Energy and Buildings 110 (2016) 120–134

Contents lists available at ScienceDirect

Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild

Post occupancy evaluation of social housing designed and built to Code for Sustainable Homes levels 3, 4 and 5

Stephen Pretlove*, Sidonie Kade

School of Architecture & Landscape, Kingston University London, Knights Park, Grange Road, KT1 2QJ, United Kingdom

ARTICLE INFO

Article history:
Received 4 June 2015
Received in revised form 27 August 2015
Accepted 6 October 2015
Available online 30 October 2015

Keywords:
Code for Sustainable Homes
Social housing
Carbon emissions
Sustainability
Building performance evaluation

ABSTRACT

In the housing sector, carbon emissions arise primarily through the consumption of energy to heat, light and ventilate our homes. Significant improvements in UK housing energy performance have been driven both by changes in legislation, and by the introduction of the Code for Sustainable Homes in 2007. Compliance with certain levels of this Code has been adopted as policy by Local and Regional Authorities, and social housing providers. The evaluation of the performance of low carbon housing requires the assessment of increasingly complex building services technology, and occupant behaviour. This added services complexity, and the expectation that tenants understand how to use it, has led to a number of unintended consequences which have resulted in a higher risk of performance failure. This study comprises the detailed evaluation of seven new social housing dwellings, designed and built to Code levels 3, 4 and 5, including comprehensive environmental monitoring, measurements of the consumption and generation of resources, and social surveys of the occupants. The results show that as the Code levels increase there is a reducing energy and water consumption rate, and an increasing energy generation rate, but only at the expense of a significantly increased risk of services system failure.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

The threat of climate change is now globally recognised, with human activity being the primary cause of elevated greenhouse gas emissions [1]. The latest published statistics from the UK Government show that in the UK over 50% of carbon dioxide emissions come from buildings and around 25% from dwellings [2]. In the domestic sector, these emissions arise primarily through the consumption of energy to heat, light and ventilate our homes and there has been a significant improvement in energy performance requirements in the UK, driven by progressive changes in the Building Regulations since 1965. Carbon emissions are considered in detail within Approved Document Part L of the Building Regulations [3] which requires heat gains and losses to be limited, and accounts for the efficiency of the building services systems. The current proposals for changes in Part L of the Building Regulations will require all new dwellings in the UK to be net zero carbon in 2016.

Building Regulations in the UK control mandatory standards of compliance for all new buildings. However, in many sectors of the market there has long been a drive towards raising the performance of dwellings beyond the basic compliance level of the regulations to higher levels of environmental performance, driven by a number of domestic and non-domestic environmental assessment methods and Codes. In the residential market in the UK this began as the EcoHomes rating system, which was launched in 2000, and soon became a mandatory standard, at certain rating levels, for social housing. The Ecohomes standard was phased out and subsequently replaced by the Code for Sustainable Homes [4]. The Code has undergone various changes since it was first introduced and was described at the time as ‘a step change in sustainable home building practice’. The most recent version of the Code was published in November 2010 [5] and in early 2014 the UK Government confirmed that the Code would be abolished and rules on energy efficiency would be incorporated into the Building Regulations.

Since the 1990s there has been a significant rise in the number of building environmental assessment schemes across the globe. Some of these schemes are mandatory, required by legislation, and some go beyond mandatory legislative requirements, are discretionary and represent good practice in the development of an increasingly sustainable built environment. There is significant variation in the methodology adopted by different schemes, some being generic, and some designed for specific building typologies. Some of the generic schemes, which have originated in one country, have been adapted and adopted in other countries and have a global reach, LEED and BREEAM being two systems that are widely adopted outside of America and the UK respectively. The NHBC

* Corresponding author.
E-mail address: s.pretlove@kingston.ac.uk (S. Pretlove).

http://dx.doi.org/10.1016/j.enbuild.2015.10.014
0378-7788/© 2015 Elsevier B.V. All rights reserved.

Foundation [6] has published comprehensive information relating to relevant codes that are being adopted in the housing sector for 20 countries across the world. The most widely adopted systems include the Leadership in Energy and Environmental Design (LEED) green building certification system, which includes a rating system for homes, adopted in America; the Green Star rating system, launched by the Green Building Council in Australia; the National Energy Code for Houses (NECH) and the National Energy Code for Buildings, which has provisions for housing, in Canada; the Regional Energy Efficiency Codes for Residential Buildings and the Evaluation Standard for Green Building (ESGB) in China, and the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) which includes a rating system for homes. In the European context, the establishment of the Energy Performance of Buildings Directive (EPBD) in 2002, and the subsequent update in 2012, requires member states to ensure reductions in energy consumption and carbon emissions as well as introduce building energy certification schemes [7]. Systems adopted across Europe, in the housing sector include the PassivHaus standard, developed in Germany, but also adopted by other countries including Austria and Denmark; the Haute Qualité Environnementale (HQE) in France; and the MINERGIE standard in Switzerland which has two relevant versions, MINERGIE-P for ultra-low energy buildings, and MINERGIE-Eco which also includes broader environmental considerations.

The Code for Sustainable Homes (CfSH), like many of the environmental assessment methodologies developed by the Building Research Establishment (BRE), assesses the sustainability of a building under a number of broad categories and awards credits under each. Different categories have different overall weightings and for some there are mandatory minimum requirements. There are six levels of compliance from level 1 which exceeds the basic requirements of the Building Regulations, up to level 6 which represents a zero carbon dwelling. The energy and CO_2 emissions category is the most significant in the current Code, representing 36.4% of the total credits available.

Compliance with certain levels of the Code have been adopted as policy by some Local and Regional Authorities as part of their Planning and Sustainability strategic plans, and, where funding for social housing is provided by the Homes & Communities Agency (HCA) there has been a minimum requirement of compliance with Level 4 of the Code.

Previous studies have shown that low carbon housing requires the use of more complex technologies, that occupant behaviour has a significant effect on performance of the building and that most low carbon schemes have been carried out by, and for, enthusiasts and experts [8]. Other studies have shown that as we have increased the environmental standards, housing is no longer one of the least complex building types [9] and that the added services complexity has led to a number of unintended consequences which have occurred directly as a result of the drive towards lower carbon buildings [10]. In a study monitoring the performance of two new low energy dwellings in the UK, it was found that the performance of these dwellings relies heavily, not only on the as-built quality of the envelope but also on the correct installation and functioning of the building services [11]. The same study, which focused on social housing, highlighted that achieving high levels of performance was partly due to problems in the construction process which required significant vigilance and scrutiny from the design team. The impact of occupant behaviour on energy consumption cannot be underestimated. It has been reported that there can be significant variations in gas consumption rates in identical homes with different occupants [12]. In a study of 25 dwellings, evaluating energy and water performance in affordable housing in the UK, it was found that water consumption varied by a factor of more than seven, and energy by a factor of more than three, in similar design and specification buildings [13]. Similarly, it has been reported that usability of services system control interfaces in low carbon housing also plays a significant role in building user behaviour and that clear design and labelling, and guidance and handover procedures for heating and ventilation systems is necessary [14].

Social housing providers, as landlords, are expected to provide a level of support to tenants in terms of commissioning, maintaining and dealing with service system failure if it occurs, but this can be problematic if the tenants do not understand how to properly operate the systems, or are unable to recognise when they are not working properly. There is also the issue of who has the responsibility for dealing with service system problems when they occur, particularly in newly built dwellings; whether it is the landlord or the installation contractor. Findings from a previous study [9] showed that housing occupants are often treated as Facility Managers, and are expected to operate their homes with limited support, training and clear guidance. The same study demonstrated the need for a formal induction for new tenants in order that they can inhabit and interact with their building properly. It also revealed uncontrollable and excessive heating, unbalanced mechanical ventilation with heat recovery (MVHR) airflow, the breakdown of the solar thermal system which was then not replaced, and, electrical meters connected to photovoltaic (PV) systems which failed to show when energy was being consumed in the dwelling and when it was being exported to the grid.

A key element of this study was to test whether higher levels of the CfSH led to reducing levels of resource consumption. At the same time the study tested whether higher levels of the Code were only achieved at the expense of an increased risk of breakdown and failure of the services systems that were installed to achieve this higher level of carbon efficiency in the first place. Given that many of these systems are designed to operate as an integrated part of a whole house strategy, when failure occurs in even one, it can be detrimental to the fundamental environmental strategy and can have more serious consequences than not installing the complex technology in the first place. A study commissioned by the Joseph Rowntree Foundation, assessed the performance of an exemplar low carbon housing scheme, and concluded that not only should services focus on whole system performance, but also that improvements are required in their commissioning, testing and monitoring to ensure effectiveness [15].

Very little consideration is given to the design life of service systems installed in low carbon homes, their initial commissioning and balancing, their controls, the appropriateness of the operation and maintenance manuals relative to the occupants and their knowledge and needs, the maintenance regime required to maintain operational efficiency, proactive rather than reactive responses to breakdown, and sensible replacement strategies for different elements of the overall environmental systems in dwellings.

2. Methodology

This study set out to evaluate the performance of a number of new domestic dwellings, in the social housing sector, designed and built to levels 3, 4 and 5 of the Code for Sustainable Homes. Comprehensive environmental, energy and water consumption data was collected in seven dwellings over a full year.

The dwellings were designed and constructed to comply with varying levels of the Code, with one dwelling being certified to level 3, 2 dwellings to level 4 and four dwellings to level 5.

The CfSH requirements for carbon emission predictions require that all of the dwellings tested were designed to perform beyond the Building Regulations current at the time. As such they incorporate a number of low energy fabric and building services systems. The dwellings are all highly insulated, airtight and incorporate a

دریافت فوری ← متن کامل مقاله

ISIArticles
مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات