Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 42 (2013) 446 – 455

Energy Procedia

Mediterranean Green Energy Forum
MGEF-13

Feedback from occupants in 'as designed' low-carbon apartments, a case study in Swansea, UK

Nooraei, M; Littlewood, J.R. Evans, N, I*

Ecological Built Environment Research & Enterprise group, Cardiff School of Art & Design, Cardiff Metropolitan University, CF5 2YB, UK

Abstract

This paper discusses the findings from the first set of occupant surveys, as a part of an extensive building performance evaluation study, in Wales, UK. The case study building is an award winning, as designed low-carbon and affordable apartment building, developed by a housing association in Swansea, UK. It consists of 69 apartments (six one bedroom, 63 two bedroom) over six storeys; designed and built to level four of the code for sustainable homes (CfSH), a benchmarking system used in the UK for stipulating environmental performance. Residents started occupying the building from February and March 2012. Semi structured interviews with occupants have been undertaken by researchers from the Ecological Built Environment Research & Enterprise group at Cardiff Metropolitan University in the UK, as part of their research for work package six of the Low Carbon Built Environment project. The first set of interviews in May to September 2012 revealed different issues in the building performance affecting comfort conditions of occupants. High indoor air temperatures, inadequate ventilation, lack of daylight, lack of cold water and lack of a proper induction are among the key issues found through the occupant surveys. Findings documented in this paper will be further investigated with physical monitoring of the internal conditions in three apartments and the communal corridors and through a second set of occupant interviews, which were undertaken from December 2012 to find out if there are any issues in the building during winter. In addition, there will be interviews with the design and construction team. This paper will be useful to academics, designers, contractors, environmental engineers and building owners.

Keywords: Low carbon building, occupant survey, Building performance evaluation, semi-structured interview

doi:10.1016/j.egypro.2013.11.045

1. Introduction

The UK government aims to achieve 80% reduction in carbon emissions, on 1990 levels by 2050 [1]. This is why all new build homes in the UK are required to be 'Zero Carbon' by 2016 [2]. However, the UK has already missed the 20% reduction target for 2010 [3]. The situation is even more critical in Wales with the highest carbon emissions per person in the UK and the 12th highest emissions in the world [4]. In addition to this, the domestic sector was responsible for just over 40% of UK's final energy use and produced a quarter of its emissions in 2004 [1]. Thus, to meet the 80% reduction target, more effort needs to be put in towards the improvement of the energy efficiency of the domestic building stock. Moreover, there is evidence of a potential large gap between homes 'as designed' and 'actual' performances [5, 6]. This discrepancy between design and actual performance is due to failure of the building fabric or building systems, or is caused by inefficient management and maintenance or inappropriate occupant use of a building. Comprehensive building performance evaluation and monitoring is an essential and no longer an optional way to check whether the actual building performance meets the design expectations and also to map the performance issues. It reveals the lessons of 'what works in practice and what doesn't' to be fed back to the construction industry [7, 8].

Occupant surveys are recognized to be a key component of any building performance evaluation study [9]. Recent research shows that different occupant lifestyle and behaviour may result in up to fourteen times difference in energy and water use for the same type of low carbon homes [10]. Also, residents provide a valuable source of information about the comfort conditions in a building and their level of satisfaction is an indicator of success or failure of the building performance. This paper documents the results of an 'occupant survey' in a code level four apartment building located in Swansea, Wales (UK) where extensive building performance evaluation (BPE) studies are being carried out as part of Cardiff Metropolitan University's contribution to work package six (monitoring the performance of low carbon buildings and products) of the Low Carbon Built Environment project. The aim of the occupant survey is to understand the residents' perception of the apartments during the first year of occupancy as well as their behaviour and also to evaluate their levels of satisfaction and comfort. Specifically, it aims to draw out key issues regarding the case study building performance and to feed back the lessons learned from mistakes to the designers, contractors and the developer.

2. Context to case study

2.1. Swansea, UK

Swansea is a coastal city in Wales, UK, with 239,000 residents in 2011; that makes it the second largest local government population in Wales [11]. There has been a great deal of urban regeneration in Swansea since 2000, particularly in the dockland area known as the waterfront at SA1. Since 2010, much of the development of new dwellings in Swansea has been undertaken by social housing developers including the organization that developed the case study building [12]. Swansea is situated in south-west Wales at latitude 51.6°N and longitude -4.0°E [13]. The climate of Swansea is temperate (moderate), "where there is a seasonal variation between under-heating and overheating, but neither is very severe" [14]. The coldest month of the year is January and the hottest month is August, with monthly average air temperatures of just under 8°C and just above 20°C respectively [15]. The climate in the UK is becoming more unstable, with unpredictably warm weather at unusual times of the year. For example, in 2012, March was the third warmest March since records began in 1910, where the highest UK temperature was 23.6 °C and in Swansea was 19.8 °C [16, 17].

2.2. Case study building

The case study building, one of winner's of the 2012 Green Apple award (affordable housing section), is situated at the waterfront area in Swansea, UK. The five storey building is of a timber frame construction and consists of 63 two bedroom and six one bedroom affordable apartments, all inhabited since February and March 2012. It was designed and built to function as a social housing accommodating mainly people over 55 years of age. It has been designed to level four of the code for sustainable homes, meaning 44% better energy efficiency than Part L1A 2006 edition Building Regulations 2000 [18]. The U values for the key construction components at the case study are 1.8 W/m² °C (interior door and windows), 0.2 W/m² °C (exterior wall), 0.26 W/m² °C (separating floor and wall) and 0.2 W/m² °C (roof) [19]. The building form is T-shaped with central corridors providing access to the apartments facing north and south, but predominantly east and west. The average residential area of the one and two bedroom apartments are 54m² and 68m² respectively. Good levels of daylight have been achieved in living rooms and bedrooms and a private and secure space is available to all occupants in the form of large private balconies. The building is naturally ventilated with a mechanical air extract system operating in the kitchen and bathrooms in each flat. Heating and hot water demand is provided by a central heating system on gas boilers.

2.3. Methods employed: semi structured interviews and spot measurements

Ethics approval was granted in April 2012, for researchers from the Ecological Built Environment Research and Enterprise (EBERE) group from Cardiff Metropolitan University, UK to interview the occupants in the 69 apartments at the case study. The intention was to interview occupants on a number of occasions during the heating and non heating season from May 2012 [12, 18]. A questionnaire was designed for a researcher to conduct the interview with the occupants responsible for paying the home's utility bills (adults over 18 years of age only). A Likert scale was used with seven categories from "poor", "unsatisfactory" or "uncomfortable" to "good", "satisfactory" or "comfortable", including a "neutral" category. Also, further comments could be provided to the researcher for some of the questions e.g. for questions on comfort or water use. Additionally, the interviewees were also given opportunity at the end of the interview to provide further comments on any other aspects of the survey and their perception of their apartment and the apartment building. The questions sought occupant opinions on comfort, water use, noise, daylight, household bills, health, behaviour, home management and maintenance; and also their general comments about the apartments. Moreover, the intention was to take spot measurements before and after each interview to record the air temperature, carbon dioxide levels, solar radiation, air movement and daylight levels in each apartment, on the exterior balcony, in the circulation corridor immediately outside the apartment, the stairwells and exterior to the building at street level. The results of these spot measurements showing high indoor temperatures in the communal spaces were documented in Nooraei et al [12]. At the start of each interview, the occupant was provided with an information sheet explaining the purpose of the study and a consent form to sign to provide their agreement to take part in the study. The first round of interviews was undertaken during May to September 2012, which is normally not the heating season in the UK. However, the summer of 2012 was the second coolest summer since 1998 in the UK (after the summer of 2011) [16]. Occupants of twenty five apartments (out of 69 apartments) were interviewed. Those who did not take part were either not interested in participating or were not available on the dates and times of the interviews. 22 interviewees occupied their apartments in February 2012, with the remainder three in March 2012. The length of interviews fluctuated between 24 minutes to 106 minutes, with an average of approximately 60 minutes, depending on the interviewees' willingness to talk. Half of the interviewees were men and half were women; with the majority older than

55 years of age. 17 interviewees were living alone, 7 and 1 had a family of two and three respectively. As expected in a social housing scheme, 18 interviewees had a family annual income of below £15,000. The interviewees spent most of their time at home during both weekdays and weekends resulting in an almost continuous occupancy in the apartments.

3. Results

3.1. Overall occupant opinion and their comments on the apartment

Fig. 1 below illustrates how the occupants rated different aspects of the apartments (the small dark dots indicate the mean scores in all figures). Whilst the rates are generally positive (mostly between six and seven on the Likert scale) there were some complaints when occupants were asked to provide further comments. "Draughts come through windows", "windows cannot be closed properly", "there are cracks here and there", "there is a faulty fire alarm that goes off frequently", and "there is no cold water from cold water tap" are some of their comments on the built quality and probably are the reasons of having the overall rate lower than six for the built quality. Occupants were asked what the best and worst aspects of the apartments and the building were to them. Best/most useful thing about the building was its "Location" for 12 interviewees and "the garden" was the next most frequent reply (stated by 6 interviewees). Best/most useful thing about the apartments were "the balcony", "the view of the water", "peace", "good size", and "having all spaces on the same floor" in frequency order (stated by 7, 6, 5, 5 and 4 interviewees respectively). There is "nothing" they dislike/have most trouble with in the building or in the apartments.

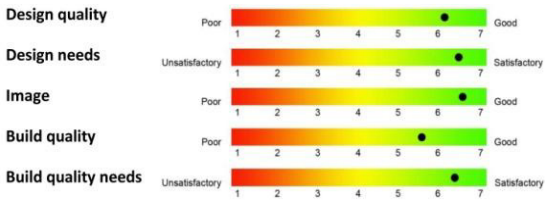


Fig. 1 Summary of occupants overall opinion about the apartments

3.2. Comfort, water use, noise, daylight, health

According to fig. 2, the occupants appeared to be satisfied with the overall thermal comfort in the apartments. However, the kitchen temperature and ventilation were not considered comfortable by 11 and 15 interviewees respectively. At the same time, fig. 3 shows that 11, 12, and 9 occupants perceive the air temperature of lounge, kitchen and main bedroom warm, hot or too hot. It is notable that at the time of the interviews, the interviewees were not wearing more than one or two layers of clothing and most windows in the apartments were open and the occupants confirmed that the situation has been more or less the same since they've moved in. Occupants were satisfied with the hot water provision in the apartments; however, 4 complained about the high temperature, especially in the kitchen: "the water is so hot in the kitchen that you could burn yourself". On the other hand, 18 occupants stated that their cold water provision was inadequate to the extent where this comment was common: "you have to leave the tap on for a few minutes to get less warm water". This particular issue had been included in the interview questions, as it had potential health implications for occupants. The overall noise level (fig. 4) in the apartments is not considered high for all interviewees. However, 12 stated that: "I can hear my neighbour above" or "There is noise from the pipes". In spite of the positive rate on the overall daylight level in the

apartments (between five and six on the Likert scale), the occupants are generally not satisfied with the daylight level in three spaces: hall, kitchen and bathroom; i.e. the spaces with no windows (fig. 5). The interviewees (11, 21 and 22 interviewees respectively) rated the daylight level in hall, kitchen and bathroom of four or lower (on the Likert scale of one to seven) with 13 and 14 occupants completely unsatisfied with lack of daylight in both kitchen and bathroom. Fig. 6 illustrates that 14 occupants believe the environment inside their apartments is very good for their health and 23 occupants never noticed condensation, damp patches or mould. The occupants were also asked if they had ever experienced high temperatures, muscle pain, headache, cough, pneumonia, or diarrhea. The reasoning for these questions was that these are all symptoms of Legionnaires' disease, an infectious disease where the bacteria grows best in water with temperatures between 20°C and 60°C [20]. Since, there is a problem with warm water being drawn from the cold taps in the apartments there could be a possibility of Legionnaires occurring. The results demonstrated that 10 occupants experienced one or more symptoms. However, for 3 occupants who experienced any of the above health conditions, they were present before residing in their current apartment.

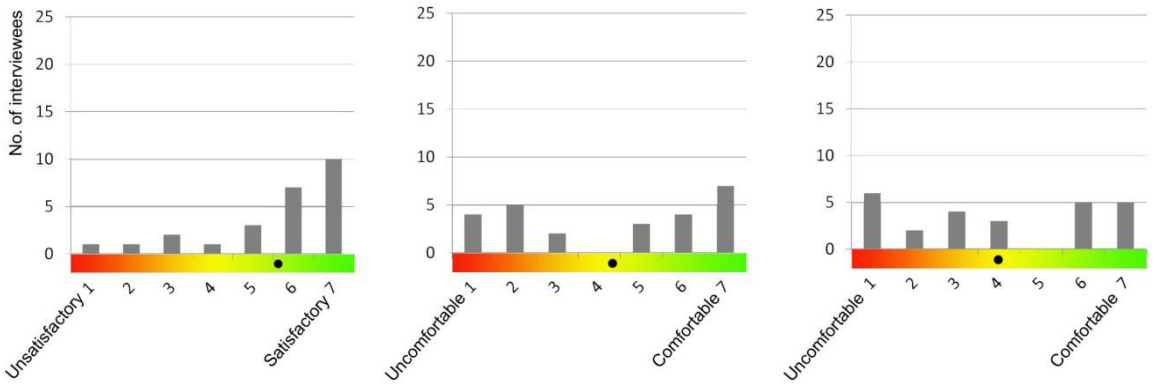


Fig. 2 Rate on overall thermal comfort (left); rate on kitchen temperature (middle); rate on kitchen ventilation (right)

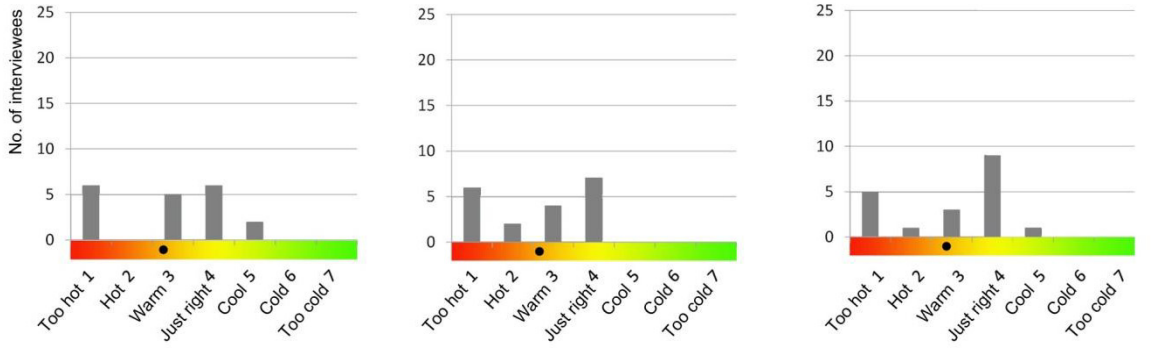


Fig. 3 Rate on air temperature in lounge (left), air temperature in kitchen (middle), and air temperature in main bedroom (right)

3.3. Household bills, behaviour towards energy consumption, and home management and maintenance

During the first set of interviews, 12 interviewees had not received their utility bills for electricity or water consumption. The cost of space and water heating, which is from gas boilers, was a fixed charge of £8.12 a week. Half of the interviewees believed the monthly cost was 'less' or 'much less' expensive

compared to what they used to pay on the gas bills in their previous home; whilst 13 stated that they were using much less or less natural gas compared to their previous home. The reason for this was that the latter occupants believed that their apartments were usually warm and therefore there was no need for space heating. Within the sub-section 'household bills' another question sought to determine the electrical appliances used by each occupant. Fig. 7 illustrates that there are 13 different electrical appliances used by more than half of the occupants.

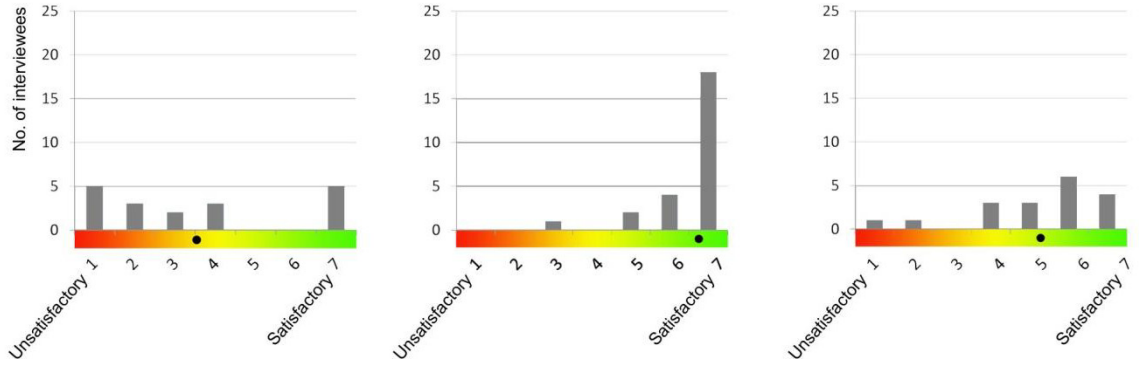


Fig. 4 Rate on the cold water provision (left) and the hot water provision (middle); and rate on the noise level in the apartments (right)

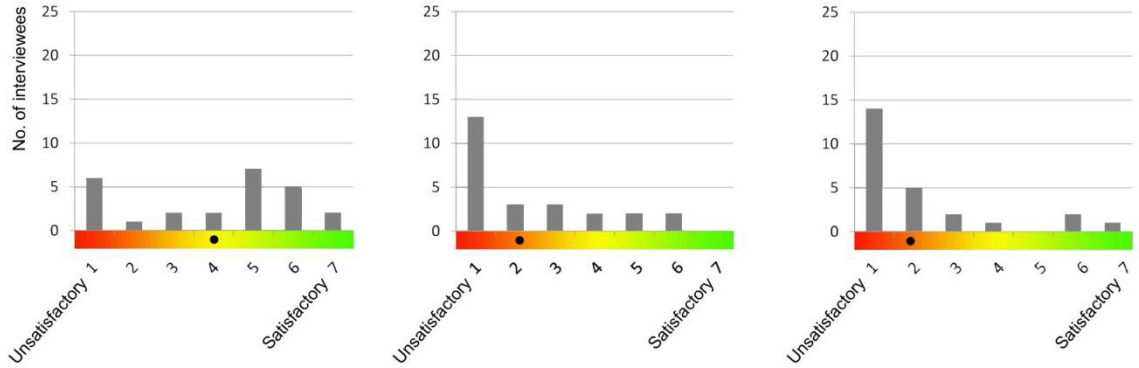
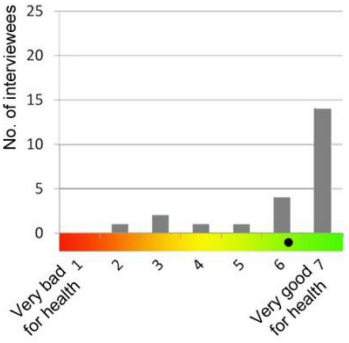


Fig. 5 Rate on the daylight level in the hall (left), in the kitchen (middle) and in the bathroom (right)

Occupants were also asked questions on how to save energy and ultimately carbon emissions. For almost half of the occupants the first thing that they do when they feel too cold inside the apartment was to wear an extra layer of clothing. 20 interviewees open window the first thing when they feel too warm inside the apartments. 22 always or usually leave the windows open. 18 occupants switch off the socket or use the main on/off switch when they were not using electrical appliances and only 7 leave them on standby mode and 22 interviewees switch the lights off when they leave a room. 17 always unplug the charger when a mobile device has finished charging. 18 only put enough water in for what they need when using appliances requiring water. More than half of the interviewees replied that they had never set the thermostat, almost 12 did not use the programmer and 10 of the interviewees had never used the heating since moving into the apartments.

The rate on the home handover and the home user guide are generally above four on the Likert scale (Fig. 8). However, according to the occupants' replies, home handover included a short guided tour around the spaces of the apartments without any information on the building systems and how to use

them. The home user guide was mainly a collection of the product catalogues, for example manufacturer's literature about controls of the heating- without any simplification or extra guidance. Overall, the rate on the management and maintenance is between five and six on the Likert scale in spite of 8 occupants being unsatisfied with the speed or effectiveness of response at the time of making requests for improvements or repairs to any aspects of the apartments.



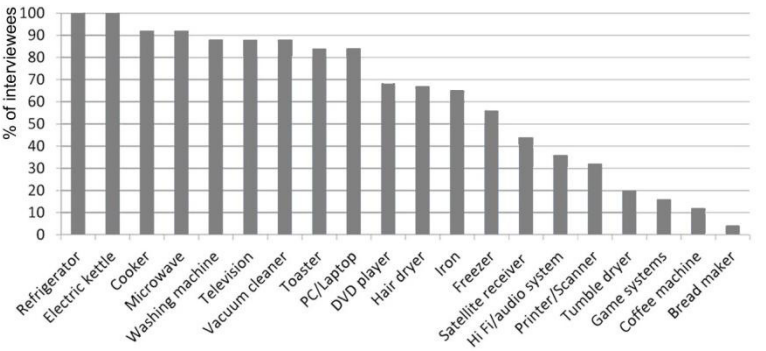


Fig. 6 Rate on the apartments' effect on health (left); Fig. 7 Electric appliances in use by the occupants (right)

Fig. 8 Rates on different aspects of management and maintenance of the building case study

4. Discussion

The results of the interviews with the occupants of the case study shows that in general people are satisfied with the different aspects of the building, giving positive rates to many items such as overall thermal comfort, overall daylight level, etc. However, asking more detailed questions or allowing the occupants to provide further comments revealed a number of problems in the building. This general satisfaction in spite of existing issues in the building is known as the "forgiveness factor", "a willingness of occupants to tolerate less than perfect conditions because they like the overall feel and design quality of a building" [21], which had been spotted in other similar occupants surveys [9, 22]. The key issues extracted from the interviews are as follows:

1. *High indoor air temperature:* Results indicate that the occupants are adapting to high indoor air temperatures by wearing less clothing and keeping windows open, which may lead to building heat loss in the heating season; whilst still feeling too warm or hot in many apartments. High indoor temperatures were recorded in the spot measurements in 2012 [12].
2. *Inadequate ventilation in the kitchen:* The kitchens have no windows and are located at the end of L-shaped spaces, the furthest distance from the lounge windows in most of the apartments. Therefore,

the dissipation of excess heat gain and odours is mainly dependent on mechanical ventilation which seems not to be effective, especially when the cooker/oven is in use.

3. *Lack of cold water in the kitchen:* The possible reason is the heat transfer from adjacent hot water pipes; apart from potentially significant waste of water and forcing the occupants to regularly buy bottled water, this may cause serious health problems including Legionnaires' disease.
4. *Lack of daylight in hall, kitchen and bathroom:* Whilst main living spaces in the apartments, lounge and bedrooms have good daylight levels, hall, kitchen and bathroom have limited or no access to daylight due to no windows. This might not be a significant problem in the hall since this space gets borrowed natural light, if doors of the bedrooms and lounge are left open. However, artificial light needs to be used in the kitchen and bathroom all day, which results in more electricity consumption and more internal heat gain. Additionally, this may negatively affect the quality of kitchen space for some occupants; "I miss having a window in the kitchen" is stated by two interviewees.
5. *Fixed charge for gas consumption:* Paying a fixed bill is no incentive for saving energy or carbon emissions and since the space heating has rarely been used in most of the apartments, the £8.12 per week seems expensive as it is mainly for the domestic hot water consumption.
6. *Numerous electric appliances in use*: There is heat gain from all these appliances that may be problematic during warm days and should have been considered during the design process.
7. *Noise transfer between floors*
8. *Possible effects of the building on occupants' health*: More than half of the occupants experienced one or more symptoms associated with Legionnaires' disease, which needs further investigation.
9. *Lack of a proper induction at handover*: Many building evaluation studies confirm the importance of familiarising the occupants with the functionality of the home and its systems prior to occupancy, in order to achieve the energy efficiency targets [9, 22, and 23]. In the induction of the case study building, a representative from the housing association (developer) showed the internal spaces of the apartments and the buildings to the occupants. However, the occupants stated that there was no explanation of the more complex items, such as user controls of the heating or ventilation system and there was no hands-on training on how to use the systems. The home user guide is giving some general information failing to provide straightforward guidelines on how to use the systems and controls. As a result, most of the occupants are not able to use the programmer, the thermostat and the thermostatic valves or they are not sure to what extent they can have control over the mechanical ventilation, even though most of the interviewees have adopted energy saving behaviours (refer to the results: behaviour towards energy consumption sub section).

The origin of these issues may be design decisions, constructional inaccuracies, management mistakes or inappropriate occupant use that needs further investigation to be well understood. Thus, further research through a number of methods is being undertaken, to provide robust information on the energy efficiency of the case study building. Second round of interviews with the occupants during the heating season, December 2012 to March 2013 is being undertaken. Since the best building evaluation includes a combination of qualitative and quantitative research [8], the internal conditions in three apartments and the communal corridors and the external climatic conditions have been monitored since December 2012; to give a clearer picture of the thermal conditions in the apartments. There will also be interviews with the

design and construction teams to understand the constraints affecting the design and construction processes.

5. Conclusion

This paper has discussed findings from the first set of occupant surveys in an award-winning, as-designed low carbon case study apartment building in Swansea, UK. The study is a part of a more extensive building performance evaluation; so, the data is still subject to verification when other parts of the research are completed. The initial findings, however, show a number of issues in the building negatively affecting comfort conditions and satisfaction of occupants. Further investigations are undergoing to find out the causes of each issue and to understand the scale and the extent of each problem. Next step would be to explore possible solutions to improve comfort conditions in the building case study before taking forward the findings and lessons in future projects of the same housing developer.

Acknowledgements

The research documented in this paper is part of Cardiff Metropolitan University's contribution to Work Package six of the Low Carbon Built Environment project, funded by Cardiff Metropolitan University, Coastal Housing Group and the European Research Development Fund's Convergence, Regional Competitiveness and Employment programmes; administered by the Low Carbon Research Institute for the Welsh Government. This paper could not have been possible without Coastal staff. Thanks are extended to Linda Toledo from Cardiff Metropolitan University, who assisted in the interviews.

References

[1] HM Government. 2011. The carbon plan: delivering our low carbon future. Cited at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/47613/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf and accessed 7th February 2013 (available)

[2] Department of Communities and Local Government (DCLG) (2007), Homes for the future: More affordable, more sustainable, Cm 7191. Cited at: http://www.official-documents.gov.uk/document/cm71/7191/7191.pdf and accessed 11th February 2013 (available).

[3] BBC News Science and environment. 16 September 2011. UK 'set to miss' climate targets. Cited at: http://www.bbc.co.uk/news/science-environment-14949188 and accessed 7th February 2013 (available)

[4] BBC News. 6 August 2007. CO2 emmissions are highest in the UK. Cited at: http://news.bbc.co.uk/1/hi/wales/6932667.stm and accessed 7th February 2013 (available)

[5] Zero Carbon Hub and NHBC Foundation. 2010. Carbon compliance for tomorrow's new homes: a review of modelling tool and assumption. Topic 4: closing the gap between design and built performance. Cited at: http://www.zerocarbonhub.org/resourcefiles/topic4_pink_5august.pdf and accessed 7th February 2013 (available).

[6] Bell, M., Wingfield, J., Miles-Shenton, D. and Seavers, J. (2010) Low Carbon Housing: Lessons from Elm Tree Mews, Joseph Rowntree Foundation. Cited at: http://www.jrf.org.uk/sites/files/jrf/low-carbon-housing-full.pdf and accessed 11th February 2013 (available).

[7] Bordass, B. and Leaman, A. 2005. Making feedback and post-occupancy evaluation routine 1: A portfolio of feedback techniques, Building Research & Information, 33:4, 347-352.

[8] Bordass, B. 2011. Built environment professionals in the Uk: 40 years back, 40 years on? Keynote lecture in world Sustainable Building (SB) conference, Helsinki.

[9] Stevenson, F. And Rijal, H. 2008. The Sigma Home: towards an authentic evaluation of a prototype building. PLEA 2008 – 25th Conference on Passive and Low Energy Architecture, Dublin, 22nd to 24th October 2008.

[10] Pilkington B, Roach R and Perkins J (2011) Relative benefits of technology and occupant behaviour in moving towards a more energy efficient, sustainable housing paradigm. Energy Policy, Vol. 39, No. 9, pp 4962-4970. Cited at: http://www.sciencedirect.com/science/article/pii/S0301421511004745# and accessed 12th February 2013 (available).

[11] City and County of Swansea research and Information Unit. 2012. 2011 Census: Release of Initial Results. Cited at: http://www.swansea.gov.uk/media/pdf/e/q/2011_Census_Summary_-_Release_of_Initial_Results_Jul-12_CCS_R_I.pdf and accessed 27th December 2012 (available).

[12] Nooraei, M. Littlewood, J, R. Evans, N, I. 2013. Passive cooling strategies for multi-storey residential buildings in Tehran, Iran and in Swansea, UK. Paper presented at the 4th International Sustainability and Energy in Buildings conference (SEB'12), 3rd to 5th September 2012, Stockholm, Sweden. To be published as a Chapter in session B 'Assessment and Monitoring the Environmental Performance of Buildings'. In: Sustainability in Energy and Buildings (SEB'12). Series: Smart Innovation, Systems and Technologies. Volume editors: Smith, M., Håkansson, A., Höjer, M. & Howlett, R.J. Vol. 13. Springer, Heidelberg, Germany. ISBN: TBC.

[13] Meteonorm 7. Demo Mode.

[14] Szokolay, S. V. 2004. Introduction to architectural science: the basis of sustainable design. Published by Elsevier Ltd.

[15] Swansea Bay. 2012b. Swansea Bay weather guide. Cited at: http://www.welshholidaycottages.com/weather/swansea-weather-guide.htm and accessed 15th May 2012 (available).

[16] Met Office 2012. Cited at: http://www.metoffice.gov.uk/climate/uk/2012/summer.html and accessed 4th January 2013 (available).

[17] Weather Online. 2012. Swansea March 2012. Cited at: http://www.weatheronline.co.uk/weather/maps/city?WEEK=02&MM=03&YY=2012&WMO=03609&LANG=en&SID=03609567 76c421b303457c2c81a20340c9294a&ART=MAX&CONT=ukuk&R=150&NOREGION=0&LEVEL=150&REGION=0003&LAN D=__ accessed 3rd May (available).

[18] Energy Saving Trust 2013. The Code for Sustainable Homes. Cited at: http://www.energysavingtrust.org.uk/Organisations/Business-services/Free-resources-for-housing-professionals/New-build/The-Code-for-Sustainable-Homes and accessed 8th January 2013 (available).

[19] Littlewood, J, R. 2013. Chapter six - Testing the thermal performance of dwel-lings during the construction process. In: Architectural Technology: research and Practice. Editors: Emmitt, S. Wiley Blackwell, Oxford, UK. pp.TBC. ISBN: TBC.

[20] NHS 2012. Legionnaires' disease. Cited at: http://www.nhs.uk/conditions/legionnaires-disease/Pages/Introduction.aspx and accessed 6th January 2013 (available).

[21] Stevenson, F. na. Post-occupancy evaluation. In: The Green building Bible, Volume 2. Green Building Press: Llandysul.

[22] Gupta, R. and Dantsiou, D. 2013. Understanding the gap between 'as designed' and 'as built' performance of a new low carbon housing development in UK. Paper presented at the 4th International Sustainability and Energy in Buildings conference (SEB'12), 3rd to 5th September 2012, Stockholm, Sweden. To be published as a Chapter in session B 'Assessment and Monitoring the Environmental Performance of Buildings'. In: Sustainability in Energy and Buildings (SEB'12). Series: Smart Innovation, Systems and Technologies. Volume editors: Smith, M., Håkansson, A., Höjer, M. & Howlett, R.J. Vol. 13. Springer, Heidelberg, Germany. ISBN: TBC.

[23] Carmona-Andreu1, I., Stevenson, F., Hancock, M. 2013. Low carbon housing: understanding occupant guidance and training. Paper presented at the 4th International Sustainability and Energy in Buildings conference (SEB'12), 3rd to 5th September 2012, Stockholm, Sweden. To be published as a Chapter in session B 'Assessment and Monitoring the Environmental Performance of Buildings'. In: Sustainability in Energy and Buildings (SEB'12). Series: Smart Innovation, Systems and Technologies. Volume editors: Smith, M., Håkansson, A., Höjer, M. & Howlett, R.J. Vol. 13. Springer, Heidelberg, Germany. ISBN: TBC.