the disabled flats. It hurts your neck and back the way it is, you know when you bend over your head goes forward; you have to look up to then read the thermostat. It's not well designed.
3. How easy is it to clean and maintain the house? I detest cleaning but not too bad is it! Very clean, I can leave it 2 months without dusting. Not like my old house where it over looked a dusty track and was a real problem to keep clean. This one is brilliant for keeping clean, now I only clean when needed. Even in summer with the windows open it doesn't get dusty with all the trees, so very good.
4. Is there anything you do not understand about your home? **-renewables** The heating is the only thing with I have a problem with. It's a shame it's not variable during the day you can only switch it on or off during the day. I wish you could turn it off during the day when I'm out. It's cold at the bottom of the stairs then you get about three quarters of the way up the stairs and it just hits you as you come in. Once you're in its comfortable but it needs a quicker reaction. Every time I get up and go to the loo in the night it's too hot and I can't sleep; I realised it's because I've got one of those beds with the drawers in. I keep blankets in the bottom of the bed and because heat comes up from the floor it acts like a radiator upwards through the bed. I keep the bedroom much colder than the rest of the house; I'd rather put an electric blanket on than keep the heating on because it's just too hot.

Do you know, three people are suffering with swelling in their legs because of the underfloor heating. I have spoken to other people living in other developments and they also had problems with their legs and their heating was taken out. It does cause problems with feet and legs, you know. Joyce, a disabled lady is really suffering with stiff legs, swollen ankles and feet. I don’t want it removed. Oh no, I don’t want it removed, it’s fine.

-fixtures

They’re fine, yeah fine.
The intercom on the main wall could be better placed. This is the main wall and this is right in the middle. Do you see what I mean; it would be better behind you or not as obvious.
Kitchen door is also in the middle of the wall which is not sensible.

-fittings

They’re fine, yeah fine.
The bathroom could do with some more light; here let me show you (*at this point we walked to the bathroom for the resident to explain*). You see how dark it is? I’d really like to put a window through onto the stairs. This is only a stud wall so you could easily put a window through here. The light in the stairwell is wasted so you could use this in the bathroom. You also wouldn’t get them hum then from the extractor fan which comes on automatically with the light and then takes 5 minutes to go off. I often shower with the hall light on and the bathroom door open rather than the bathroom light, then the hum stops.
It needs a women, disabled person and older person to help with future designs. The kitchen cupboards are too low and too deep and some are too high. Some of the shorter people are using step ladders to get into cupboards and open windows and that’s not safe. The worktops are too wide to be able to reach the window vents. I’m ok because I’m tall but some of the other residents are struggling. You need large pull out draws rather than cupboards. My daughter is disabled and she has future proofed her house be using large pull out draws rather than cupboards.

5. How satisfied are you generally with living in this house?
-appeal

Oh yes, couldn’t be better. Wouldn’t necessarily want some of the other flats but I love this flat. It’s so light. Would like to have open doors, you know as I don’t have a garden it would be nice to have patio doors on to a balcony to be able to let the air in. I can’t open windows because of the cat.

-ease of use

It’s fine, apart from what I said about the kitchen. I can get up and down the stairs without holding the banisters which I had to do in my old house. In my old house I thought I was going to have to get a bungalow because it was hard getting up and down stairs but this is great. I can get up and down stairs without holding the banister unless I’m carrying things, you know. They’re lovely wide stairs.

-family friendly

Oh yes. I don’t have children but downstairs they’ve always got children around, constant children. Daughter delivers children at 6:40am every day and then goes to work. I hadn’t anticipated children being around; I didn’t think it was designed for children. But I suppose people have got their grandchildren, trouble is when the windows are open in the summer and during holidays you can hear them screaming. I’m not really a child person but it’s not a problem though.

-livability

Very easy, brilliant, yeah.

Section B: COMFORT AND CONTROL

6. How well does the heating system perform?
-temperatures

If we were able to adjust it and be able to control it better with the weather. Sun has got a big impact on how hot it gets.
Ok with it basically. I have to open windows if it gets too hot, and I’ve got 2 fans; one in the kitchen and one in the bedroom which I can put on. I’ve put sticky notes on the wall by each of the thermostats so I know what to set it at, temperatures which I’m happy with.

-ease of use

The thermostats are very difficult. I would like to be able to time heating during the day. Controls only allow day and night setting not daytime changes. It’s not like a standard timer, this would be much better for me. If you could control it better it would be better for the environment and our pockets.

At this point Connect Housing discussed the possibility of changing the thermostats in the future. The aim is to ask several thermostat manufacturers to attend the energy awareness day and offer the residents’ time to look at the different options available and decide what they liked. This was received with enthusiasm.

That would be great, yes thank you.

-responsiveness

It’s very slow but I suppose that’s expected with underfloor heating. I get up at 5am and it’s not that hot then but then as time goes on it gets warmer. I suddenly think right, it must be up to heat now, probably about 7 it feels warm.
I use a fleece at night if it’s cold.
I’ve set the times for this flat but really wish I could change temperature during the day; I’d like it lower during the day you know when I’m out.

-quality of heat

I’m fine with the heat. I wouldn’t want it to be any colder. It’s a comfortable heat, I prefer dry heat; really don’t like dampness, sticky heat.

7. How effective is the day lighting in the home?
-different rooms

Fantastic, no problem in any room. Bathroom is the only room which is dark. I’m lucky as I don’t have the trees like some of the others do. It’s fine.

8. How effective is the artificial lighting in the home?
-different rooms

Other rooms are ok but I wish the lounge was brighter. I can’t change the bulb in here; I have to go to a specialist firm. They’re really wide; the bulbs have got a really wide fitting so you can’t get them in normal shops. Someone has said B&Q may have them but I had to get them from Harrisons. They keep going too, I’ve had to change 4 bulbs since I’ve lived here and they’re supposed to be long life. It’s very hard to remove the bulbs.

9. Are there any acoustic issues in the home?
-inside/outside

No, no problem. We don’t hear each other unless someone drops something heavy. Although since they did the doors we have to slam them. We had a problem with the intercom and when they came to fix it they did something to the door which makes it hard to close now. You really have to slam the door to close it and the button on the intercom doesn’t work. If you shut the door and push the handle up the intercom button to open the door doesn’t work.

10. Do you ventilate the house?

Yes, I open the vents but keep them shut in bad weather. I also tend to leave the front door open if I’m in and it’s really warm. I figure I will hear anyone coming in if I’m up here, they’d have to walk right past me to get in.

-when during day

When I need to. I don’t like the damp so keep it closed when it’s what I call mizzly outside but I like to have them open when it’s cold and clear. In summer I sometimes shut them to keep the place cool.

-using what?

Mainly the window vents, I can’t open the windows because of the cat. I sometimes open them so they’re on the notch, so they’re shut but you can still get a draft.

-any problems?

No, not at all.

-air quality

Fine, no problem. As I say I will open the door and put windows on the notch if I want to freshen the place up.

-ease of use

The only difficulty is the vent over the kitchen sink as it's difficult to reach. But once they're open they stay open for the summer so it's not a problem.

-responsiveness

When the windows and vents are open it responds well. In the summer I sometimes close them to keep the heat out. It's fine.

Section C: FLEXIBILITY AND SPACE STANDARDS

11. How flexible is the house in accommodating your needs?

It's very flexible. There's plenty of storage space and kitchen is fine. As I said the stairs are good and yeah it's fine.

Use of space

Apart from the comments about the intercom and the kitchen door it's fine.

Workspace

I only use one of the bedrooms, so the little bedroom is used as my office. The thermostat was broken in this room and now they've fixed it so it's much more comfortable.

Visitors

If I have visitors they can sleep on the sofa.

Other features

No other comments really

12. How satisfactory are the room sizes?

The lounge is great and the one bedroom is fine. The little bedroom could be bigger but really only because I have lots of stuff. I got rid of a lot of things when I moved but I still have a lot of stuff so I think that's why I struggle for space. I do wish the shower had a glass screen and not a curtain. I hate curtains they stick to you; I hook mine out of the way.

13. How satisfactory is the storage space in the house

Brilliant.

-kitchen

I think I've adapted to the size, my old kitchen was bigger but I've got rid of a lot of stuff since moving. One thing is the shelves need better studs on the walls to keep shelves up. Some of the other flats have had the shelves in the cupboards fall down. Mine are ok but there are little cracks on the pegs.

-bedrooms

Lovely.

-bathroom

Well you buy your own for that don't you.

14. How functional are the rooms?

Fine, yeah no problem.

15. How well do you think this house could accommodate your future needs?

Fine, the stairs are wide enough for a stair lift if I needed one.

-old age

Slightly taller toilets would be useful as it gets harder to get up and down on these ones. Even public toilets are higher than the ones here. It could reduce the need for frames for a while longer.

-disability

No comments

Section D: GENERAL

16. What are the best aspects of the house?

The convenience; how useable it is inside and how close it is to the village and church. Also the cleanliness.

I'm not really a people person but just knowing there are other people around is nice, where I am on the end it means I can look out and see if so and so's car hasn't moved or the curtains haven't moved and make sure people are ok. I can check on people. Just knowing people are around if needed is nice. Much better than on a row or street.

17. What are the worst aspects of the house?

Nothing that bothers me about living here other than what we've already spoken about.

20. Are there any other comments you'd like to make

I have to say it's not as affordable as we were led to believe, it certainly costs more to live here than my pension.
Electricity bills are big; they're about £40 a month plus service bills. I don't think I've changed the way I live or how the house is used but I also have to pay £64 on service charges, £16/week on heating and about £15 for general maintenance.
Also some of the residents have had letter saying their bills are going to go up. I haven't had a letter so don't know what's happening there.
Also we have to pay for the flagstones to be cleaned. I think that's a bit wrong because it's not the residents fault is it? And it doesn't affect everyone but we all have to pay. Surely getting the trees dealt with is the answer. Gardening and car park needs maintenance but the trees are not our fault.

Occupant Walkthrough - Flat B

Outside
Front Yeah I'm pretty happy; the plaster keeps dropping down but nothing else.
Back No problems. There's the communal bit for those that want to do it, there's also a washing line, but only 2 for the whole development. I don't mind as I don't hang outside but might be difficult for the others. *Comment that the resident maintained one of the communal flower beds to ensure her downstairs neighbour had something nice to look at. Neighbour is disabled.*
Grounds No comment
Other Comments Parking is on a first come first served basis, it's not allocated. You would think that the five spaces closest to the building would be for the five flats on that side but that's not the case. I have to park on the opposite side of the car park which is difficult in bad weather. It's annoying that some people have got two cars and don't park closer to their own buildings.
Inside
Hallway & Stairs It's too cold at the bottom of the stairs but I do use it as additional storage. I've got 60 mince pies there at the moment for the church. Quite handy as a cool storage area but does make opening the door difficult. Two thirds of the way up the heat hits you but there's no draft.
Storage Lovely storage, but we've already talked about that.
Bedroom 1 The only problem is the position of the plugs and TV sockets. They're in the middle of the wall and I've got large wardrobes which means I can't get to the sockets. They cut a hole in the back of the wardrobe so I could get to them but they're not really big enough so I still can't use them. I think the assumption was that we would only have

single wardrobes but that's not right. There's not really enough sockets, you have to trail an extension cable across to get the other side of the bed. The view is also spoiled by the poly-tunnel. I wish they'd never agreed to that thing going up. I understand they need the sun, but they never actually use it. It's right in the line of sight.
Bedroom 2 It was much cooler but the thermostat was replaced and now it's comfortable. It was actually broken I wasn't imagining it. All the thermostats are at different temperatures ranging from 18 to 23°C.
Bathroom If it's possible to add a window that would be great. Glass panels would be better than the shower curtain but you would have to move the shower to accommodate it. That's just bad planning to be honest. The curtain makes a puddle in the corner at the moment. The DHW is ok but I would like to have it slightly hotter for baths and washing up. If you run a bath you have to get on with it, the same with washing up. It was good when the system was broken to be honest; it was a much better temperature.
Lounge Well the door is mid wall as we said earlier. The intercom is on the main wall and it should be in the hall or behind you when you're in the lounge. The position of the TV sockets limits how the room is laid out. There is a good number of plug sockets.
Kitchen As we mentioned earlier the only things are the height of the cupboards and the cupboard supports are cracking. Also I don't know who designed the fact that the towel rails are next to the fridge rather than the sink!
Other Comments No other comments