ABSTRACT

This project evaluation for an innovative social housing scheme in the Highlands of Scotland incorporates elements of quantitative post occupancy evaluation (POE) as well as environment behaviour and interviewing techniques. It presents a hybrid POE methodology for housing which has successfully highlighted some key issues for innovative timber housing design in Scotland. Tenant interviews were triangulated with the client, manager, designer and contractor experience, and actual fuel costs compared with perceived fuel costs, as well as on-site analysis. The use of in-depth interviewing combined with environment behaviour analysis yields a “thick description” of how the buildings are experienced by users compared to the build and management experience. The methodology is particularly suitable for small scale developments and allows for a holistic appraisal which moves beyond monitoring into the complexity of user perception and value systems influencing behaviour. The use of narrative to establish the users value system is compared with more traditional quantitative and mechanistic POE techniques such as those used for larger buildings.

INDEX TERMS
Post occupancy evaluation, Tenant satisfaction survey, Domestic dwelling design feedback, Innovative housing in Scotland

INTRODUCTION

An evaluation of 14 all-timber rented houses, comprising the Innovative Rural Housing Design Project in Kincardine O’Neil, Aberdeenshire, was commissioned by Communities Scotland in January 2002 and completed in June 2002 by EDG (Ecological Design Group) two and a half years after the development was completed. A follow-up study was commissioned in March 2004. The housing development was the eventual outcome of a long research study (The Robert Gordon University, 1994) which addressed the need for affordable and life-time rural housing in Scotland through the development of key design principles.
Illustration No 1: Innovative Rural Housing Design Project - example of terraced housing showing all-timber construction.

The aims of the study were to evaluate the success of the housing development in two key areas:

- its innovative design features
- its contribution to the economic sustainability of the community

This paper will focus on the first aim in order to explore issues relating to Post Occupancy Evaluation (POE) methodologies.

Objectives included establishing:

- the level of heating bills and energy costs compared to normative measures
- the effectiveness of the flexible design concept
- the overall tenant satisfaction with the houses and level of rent
- the level of turnover, achievement of targets in allocation policy and any management issues

**METHODS**

The methodology drew on previous experience of evaluating numerous innovative housing projects in Scotland (Stevenson and Williams, 2000) and a combination of

Semi-structured in-depth interviews with 12 households were undertaken in their own homes using open questions with appropriate probes and open questions (see appendix 1). Each interview lasted approximately 60-90 minutes. The interviews were discreetly recorded and transcribed for later analysis. Tenants were also encouraged to show the interviewer the physical issues in the house as they raised them. This allowed the interviewer to observe tenant behaviour at the time of the interview and note any unusual features of their home making that might influence the effectiveness of the design (Ziesel, 1981).

A standard satisfaction survey was rejected on the grounds that it would not yield a “rich” texture of information or any unforeseen factors, although a simple questionnaire was used initially to elicit basic demographic information and perceived occupancy patterns.

The landlord, manager, architect and contractor were also interviewed to ascertain their views on the housing development and these were compared with the user experience. Fuel bills and maintenance records were obtained for a one-year period and compared to tenant’s observations. Finally the design and working drawings for the scheme, as well as the buildings themselves, were cross-evaluated for technical and design quality by the architect-interviewer in relation to the previous factors. The main interviews ran over a two week period, with a month of preparation and two months for analysis, evaluation and completion of the report.

RESULTS

A strong rapport was developed with all parties interviewed and a number of unexpected issues emerged out of the “rich” descriptions, as well as the usual issues relating to comfort and control (GAIA research, 2003). The numerous visits to the project at different times of the day and week also yielded a wide range of environment behaviour and observational data on the buildings themselves.

The housing development successfully achieved the following objectives:

- provision of barrier-free, flexible lifetime homes
- housing families and retired households in housing need and on low incomes
- affordable rents
- low turnover
- high tenant satisfaction overall (82%) after two and half years occupation

Evidence on the achievement of anticipated savings on running costs proved inconclusive, however, as it was impossible to establish an equivalent benchmark.
scheme for comparison, and the fuel bills varied very widely from £11.70 -£22.16 per week. The carbon dioxide emissions for each house were disappointingly high, varying from 99-251 CO$_2$kg/m$^2$/year, which compared poorly with the UK EPI (Environmental Performance Indicator) best practise benchmark of 30-55 CO$_2$kg/m$^2$/year for housing in 2001 (see www.constructingexcellence.org.uk/resourcecentre)

Additional results which emerged from the interviews included:

- poor acoustic insulation between houses (83% of households)
- problems with mechanical ventilation and mould growth in shower rooms (50%)
- high heating costs (83%)
- high temperature in the summer due to building overheating (50%)
- poor control and comfort due to electric central heating (58%)
- low temperature in winter (66%)
- poor aesthetic appropriateness (50% generally, 100% in relation to the context of the conservation village)

DISCUSSION

**Heating and ventilation** - Given the relatively low u-values of the housing (typically 0.2 for the roof, 0.2 for the wall and 0.25 for the floor), which were substantially better than the building regulation requirements at that time, and the compact terraced planning involved in all cases except the two detached gatehouse dwellings, several questions stand out in terms of heating and ventilation performance arising from the 12 households interviewed:

- why is the overall level of carbon dioxide emissions so high?
- why are 50% of households experiencing overheating in the summer?
- why are two thirds of households dissatisfied with temperatures achieved in the winter?
- why has mould occurred in 50% of households?

The picture is a complicated one with multiple factors. These can be summarised as:

a) Design issues:

*Flexible/variable volume housing:* The open plan layout meant tenants were heating the unused attic space as well as having to heat the kitchen, dining and living areas to the same temperature as the living area, when it may have been preferable to shut them off to conserve heat.

*Choice of Heating System:* The lightweight construction is more suitable for quick response heating systems, and
tenants resorted to various (unsuccessful) strategies to try and get the slow response storage heating to generate appropriate comfort conditions. This system was chosen on the basis of low capital cost, rather than energy efficiency or user control.

**Thermal mass:**
The lack of any thermal mass available in the timber buildings to absorb solar gain, combined with inadequate cross-ventilation or external shading in the kitchen/living room areas, led to overheating in the summer (Borer and Harris, 1998, Roaf, Fuentes and Thomas, 2001). It should be noted that the buildings comprised, unusually, of timber roofing shingles, timber cladding and timber frame. Historic buildings in Scotland often used timber for these elements (Davies, Pendlebery and Walker, 2002) but usually combined with some form of thermal mass. The concrete raft flooring in this particular project, which could have provided some thermal mass, was usually covered with wall-to-wall carpeting.

**Shower rooms:**
The size of the shower room, to accommodate wheelchair access standards in this development, combined with the lack of an opening window and the inadequate fan specification generated problems with mould due to excessive moisture retention in the room.

**Airtightness and Natural Ventilation:**
It was impossible to ascertain the degree of airtightness in the housing, but it was noted that the project relied largely on natural ventilation through trickle vents, assisted by extract fans in the kitchen and bathroom. Trickle vents were sometimes sealed up and a number of tenants over-ventilated their houses as a result by leaving windows open instead.

b) User-related issues:

**Tenant strategies for heating and ventilating:**
The over-ventilation may have been partly in response to the perceived need to dehumidify the house given the mould problems that appeared in a number of the shower rooms and some bedrooms. There is however a broader cultural issue in the fact that a number of tenants felt the need to keep at least one window open all the time, regardless of the temperature inside.
A number of households admitted keeping their windows open all the time, defeating attempts to save energy by the designer through insulation and air-tight construction.

The need for tenant education:
Failure by both the Landlord and Design team to provide specific training for tenants at the outset may also have contributed to the use of inappropriate strategies for heating and ventilating. The documentation provided by the energy supplier was not particularly transparent and appears to have caused confusion among some tenants.

Perception of heating costs:
In every single case, the tenant overestimated their expenditure on fuel costs, which raises the question of what other factors may be at play influencing tenant perception. In this instance, the poor performance of the heating system, as well as the expectations of moving into a “low energy” house may be leading tenants to exacerbate their predictions.

Establishing Energy. V. Heating Costs – It was decided that obtaining the fuel bills for each household was the most effective way of establishing energy costs, short of continuous monitoring, as this would accurately reflect the amount of energy being used by the tenant, rather than the amount of energy being lost by the building. Ultimately, however “well” the building is performing physically in terms of preventing heat loss, it is the amount of fuel used that is important and the various reasons for that. Unfortunately, because the houses were “all-electric”, the fuel supplier was unable to provide a break-down of costs for heating compared to other electrical costs such as lighting and “white goods” (fridge, cooker, washing, machine,
It therefore became impossible to verify exactly how much energy tenants were using for heating in relation to other energy uses. The assumption was made that the tenant group as a whole was not using excessive amounts of energy on non-electrical heating items, given the wide variety of lifestyles and demographic variation present in the group. It is easier to establish heating costs for households using non-electric heating such as gas, oil or wood and this should be borne in mind for future domestic POE studies.

**User values**– The tenants appeared to place greater value on the spatial qualities of the buildings than the nuisance factors, which suggests that people will put up with a relatively high degree of discomfort providing they like the “feel” of the space. They clearly appreciated the generous space and flexibility afforded by the design, as well as the ease of undertaking housework. Many commented on how much they liked the barrier-free layout and the levels of daylighting. The general satisfaction with the low rent levels, and a very pro-active landlord who involved the whole village in the development of the housing, may also be factors that are feeding into the high level of overall satisfaction with the scheme. Previous POE’s have highlighted how seemingly poor design can be mitigated by good management (Leaman and Bordass, 1999).

**Aesthetics. V. Comfort** – An additional dimension in the interview, not usually present in many traditional POE’s, covered tenants attitudes towards the external aesthetics of the building because of the sensitive nature of the site. This was introduced in order to discover whether or not the tenants felt comfortable with the aesthetics of the building as well as its functionality. The results would appear to imply that the aesthetics of the buildings in this case, which were felt to be relatively inappropriate to the context by the users, did not detract from the overall sense of satisfaction with the scheme. Tenants felt strongly about the “inappropriate” aesthetics externally but appeared to be quite happy to put up with them, given their satisfaction with the internal spatial qualities of the buildings. This introduces a further question of the degree to which aesthetics, or image, influences user feedback in relation to other factors such as comfort and how important it is, in itself, to the user (Leaman, 2002).

**In-depth interviewing techniques .v. surveying** - POE often involves a negotiation with the user (Watson, 2003) as well as attempts to establish absolute objective data (Leaman and Bordass, 1999). Establishing how people’s value-systems influence their perception of building performance and design quality is a subtle art compared to the hard-science of establishing physical building performance through monitoring. Surveys can be somewhat limited insofar as “closed” questions which are predefined fail to elicit “thinking out of the box” by the user, which can usefully reveal issues previously hidden to the researcher (Doidge, 2001). In-situ interviewing in groups is used in POE (Watson, 2003) as a means of eliciting additional information about how the user perceives the building. By extending this technique into an in-depth interview with individuals, which included observing individuals interact with their
environment at the same time, and triangulating the information obtained with an inspection of the buildings and drawings, a holistic appraisal was achieved which allowed the physical realities of the building to be evaluated, in some instances, against the tenants perceptions.

**Comparison with PROBE office questionnaire** – The most well know POE methodology in the UK for larger buildings is that developed under PROBE (Post Occupancy Review of Buildings and their Engineering), a government sponsored programme which ran from 1995-2002 in two phases and covered numerous buildings (the case studies were published regularly in the *Building Services Journal* during the same period). The succinct questionnaire used for these studies used scale ratings of 1-7 to establish user satisfaction levels in relation to specific questions on key building issues. Many of these issues are clearly appropriate for domestic POE, such as comfort, noise, lighting, user control. Other issues, such as work-desk area, cleanliness, and productivity are perhaps more particular to the work-place domain. The questionnaire was honed over the years to an optimum of efficiency in terms of covering the essential POE issues for large numbers of users. It attempted to elicit user comments beyond the specific questions asked, but was limited by the sheer physical size of the boxes for written answers, which were relatively small. It is arguable that the narrative structure of an interview, and its transcript, allows for greater possibilities of the user developing their own value-relationships and interrelationships, complete with “weightings” by degree of repetition and emphasis, in relation to the issues discussed.

**Cost-benefit of study** – The study was costed at £5,000, but this was an underestimate, given the amount of time required to set up the interviews with tenants and the design team, the relative inefficiency of having to adapt to participant availability and the time taken to analyse the transcripts. Here the one-to-one interview is at a distinct disadvantage to the questionnaire, which can be returned within a given period without tying up valuable research time and processed very quickly. Nevertheless, the rich data obtained in the interviews, combined with the more objective analysis of aspects of the building performance such as energy costs and maintenance, provided invaluable insights for the design team. It also revealed major surprises, such as the poor sound performance and mould growth, which emerged spontaneously from the interviews and by observation. The use of a design expert carrying out the interviews in-situ also maximised the efficiency of the POE by allowing for this multi-modal analysis to take place at the same time (environment behaviour, interview and physical observation of the building condition). Physical monitoring by contrast is both expensive (£15,000-£20,000 on average for a similar type of housing scheme) and relatively intrusive for the user. It does, however, provide the hard evidence of building performance so essential to a comprehensive POE. It would be interesting to compare the cost-benefits of the innovative methodology adopted for this study with others used for housing POE.

**LIMITATIONS**
There are a number of limitations which prevent this POE from being more than a qualitative case study and providing a statistically significant model for POE issues in relation to all-timber innovative housing in Scotland:

- lack of air-pressure testing
- lack of continuous physical monitoring
- small project size
- energy costs not separated for heating and other usage

In addition, the POE techniques adopted have certain limitations in themselves:

- need for interviewer to have experienced understanding of building performance and design quality
- time intensive
- sensitive issues need highly experienced interviewer

The above points would tend to restrict the use of in-depth interviewing to small projects, in order to obtain a relatively meaningful sample without excessive time input. The technique also relies on the interviewer having expert knowledge both in the design and building performance fields in order to meaningfully cross-relate user observations to the technical performance and design qualities of the project. In housing, some of the issues such as acoustics and thermal comfort can raise delicate issues for the household, and require a sensitive and experience interviewer to ensure the interview is relatively easeful.

**CONCLUSION**

The high level of overall tenant satisfaction with the innovative housing after two and a half years (82%) validates a design approach which placed an emphasis on the quality and size of internal space rather than spending additional money on the external appearance for the sake of aesthetics. The perception of relatively high heating costs, poor acoustics, poor temperatures and the presence of mould appears to be overridden by the high value placed by the tenants on the quality of the space inside the housing.

Nevertheless there is a clear concern over the failure of supposedly “low energy” innovative housing to deliver reduced energy costs and provide adequate comfort conditions. In particular, the increasing use of timber, with its lack of thermal mass, in housing construction must be carefully evaluated in relation to heating, ventilation and acoustic strategies. It is arguable that some sort of thermal mass should always be provided in timber construction to mitigate increasing problems of overheating in the summer months due to climate change. This could also alleviate some of the acoustic problems.
The use of all-electric storage heating should be avoided in lightweight timber construction in Highland Scotland due to its slow response to a quickly changing thermal environment with high diurnal temperature swings. The use of electricity for heating, unless it is from a renewable source, also exacerbates carbon-dioxide emissions compared to other forms of heating. It is important, particularly in housing which aims to be affordable, that capital cost saving decisions at the design stage do not sacrifice building performance and sustainability.

The POE techniques used here are replicable for small projects only, and have certain limitations, but proved very effective in studying housing performance in relation to user perception in this instance. There is considerable mileage in using in-depth interviews to obtain a “richer” description of user perceptions than normal tenant satisfaction surveys afford. On their own, however, the interviews do not verify actual building performance but they do provide a deep understanding of the tenants experience. When these interviews are combined with quantitative analysis of the actual building performance, a very complex picture emerges of tenant satisfaction being related to numerous factors with different values attached to them by the tenant. It is therefore essential that both qualitative and quantitative techniques are used to obtain a holistic POE that balances user perception and values against physical building performance.

REFERENCES


Appendix i)  Tenant Interview Guide

Interview Schedule for Kincardine O’Neil –Canmore Place

Thank you for being willing to take part in this interview. Can I assure you that you will remain completely anonymous and no records of the interview will be kept with your name on them. I will be taping this interview but the tape will be destroyed once I have made an anonymous transcript.

Section A: BASIC DETAILS  (to study occupancy patterns, fit with target group)

Can I first ask how long you have live here?
probes
-since start?

How much time do you spend in your house?
probes
-during the week
-day
-evening
-over the year

Are there any other occupants?
probes
-members of the family?
-children (ages)

How do they spend their time in the house?
probes
-go through each member

Are you working at the moment?
probes
• what
• where
• how much time
• retired

What age category do you fit into?
18-30, 30-50, 50-65, 65 +
Section B: SATISFACTION (to compare to conclusions of original 1994 study)

How satisfied are you generally with living in this house?
probes
- running costs
- rent level
- ease of maintenance

Section C: HEATING (to compare with actual heating bills and control study)

Are the heating bills in this house different from your last one?
probes
• size of last house
• type of last house
• type of heating in last house
• location of last house
• cost per week/month/year

How well does the heating system in your house perform?
probes
• comfort levels
• temperatures in all seasons
• ease of use
• responsiveness
• quality of heat

Do you ventilate your house?
probes
- when during day/season
- using what
- any problems
- air quality

Section D: FLEXIBILITY AND SPACE STANDARDS (to compare with 1994 study)

How flexible is your house in accommodating your needs?
probes
• use of moveable panels
• workspace
• visitors
- family
- acoustic privacy
- other alterations that you’ve made

How satisfactory are the room sizes?
probes
- living room
- bedrooms
- kitchen
- bathroom
- comparision with previous home

How well do you think this house could accommodate your future needs?
probes
-old age
-disability
-growing family
-shrinking family
-workspace

Section E: General (to compare with views of others, sustainability etc.)

What are the best aspects of your house?

What are the worst aspects of your house?

What are the best aspects of the housing development?

What are the worst aspects of the housing development?

How do you find the aesthetic appearance of the housing development?
probe
-compared to the rest of the village
-compared to the Deeside area

Do you use the village much?
probes
- filling station
- post office
- shops
- school
- pub
- others

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