Energy and Buildings 43 (2011) 117–125

Contents lists available at ScienceDirect

Energy and Buildings

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

Measured energy and water performance of an aspiring low energy/carbon affordable housing site in the UK

Zachary M. Gill[a,b,*], Michael J. Tierney[b], Ian M. Pegg[a], Neil Allan[b]

[a] Buro Happold, 17 Newman Street, London W1T 1PD, United Kingdom
[b] Industrial Doctorate Centre in Systems, The University of Bristol, Queens Building, Bristol BS8 1TR, United Kingdom

ARTICLE INFO

Article history:
Received 23 March 2010
Received in revised form 23 August 2010
Accepted 25 August 2010

Keywords:
Domestic
Energy
Water
Building performance
Low-energy
Post-occupancy evaluation

ABSTRACT

This paper reviews the annual energy and water performance of an aspiring low energy/carbon affordable housing development in southern UK, comprising 25 houses heated by a biomass fueled district heating network. Electrical, heat and water consumption data was collected for all dwellings and more detailed data logging was conducted on a sample of four. The data was analysed to benchmark the overall site performance and compare the individual dwellings.

The individual dwellings performed efficiently in terms of electricity, heat and water consumption. Significant variation was identified between maximum and minimum consumers, even when typical performance correlates (i.e. number of occupants, floor area) were accounted for. Water consumption varies by a factor of > 7 and heat and electrical consumption by > 3 which, given the homogeneous design and specification of the buildings, suggested that occupant behaviour was important. Site-wide energy consumption and losses (over and above individual dwelling use) reduced energy and carbon emissions performance by 85% and 70% respectively. Although energy consumption in UK homes can be substantially reduced, the challenge for zero-carbon design is to address issues of total system performance, occupant behaviour and whole-building energy performance.

© 2010 Elsevier B.V. All rights reserved.

1. Introduction

The demand to reduce energy consumption and carbon emissions in the built environment is well documented [1–3]. Dwellings play an important role within this (contributing approximately 30% of end-user carbon emissions and energy use [4,5]) and correspondingly the UK government has stipulated that by 2016 all new homes will be zero carbon [6]. Whilst the effectiveness of these policy measures has come into question (primarily due to their clarity and implementation costs) [7], in principle low and even zero-energy or carbon homes in the UK[1] are achievable through a combination of improved insulation, more efficient mechanical and electrical equipment, higher air tightness (with controlled ventilation) and renewable technologies [8–14]. However, available post-occupancy evaluation (POE) research shows real-world building performance aligns poorly with design expectations and some nominally low-energy buildings perform no better than their more traditional counterparts [15,16]. Computational prediction of energy consumption also shows poor correlation to monitored performance even when it is based on as-built construction details and actual building occupancy/utilisation [17]. One must inevitably question the use of computed in situ building performance in the absence of measurement. Measurements in 'traditional' dwellings show that characteristics of the building (for instance floor area, number of occupants, terraced or detached) play a role in determining actual energy consumption [18]. Statistically significant variation in heat and electrical energy consumption is noted even in similar dwellings and consumers can be categorised into high, medium and low bands. Furthermore there is an increasing trend of energy consumption over time in the UK contributed to most significantly by 'high' energy consumers [19,20]. Achieving low and even zero carbon/energy buildings in the UK is complicated because; design and reality align poorly; zero carbon dwellings are required but are not fully understood by the industry; house characteristics are not the sole determinants of performance; and energy use is increasing over time.

This study assesses the performance of an affordable, low energy/carbon site in the UK where the construction and specification of the buildings is homogeneous, and the results from monitoring are presented and analysed. It is intended that this comprehensive measurement of building performance will provide insight into the impact of identified issues on low energy building variants.

* Corresponding author at: Buro Happold, 17 Newman St, London, W1T 1PD, United Kingdom.
E-mail address: Zack.Gill@BuroHappold.com (Z.M. Gill).

[1] With a mid-European coastal climate.

0378-7788/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.enbuild.2010.08.025

Table 1
Dwelling characteristics.

Type	Floor area (m^2)	Bedrooms	Storeys	Number of	Currently occupied
1	68.13	2	2	10	9
2	74.58	2	2	3	3
3	81.11	3	3	9	9
4 (1st end)	56.38	1	1	1	1
4 (1st mid)	49.02	1	1	1	1
4 (Ground)	44.70	1	1	2	2

2. Site description

The East-Anglian site comprises of 13 two-bedroom and 9 three-bedroom houses, plus 4 one-bedroom flats, each constructed to the same design specification and was awarded BRE's EcoHomes Excellent certification. The site systems exceed the requirements of UK Building Regulations and typical UK dwellings. Low in-use carbon emissions and energy/resource consumption are facilitated by;

- *Biomass District Heating Network*: A woodchip-fired community heating network (with a gas back up boiler for peak loads) services the heating and hot water demand of dwellings. Pre-insulated pipe work circulates heated water to local heat exchangers (one per dwelling) which extract heat according to demand. Each dwelling is individually controlled by a single programmer (with thermostat) and TRVs on all radiators.
- *Whole House Mechanical Ventilation with Heat Recovery (MVHR)*: Replaces the background ventilation usually provided by trickle vents and infiltration. Air is extracted from wet rooms (bathrooms and kitchens) and heat is exchanged to filtered incoming air for living spaces (bedrooms and living room).
- *High Air Tightness*: As constructed the buildings achieve a mean air tightness value of 3.47 m^3/m^2 h at 50 Pa (with a standard deviation of 0.367 m^3/m^2 h). This is a 65% improvement on the minimum regulatory requirement (10 m^3/m^2 h [21]) and 30% improvement on the design target value.
- *Massing*: In groups of three to reduce the area of exposed facade. The two and three storey buildings are grouped to ensure winter solar gain is maximised by staggering the blocks (minimising overshadowing) and by limiting the height of the southern block in each group to two storeys.
- *Rainwater Harvesting*: A header tank (50–60 l capacity) is fitted in each dwelling and supplies filtered, unmetered greywater (with mains water backup) for toilet flushing and garden irrigation.
- *Optimised Solar Orientation*: The main portions of glazing are located on the South facade to enable useful solar gains in the winter. Operable windows and thermal mass in party walls are provided to ensure that the temperatures are stabilised. Initial dynamic thermal modelling in IES VE showed that internal temperatures peak at 25 ° C in the summer months, thus avoiding overheating.
- *Improved Insulation*: Installed insulation is better than mandated in the UK Building Regulations [21]: Walls are 0.25 W/m^2 K (vs. 0.35 W/m^2 K), Glazing 1.9 W/m^2 K (vs. 2.2 W/m^2 K), Roof 0.12 W/m^2 K (vs. 0.25 W/m^2 K) and Ground 0.25 W/m^2 K (equal to regulations)
- *Low Energy Lighting*: Installed throughout the homes.
- *Low Flow Fixtures*: Installed throughout the homes.

There are four dwelling types (Table 1). The site opened in September 2008 and 16 of the 26 dwellings have since been occupied fully. Seven were subsequently occupied from January 2009. Two were occupied in February 2009 and then November 2009. Monitoring data was collected between September 2008 and November 2009 inclusive.

3. Methodology

During the design, an arrangement was negotiated with the site landlord (a Housing Association) to conduct on-going site monitoring. Consumption monitoring was permitted for all dwellings and a shortlist of potentially willing residents was provided to instigate more detailed monitoring; Four of the five shortlisted dwellings agreed to participate. No energy performance information was fed back to any of the participants during the monitoring period.

3.1. Detailed monitoring—4 dwellings

Electrical energy consumption was monitored via a single-phase current clamp and data logger attached to the main incoming supply to each building. An instantaneous current measurement was recorded every 10 min at 0.4 A resolution providing a detailed electrical load profile. Small equipment load switching (<100 W) and short equipment use (not occurring at one of the logging intervals or <10 min use duration) was missed and therefore electro-mechanical induction meters reported cumulative consumption (in kWh). Water consumption was monitored via a pulsed output data logger connected to a manufacturer supplied reed switch mounted to the top of the rotary water meter housing. A pulse was outputted for every litre of water, and cumulative consumption was logged at 10-min intervals. Accuracy of the monitoring equipment was checked via comparison to manual meter readings and was better than 0.1%. Heat consumption (supplying heat and hot water demand) was also monitored via a pulsed output data logger recording cumulative consumption in 10-min intervals. The logger was connected via a manufacture supplied pulsed output module connected to the heat meter located at the heating network heat exchanger. The measuring accuracy of the installed heat meter exceeded the requirements of EN 1434 Class 2 and 3 [22]: better than ±2% across it's operating range. Internal temperature and relative humidity was logged in 30-min intervals using compact HOBO® H08 data loggers. Readings were taken for the summer and winter periods in a frequently used space within the house—the combined kitchen–dining room. All loggers required information to be downloaded manually onto a computer and therefore provided no instantaneous feedback to the residents. Loggers were also concealed to minimise their influence on the occupant's behaviour. All of the dwellings had three occupants and were end-terraced (2 West and 2 East). Three of the houses were the largest Type 3 whereas one is Type 1.

3.2. Monitoring—all dwellings

All dwellings were monitored manually using installed utility meters. Electric and water meter readings were taken periodically via externally located meters. Heat meters were all located within the dwelling on the heat exchanger pipe work, and were therefore less accessible. Readings were taken on the date the occupants moved in and further readings were taken at 6 monthly intervals (April 2009 and October 2009). Dwellings were billed pro-rata for electrical and water consumption. Heat consumption was charged

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