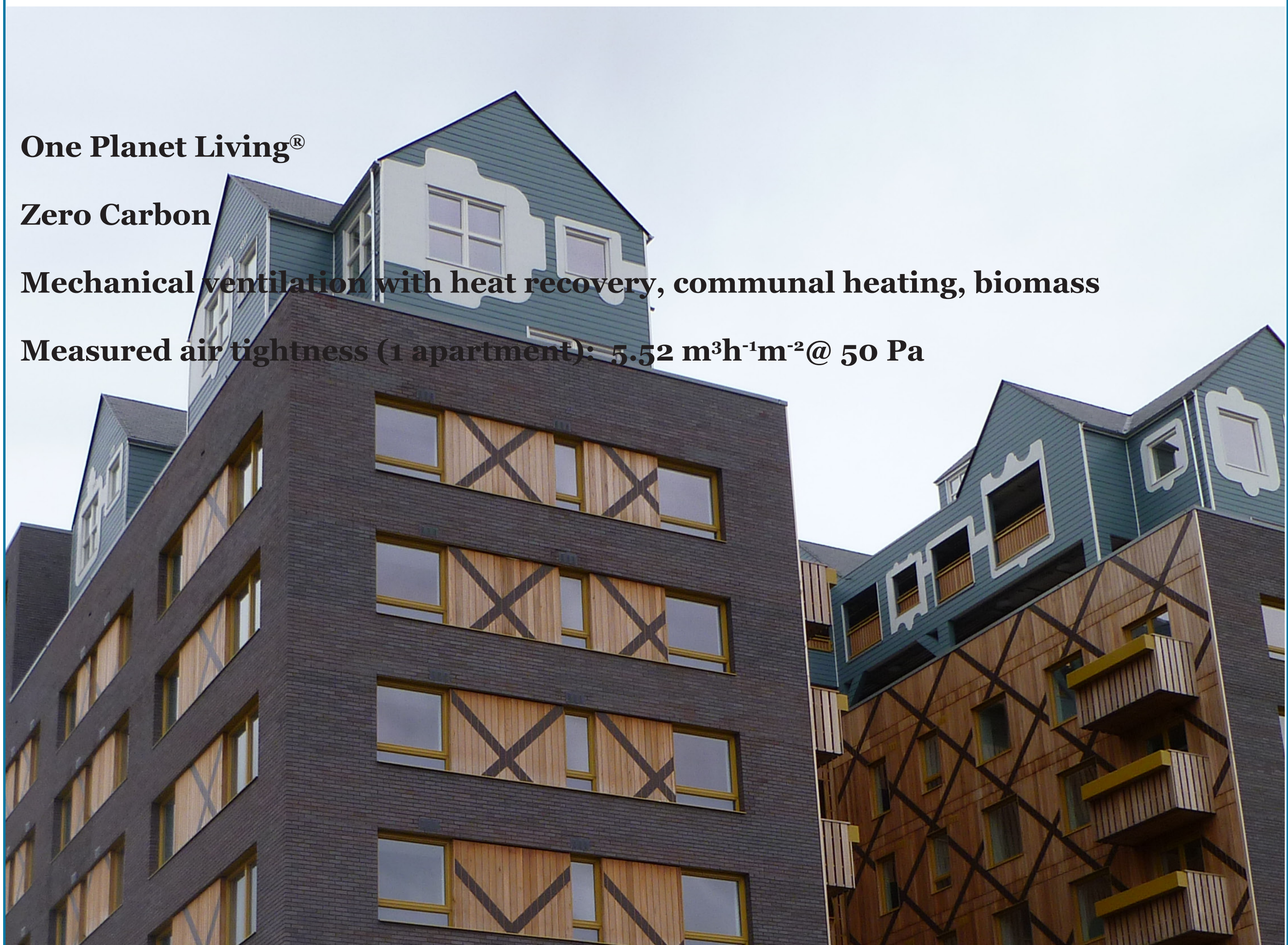
BUILDING PERFORMANCE EVALUATION CASE STUDY
COMMUNITY IN A CUBE, RIVERSIDE ONE



One Planet Living®

Zero Carbon

Mechanical ventilation with heat recovery, communal heating, biomass

Measured air tightness (1 apartment): 5.52 $m^3h^{-1}m^{-2}$@ 50 Pa

Building Performance Evaluation Team

Good Homes Alliance

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Technology Strategy Board
Driving Innovation

The project reported here is part of the Technology Strategy Board's Building Performance Evaluation programme and acknowledgement is made of the financial support provided by that programme. Specific results and their interpretation remain the responsibility of the project team.

This case study examines a one bed, 42m[2] apartment on the 5th floor of the CIAC development. This apartment was completed in December 2011, and the study ran from February 2012 to June 2013. This evaluation was conducted under the Technology Strategy Board's (TSB) Building Performance Evaluation programme.To determine the effectiveness of the design and delivery strategy at the CIAC, real performance indicators were tested to compare these results with anticipated performance. The project team followed the TSB protocols for fabric and services testing, conducting the following examinations:

- Thermographic survey
- In-situ u-value tests
- Airtightness tests
- Coheating test
- Services commissioning checks
- Design and Construction review
- Occupant induction review

Additionally the BUS survey was used to capture occupant perceptions about their dwellings.

The results from this evaluation indicate that the apartments have not completely fulfilled their design intentions. Thermal bridges and heat loss through the superstructure were identified, but it also appears that some building services, particularly the MVHR system, have not been designed, constructed or commissioned effectively. Issues with heat loss through the communal heating system and MVHR system are also likely to contribute to an overheating problem.

Design and Construction

Community in a Cube (CIAC) was designed to be a zero carbon mixed-use development comprising 80 residential units and retail/leisure space. Constructed between 2011-2012, CIAC is located at the Riverside One development in Middlesbrough. It is first building to be constructed in the 40 acre, £200 million regeneration project, planned to eventually be 16 buildings in total, providing residential accommodation, commercial opportunities and community spaces.

CIAC incorporates the 10 One Planet Living® principles (Bioregional Quintain, 2012) and was designed to provide a lifestyle-orientated approach to sustainability by making it easy, attractive and affordable to live sustainably.

The studied apartment has an open-plan living/kitchen area on the South and West façade of the building, a West-facing bedroom and a South-facing bathroom. All of the apartments have dual aspect, large windows, with high ceilings and exposed concrete soffits.

The building has a concrete frame, with site-built timber-frame in-fill panels for external walls, with timber or brick skin cladding. Some of these panels have been constructed around the concrete columns which form part of the building structure.

The windows are double-glazed, argon filled low-e aluminium faced composite units (aluminium/insulation/timber), while the doors are timber.

The predicted fabric and services performance figures are listed in Table 1.

Table 1. Design Targets

Air permeability (design SAP, 2010)	3 $m^3h^{-1}m^{-2}$@ 50Pa
U-value: walls (design SAP)	0.18-0.21 W/m^2K
U-value: windows (design SAP)	1.3 W/m^2K
U-value: doors (design SAP)	0.63 W/m^2K
Y value (design SAP)	0.04 W/m^2K
MVHR heat exchanger efficiency (SAP Appendix Q)	92%
MVHR fan Specific Fan Power (SAP Appendix Q)	1.04 W/l/s

Space heating is provided via a LTHW heating coil within a whole house MVHR unit, installed in the ceiling void in the bathroom. A wet heated towel radiator is also provided in the bathroom. A heat exchanger unit, supplied by the communal heating network, is installed in the cupboard in the hallway of the apartment. This provides LTHW to the MVHR heating coil and the bathroom towel radiator, and supplies domestic hot water to the apartment. The MVHR system incorporates a motorised heat exchanger by-pass damper (summer bypass).

Communal heat is provided by a 320kW biomass boiler located on the ground floor of the building, supplied with wood pellets. A gas-fired boiler was designed as backup, with the biomass boiler as lead. However, according to operations staff, due to the low level of occupancy within the building, only the gas-fired boiler has been used so far. The biomass boiler is set to become operational once the building becomes 75% occupied.

CIAC had difficulties brought about by the economic downturn, which resulted in the developer (after completion) and the Mechanical and Electrical contractor ceasing to trade. Further, it was intended that the whole Riverside One regeneration project would be undertaken over a number phases, with CIAC being just one building of many on the site. However the regeneration of this area of Middlesbrough was halted, waiting for better economic times to prevail. CIAC was originally designed to import heat from a larger district system, intended to supply a number of other buildings at Riverside One. As a result, the energy strategy had to be revised during construction with a communal plant room with a biomass boiler and wood pellet fuel store added at the ground floor level of the building.

An air tightness strategy was not clearly communicated in the documentation, with no primary air barrier identified on any of the drawings for the test apartment. Additionally there is a lack of detail regarding the U-values. Construction details and U-values were not available for all of the external wall types for the test apartment.

Real performance

Although it was only possible to undertake one set of site observations on the apartments during the construction phase, a number of issues which, if left unaddressed in construction, would likely contribute to an increase in fabric heat loss and air leakage were highlighted.

The Coheating test was undertaken on the test apartment between 14th February and the 4th May 2012, in accordance with the TSB adopted protocol developed by Leeds Met. A number of significant difficulties were experienced. Warm weather, coupled with subsequent equipment failure, and the resumption of communal heat back into the apartment meant that of the 7 weeks of Coheating data that was recorded, only 9 days of usable data was obtained. Ultimately, because of the lack of useable data and high solar insolation, the heat loss coefficient figure obtained is not deemed to be reliable.

In-situ measurements of the U-values of various elements of the building fabric were taken. With the exception of the windows, external elements U-values measured in-situ failed to perform close to their design specification. Measurement of the party elements revealed a possible heat loss issue of ‘heat stealing’, as only acoustic insulation is incorporated in these elements.

Air pressurisation tests and leakage identification was undertaken on the test apartment. Tests were conducted twice: before and immediately after the Coheating test. The results indicate that the apartment is of average air-tightness by UK new build standards. Despite having no identified primary air barrier, the value was significantly better than the target of 10 $m^3h^{-1}m^{-2}$@ 50Pa found in one design SAP worksheet, but also higher than the original target of 3 $m^3h^{-1}m^{-2}$@ 50Pa (which the developer thought to be the correct target).

Infra-red thermographic images were taken on a number of days to examine fabric performance. The survey revealed that thermal bridging was occurring at the junction between floor and external wall, the windows were ineffectively sealed, heat gains were coming from the communal heating heat exchanger unit and the concrete frame of the building was acting as a conduit for heat transfer throughout the superstructure.

The MVHR installation was examined and measurements taken in the test and adjacent apartments. Based on these observations, the air flow rate measurements, and the limited commissioning information provided, it does not appear that these systems have been commissioned correctly in-situ.

During the time when the occupant perceptions were being examined, many of the apartments in the development were still unoccupied. Additionally, the majority of occupied apartments were inhabited by temporary overseas workers, who were attending a 6 month training course in the area. At the time of the BUS survey distribution there were only 9 permanent occupants.

Because of the low occupation and difficulty engaging directly with occupants, the CIAC building manager was interviewed to gather any feedback that they had received. It was found that occupants had complained of overheating in apartments, trickle vents blowing open during periods of high winds, allowing water to enter (advice was given to seal the vents permanently), building access, and the look of the exposed concrete ceilings in the apartments.

Conversely, residents spoke highly of the building aesthetics. Users reported great satisfaction in the design, location and apartment views.

The table below compares the design targets with the measured values for the fabric tested apartment. Overall the apartment, as constructed, does not perform as well as intended in design.

Table 2. Performance Gap

	Predicted	Measured [Leeds Met]
Air permeability	3 $m^3h^{-1}m^{-2}$@ 50Pa [design SAP, 2010]	5.52 $m^3h^{-1}m^{-2}$@ 50Pa
Wall [timber panel section]	0.19 W/m^2K [design SAP]	0.18-0.30 W/m^2K 0.25 W/m^2K [mean]
Wall [concrete column section]	0.21 W/m^2K [design SAP]	0.32-0.66 W/m^2K 0.42 W/m^2K [mean]
Window [kitchen & bedroom, centre-pane]	1.24 W/m^2K [design SAP]	1.33-1.54 W/m^2K 1.41 W/m^2K [mean]

Key Observations

1. Although the apartment tested is of average airtightness by UK standards, it is leakier than it should be when an MVHR system is installed.
2. With the exception of the windows, external elements U-values measured in-situ failed to perform close to their design specification.
3. Significant issues have been identified with the MVHR system related to its design, layout, the type of air supply and extract diffusers used, and filter access. These issues, coupled with the duct flow measurements (and the inability to some measure flow rates because of the installation), suggest that the MVHR system is not performing as intended and was never commissioned in-situ. Initial feedback from the occupants suggests that this is the case, as they perceived there to be stale regions of air within the apartment.

Key Lessons

1. A number of the construction issues identified could be avoided if appropriate quality control processes were in place to monitor insulation and airtightness measures during construction. It would have been beneficial if the CIAC development had adopted a dedicated onsite airtightness and thermal insulation champion.
2. A number of the design intentions were not fulfilled in construction. This may be in part be due to number of key stakeholders involved in the project ceasing trading either during or immediately after completion of the project as a result of the economy.
3. In order to minimise air leakage and achieve a level of airtightness appropriate for incorporation of MVHR, it is advised that an airtightness strategy is adopted.
4. The commissioning information that was available varied considerably and there does not appear to be any standardised method of commissioning particular services. The development of a standardised method would be useful and would enable comparability between dwellings.

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