Architects need environmental feedback

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The role of environmental feedback within architects’ offices is examined as a fundamental ingredient of sustainability. Three case study buildings are examined using a feedback exercise encompassing the whole building process from early key design decisions to occupation. Results show that sometimes design decisions are taken for aesthetic reasons without certainty on their environmental impact. Improvements are possible especially in energy consumption, glare, the usability of controls, the communication of strategies and comfort conditions. The architects report the feedback lessons relevant for their work. A systematic approach to project feedback is proposed with emphasis in feeding forward to new projects and recording decision-making. To close the information loop, briefs need explicitly to mention performance targets for energy use, management expectations, control requirements and to promote feedback itself.

Keywords: building performance, comfort, energy consumption, environmental performance, feedback, feed-forward, post-occupancy evaluation, sustainability, usability

Introduction

The following premise is tested: environmental feedback is needed in current architectural practice in order to achieve sustainable buildings that seriously fulfil their claims on both energy efficiency and the provision of adequate environments for the functions they house. The process of feedback within an architectural practice is considered through case studies, and feedback is linked back to the whole design process.

Architects rarely get involved in their projects after completion, the point when buildings start their oper-
national lives. Their prior knowledge of the original intentions is an invaluable source when it comes to judge how successful a building has been.

The use of new materials, building techniques and 'innovative' design strategies requires some measure of their performance in practice. Otherwise, they constitute theoretical myths, unsupported by results in use. The environmental impact of most buildings is not assessed after occupation. When predictions are made in the design stages, they are not necessarily checked after occupation on for corroboration of results, and improvement is thus stalled.

The designers' responsibilities of assessing the performance of their building are captured through the evaluation of three buildings in use designed by the same practice. The feedback lessons from the study are presented back to the architects and their opinion of the relevance of the lessons for future projects is evaluated by means of a questionnaire survey. Recommendations are provided for procedures throughout the building design and construction process to achieve smooth information loops that promote feedback and ultimately improve building environments.

The totality of the building process is considered from early design decisions to commissioning, occupation and feedback into new projects with the help of case studies. Figure 1 shows the stages of the overall process from which information was gathered in order to obtain as complete a picture of the building as possible.

**Precedent**

A special issue of *Building Research & Information* (2001) and subsequent Forum papers (2001a, b, 2002) presented and assessed major issues in post-occupancy evaluation (PoE) in the UK, including the major post-occupancy review study of buildings and their engineering (Probe).

Since 1995, Probe has analysed more than 20 buildings in use. The Probe studies aimed to include a cross-section of buildings, technologies and designers. However, speculative buildings were not included in its case studies due to difficulties in obtaining permissions from both owners and tenants (Cohen et al., 2001).

The top-scoring Probe buildings in terms of comfort include all three strategies: naturally ventilated, air-conditioned and mixed-mode buildings (Bordass et al., 2001). However, there is no perfect building, as Leaman and Bordass (2001) put it: 'it is unrealistic to expect everything to work well everywhere, all the time'. They advocate a 'satisficing' philosophy whereby the means are provided for good enough conditions to be experienced by allowing occupants some degree of control to alleviate and minimize discomfort.

Reviewing the implications of the Probe studies, Bordass et al. (2001) emphasized the need for questioning any preconceptions and assumptions any member of the team might have about the project. This is performed to improve communications and achieve a building well matched to the users' expectations.

Whyte and Gann (2001) suggested that PoE should develop to offer an evolutionary approach capable of taking long-term changes into account and of analysing the consequences for building developers, designers, owners and users. The basis of such a dynamic system should be a wide body of knowledge about the quality and value of design, including building performance.

Despite the editorial success of the Probe studies in improving the knowledge base of the engineering community, the team recognizes that feedback is still missing at all levels, and few architectural or engineering design practices consistently collect information on whether or not their buildings work (Bordass et al., 2001).

Why are feedback and PoE so elusive? What are the perceived barriers for feedback to take place effectively? Are the knowledge benefits not sufficient?

Jaunzens et al. (2001) found four main possible barriers:

- uncertainty in funding responsibility if clients are unwilling to pay for it
- perceived low value of the benefits gained
- breakdown of relationships as the project comes to an end
- designers’ possible liability for any problems encountered whilst carrying out PoEs

Cooper (2001) questioned not only who is responsible for commissioning PoE studies, but also who is profes-
sionally responsible for undertaking them. On one hand, it is clear that an auditor should not audit himself. However, given the nature of the feedback, previous knowledge of the brief and the building is invaluable. This serves to encourage the virtues of a self-criticizing practitioner.1

Case studies: methodology
Three buildings are presented: a glass museum (Figures 2 and 3) and two speculative offices (Figure 4).2 The designers had not made grand energy efficiency claims, but implicitly they aspired to provide environmentally sensitive solutions. However, the lessons obtained from the study, however, should be widely applicable to the practice’s normally speculative projects.

For each case study, interviews with the designers provided information on the pre-occupancy stages of the buildings. During informal interviews, designers were queried about key design decisions, which in their opinion influenced the environmental performance of their buildings, together with the development of the project during construction and commissioning.

The post-occupancy study compiled information on energy use, user comfort satisfaction and on actual conditions encountered. Available data included energy bills for a complete year, the Building Use Studies (BUS) Questionnaire survey (Leaman, 2002), visual inspection during building visits (one in summer and one in winter), and the monitoring of temperature, relative humidity and illuminance by means of HOBO3 data loggers in both summer and winter.

The lessons drawn from the pre- and post-occupancy studies were then fed back at a seminar, with the architects of the buildings included as participants. Their judgement on the relevance and applicability of the feedback was recorded by means of a questionnaire.

Pre-occupancy: design and construction
The museum key design decisions included the following:

- differentiation between the exhibition ‘black’ boxes and a glass square (Figure 5)
- use of thermally massive elements (bricks volumes and solid floor slabs) to even out temperature swings, and diverse glass facades to provide different solar control according to orientation
- aim to minimize air-conditioning and provide controls for both natural and mechanical services by means of a building energy management system (BEMS)
- promoting the use of local products throughout the construction process

Some thermal modelling was carried out to determine the impact of solar gains through horizontal glazing

Figure 2 Museum plans
Figure 3  Museum sections

Figure 4  Offices: plans and entrance view (Office 1 above, Office 2 below). Section through shading
in the glass square around the perimeter of the brick boxes. The horizontal glazing was reduced to cover only the perimeter of the glass square. The exercise was not combined with any lighting assessment and no natural light reached the centre of the building.

During construction, the client decided that a carpet finish was to be added to the massive floor throughout. This decision will affect the internal environment by decreasing the exposed thermal mass available and raising the air temperature of the interior.

Office 1 was developed a year before Office 2 for the same client. The same design team was retained for both offices. Their designs differ on the type of heating chosen (Office 1 has a heat exchanger and traditional boilers, Office 2 uses condensing boilers), and the orientation of their entrances, which was governed by the approach to the site. Although both buildings were designed to be multitenanted (Figure 6), Office 2’s main tenant was involved in the design process and continues to be closely engaged in the building management. In contrast, Office 1 tenants were not involved on the design and leave all management to the landlord.

The design of the offices focused on:

- Use of a rectangular shape to maximize the net to gross floor area ratio.

- Provision of an atrium mainly to introduce natural light into the interior of the buildings. Mechanical air extract from the offices discharges into the atrium and is taken out at plant room level.

- Careful building orientation and the provision of solar shading only to those areas that require it.

- Air supply and extract from the floor void to reduce section height. The chosen system allows a smaller floor-to-ceiling height than a fan coil system traditionally used in speculative developments at the time of design. The air-conditioning system chosen allowed three tiers of control: personal at the supply terminal device, local with the setting of zones and general at the plant overall settings.

Fit-out guides were prepared by the designers to convey to the prospective tenants the main design issues. However, these were not passed down to the tenants and hence the communication chain was broken.

Post-occupancy: environmental feedback results

Energy consumption

No specific energy targets had been set during the design of the three study buildings. Their performance is compared with published best-practice guidance. For the museum, monitored energy consumption was compared with a ten-year-old energy survey of museums (Oreszczyn et al., 1994a) and the Energy Efficiency Office recommendations for museums, galleries, libraries and churches (Department of the Environment, 1994). For the two offices, comparison was made with the latest versions of the Energy Consumption Guide 19 (DETR, 2000) and the Guide of the British Council for Offices (2000).

The museum contained a glass furnace, in use throughout the year. The gas consumed annually by this activity was estimated to be 233 kW h/m² from summer gas bills. The furnace energy consumption has been separated in Figure 7 from the museum gas consumption without the furnace (256 kW h/m²). Figure 7 compares the monitored electricity and gas consumption with the Energy Efficiency Office’s yardsticks for high- and low-energy-consuming museums. Both the museum’s gas and electricity annual consumption figures are significantly above the Energy Efficiency Office’s recommendations (gas use 38% above, electricity 45% above).

Possible reasons for the high energy consumption include miscalculations on the allocation of gas use, particularly regarding the furnace, uncontrolled settings for heating/cooling, and energy inefficiency of the building with high heat losses through air leakiness and the building fabric.

In contrast, the cost of running the museum’s energy bill (£9.3/m² without the furnace or £11.7/m² including the furnace) compares well with Oreszczyn et al.’s (1994a) survey of 43 museums with diverse servicing strategies (£9.1/m² average cost for partial air-conditioning, £7/m² average cost all types of servicing). At present, energy prices are low compared with the 1994 study.
and, for the average cost of a museum’s energy expenditure ten years ago, in 2000, a museum consumes more energy and has higher carbon emissions.

Figure 8 shows a comparison of the adjusted annual energy consumption of the two case study office buildings with both typical and good practice benchmarks for standard air-conditioned offices. The benchmark data were collected in the 1990s for the Department of the Environment Transport and the Regions (DETR). Typical values represent the median of the database and good practice figures for the lower quartile (DETR, 2000). If unadjusted energy use data is examined, Office 2 uses 16% more energy than Office 1. However, Office 2 has extended hours of operation (24 hours in two zones) and intensive energy use (a dedicated computer room and catering kitchen areas) that are not present in Office 1.
The adjusted data in Figure 8 show Office 2 performing better than Office 1 both in the use of electricity (7% below) and gas (42% below). Possible reasons for the difference in gas use between the two offices include the choice of heating system, the settings and maintenance quality. Gas use for heating compares well with the benchmark in both buildings: Office 1, 23% below typical use; and Office 2, 18% below good practice. Electricity use is high in both buildings: Office 1, 25% above typical; and Office 2, 16% above typical.

The energy metering in Office 1 could not split the energy consumption by tenancy or use. Office 2, however, had separate meters identifying tenanted and common areas. Use in common areas accounts for 40–45% of the total electricity consumption. Further assessment of electricity use in Office 2 (Table 1) allocates large items of the central plant (chiller and pumps – 28 and 8%, respectively, of the total energy use) to the common areas. A clearer and more accurate understanding of the energy use of the building would have been possible if large items of plant were metered separately.

Electricity use for lighting within Office 2 can be marked as good practice (26 kW h/m² for office lighting and 8 kW h/m² for other lighting). This is due to the use of energy-efficient luminaires rather than to the effective use of daylighting or good control of artificial lighting. Further improvements in lighting electricity use are, therefore, possible.

### Building in use

At the end of the design and construction process, the buildings received reasonable critical acclaim from the architectural profession, the offices with regards to their design and construction process (Anon., 2000), the museum in relation to its use of brickwork.
and glass (Dawson, 2000; Gonzo and Vicari, 2001), and lighting design (Sims, 2000).

Subsequently, the buildings’ users were questioned in the winter of 2002 through the use of the BUS Questionnaire (2002 version) modified to include issues relevant to the museums rather than to offices for which the questionnaire was originally designed (Carmona Andreu, 2002).

The questions sought occupants’ rating on a seven-point scale of various design and environmental parameters. Figures 9–14 show the mean responses for the monitored buildings. Responses to the environmental questions were compared with the BUS database benchmark and, in the case of Office 2, with an exemplar building.

Results from the questionnaire surveys indicated that users appreciated the overall building design and image (Figures 9 and 10). The greatest disappointment came on the storage provision in the museum, which was considered to be very inadequate by museum users.

Figure 9 Museum: mean staff impressions on design features

Figure 10 Office 2: mean users’ impressions on design features

Figure 11 Museum: mean staff impressions on comfort and comparison with the BUS benchmark

Figure 12 Museum: mean staff impressions on controls and comparison with the BUS benchmark

Figure 13 Office 2: mean users’ impressions on comfort and comparison with the BUS benchmark and the Elizabeth Fry building

Figure 14 Office 2: mean users’ impressions on controls and comparison with the BUS benchmark and the Elizabeth Fry building
staff. The facilities of the workshop areas and the general use of space were also criticized.

The environmental performance of the case study buildings was compared with the BUS benchmark (Figures 11–14).9

The museum provided comfortable conditions overall and in terms of temperature and air quality, especially in winter. However, it presented problems with contrast glare from both natural and artificial lighting (Figure 15). Although the users perceived the level of controls over the various environmental variables as low, it seems to be the typical scenario as the comparison with the BUS benchmark indicates. However, the perceived control over ventilation and lighting was significantly lower.

Figure 16 shows the recorded light levels, through two cross-sections of the buildings, during a summer visit under clear conditions at 14.00–15.00 hours (August 2001). Very low lighting levels can be seen in the core of the building, which would explain the high contrast glare conditions witnessed.

The original design intention was to include centrally located roof lights, but as the design developed, these were omitted to avoid solar gains and to reduce costs. The use of tools to predict daylight levels in the building during the design phase could have provided a clearer understanding of the design options.

The results from the Office 2 questionnaire survey suggest that this building was typical of air-conditioned buildings, with overall comfort variables around the BUS benchmark. For comparison with a salient building, data for the Elizabeth Fry building (Probe Team, 1998)10 has also been included in Figures 13 and 14. Occupants’ perception of the environmental controls was consistently below the BUS benchmark and they pointed towards the following vicious circle found in operating a system with poor controls. Both offices have fan tile units (Figure 17) as terminal supply devices, which can provide a high degree of local environmental control. They are recessed on the floor void and are in the personal control of the users. Both the temperature and velocity of the air supply can be altered. However, the occupants get frustrated with the fan tile units and switch them off; later, they forget they had done so and complain of being either too hot or too cold. Figure 18 shows the instructions provided by the manufacturer to one of the tenants in Office 1. Even with the instructions, many occupants would be confused and subsequent discussion with the users of both offices suggested that the main mechanism for controlling these units was simply the clearly labelled on/off switch.

The designers’ expectations in terms of the flexibility of conditions provided by the control system have not materialized at various levels. Not only do the occupants have problems controlling the system locally, but also there have been difficulties in fully commissioning the systems, as the control software for the plant room unit was not provided in full. Maintenance staff at Office 1 still cannot alter the settings either for time or for temperature some four years after completion.

In both case study offices, electric lighting is controlled via remote controls at each column position. However, occupants were unhappy with this method of light switching because the control units would be frequently moved from the columns to people’s desks. Each 9-m bay is switched independently. At the perimeter, this level of control is not sufficient as it results in lights being left on for users in the deeper zone, whilst there is more than sufficient daylight at the perimeter (Figure 19). Retrofitting controls is expensive and disruptive, whereas including separate perimeter switching during the building design stage improves the energy efficiency of the installation at a small cost.

**Monitored environmental conditions**

Air temperature, relative humidity and light levels conditions were monitored in four locations...
in the museum and in two locations in each of the office buildings for one month in summer and winter.

Internal conditions recorded in the museum were variable and followed regular patterns matching the cycles of both solar gains and internal heat gains. The exception being the air-conditioned exhibition space, where the temperature only varied by $\pm 5\%$.

A large variation in relative humidity (25–30 to 60–65\%) was recorded both in the mechanically ventilated and in the air-conditioned exhibition spaces (Figure 20), whereas objects from a mixed
collection on display ideally require a relative humidity of 40–60% (Blades, 2002). Therefore, conservation of the objects is heavily dependent on the environmental control provided by the display cases.

The average temperatures logged at the office buildings stayed within the comfort set design conditions (22 ± 2°C), and differences of internal conditions between the two buildings or the various tenancies resulted from the preferred conditioning settings entered at plant level.

Feeding forward

Results from the above case studies with the following environmental lessons were presented back to the architects. Some of the lessons were of a general nature, whereas others referred more specifically to the building type.

General lessons

- ‘Good’ design image does not equate to good environmental performance of buildings. The buildings scored well in the occupant surveys on design image, but presented problems with environmental issues.

- Aesthetic design decisions have complex environmental consequences that need to be understood, e.g. the choice of the ‘black box’ strategy for the museum cuts off unwanted solar heat gains and sunlight on display objects, but it makes constant artificial lighting necessary, which in turn increases cooling loads.

- Design changes can have more than one environmental consequence and predictive computer simulations often focus on one aspect of design to the detriment to others. For example, thermal performance models do not look at lighting levels. A holistic evaluation of environmental performance is therefore recommended.

- Complex control systems are difficult to use properly – the central management systems used complex software and user training was difficult. Simple local control systems also need to be foolproof and accessible to avoid occupants resorting simply to using them as on–off controls.

- Success of the environmental design can depend on how the organization occupying the building is managed. The style of management used influences the flow of information, which can vary from the straightforward as in the museum to the over complex communication chain apparent in Office 1. However, buildings are not designed with a specific management style in mind.

- In all three cases, there was little follow through communication between designers and end users. For both offices, tenant fit-out guides were prepared, but the landlord did not pass them to the tenants!

All three buildings used more energy than good practice levels. Design targets were not set. Nor did users set any consumption targets either.

Lessons from the museum study

- Low temperatures in winter helped to keep the relative humidity high within the exhibition areas.

- No active relative humidity control to overcome short time fluctuations in relative humidity – exhibition cases are therefore required to provide relative humidity stabilization, and any failure in their design or fit-out will lead to instability. A more robust approach may use the building fabric to buffer conditions and stabilize relative humidity (Oreszczyn et al., 1994b).

- Lighting levels were low but electricity consumption high, with lights on all the time. Increased electric lighting would reduce contrast glare but would
further increase energy consumption. The full environmental implications of design changes, such as the omission of roof lights, need to be predicted with confidence and communicated to clients.

- BEMS is under used – no clear monitoring and targeting is currently in place. Control settings are not fine tuned. The BEMS installers are more interested in setting up energy management contracts and thus directly benefiting from the savings made by using the system properly than in providing training to the building users.

- Submetering would help to quantify the energy cost of large consumers such as the furnace. It would also clarify the power used for ventilation and cooling and provide some markers for possible savings. In addition, it would allow the comparison of energy consumption by standard buildings services between museum buildings.

- Published energy data for this type of building require updating.

- Building design could have promoted energy efficiency further by carefully considering the insulation and thermal mass needs, thus minimizing heat losses; and by setting close control of ventilation, it would avoid clear air paths and ensure an airtight construction.

- Material detailing followed predominantly aesthetic rather than environmental reasons. The glass square corner details present a three-dimensional fine joint of three single glazed panes, exactly where heat losses are greatest. Such decisions might be justifiable on aesthetic grounds, but the physical and environmental consequences are often not considered fully.

**Lessons from the study of Offices 1 and 2**

- Metering the large energy consumers separately will help to monitor wasteful use and suggest possibilities for improvement. Large items of plant (chiller, pumps, boilers) are included in common metered areas. Time settings and controls remain within the control of the general building management. Tenants are charged proportionally to their rented areas, not to their demand. Hence, there is little motivation to reduce the energy cost.

- Glare from both natural and artificial lighting led to a ‘lights on, blinds down’ scenario.

- With the blinds up, lights remained on around the perimeter of the buildings, questioning the efficiency of the artificial lighting manual controls. A separate, daylight-linked automatic controlled perimeter zone extending to a depth equal to floor-to-ceiling height is suggested as a design alternative. Tenants are reluctant to retrofit additional zone controls and switches because of costs, whereas the cost of these controls would be minimal if considered at the design stage.

- Remote control light switching proved unpopular because moveable controls positioned on columns went missing.

- Potential flexibility of environmental control by the three-tiered air-conditioning system has not yet materialized. This appears to result from a lack of clarity at the commissioning stage, varying maintenance support and frustrating controls at the point of use. Flexibility will be put to the test even further when fitting out for new tenants takes place.

- A clear method of communicating design intentions through a long chain of management is required. Designers cannot control the environmental performance of their buildings unless users understand the modes of operation of the building. Possible methods include logbooks, as required by the new part L2 document (DoE, 2000), and presentations by the designers directly to the users of the building operation strategies.

- Flexibility in the future with little control over the pattern of use points towards the need to design more robust buildings capable of withstanding a greater variety of conditions. This is likely to be pushed more by strong design attitudes than to be led by developer clients, but it certainly implies a general responsibility on the designer’s side towards the use of energy within buildings and ultimately towards the sustainability of the environment.

**Architect’s reception to the study**

The value of environmental feedback for architects was investigated during an in-house seminar held at the design office where the buildings were designed. The feedback lessons from the three case studies were presented at this seminar. A questionnaire survey (Carmona Andreu, 2002, appendix A10) assessed the views of the audience on the following areas:

- advantages and disadvantages of feedback

- relevance of the information presented for their work

- reasons for commissioning a feedback study

- acceptable cost of feedback studies
The questionnaire sample was small (20 attendees), but the response rate was high (85%). As attendance was voluntary, the attendees should be assumed to have been self-selecting and interested in the topic. Thus, 16 out of 17 respondents believed that feedback was necessary. Nine people believed there were no disadvantages to feedback; five, however, mentioned time and cost as problems, and only one was worried that it might curtail design freedom.

Feedback advantages mentioned included improvement of future designs and informing new briefs, assessing building performance, getting user design input, and providing a basis for discussing comfort with clients at an early stage.

All the feedback lessons presented at the seminar were relevant to the designers’ work, with emphasis on the occupant comfort and energy use issues, followed by the key design decisions (Figure 21). Management issues and considerations on the feedback process were the least relevant.

Attendees were asked to rate, on a scale of one to ten, a series of reasons for commissioning feedback and to suggest any additional reasons not listed. Figure 22 shows the ratings in descending order of importance. Improving future briefs was rated as the most important reason, followed closely by improving design solutions and obtaining information on the sustainability/environmental performance of the project. Surprisingly, providing good marketing and strengthening the client relationship were considered less important reasons for feedback. This result is optimistic as it indicates that providing a product that performs well environmentally is important to designers.

The questionnaire asked respondents to rate the cost, ease of justification and the value of feedback if a typical survey of this type were to cost around £10 000 for a building costing £10 million to build, i.e. 0.1% of construction cost (Bennetts, 1998) (Figure 23). Although it was found that it would be money well spent and even on the low side, the expense does not seem easy to justify. The main drawback as pointed out by Cooper (2001) is one of ownership of the cost. When a feedback study is done two or three years later, the project budget is no longer available and, for designers, non-project allocated time is a clear overhead. Since the benefits are mostly for improved design and knowledge acquisition for new buildings, it should be possible to link this type of case study to the beginning of projects rather than to the end, with a clear perspective on closing the feedback loop and implementing its lessons.

**Feed forward process**

The link between each of the stages of a building life is a continuous line of communication, which includes all aspects of the building from the original design intention to construction anecdotes, to understanding the way the building is used and to
covering lessons to be taken up by other projects (Figure 1).

Lawrence et al. (1998) gave a wide definition of feedback:

in its simplest form, feedback is a means of learning from experience by carrying out the processes of reflection and deduction.

In the construction industry, which is a project-based culture, lessons can be learned not only after completion of a project, but also throughout its development, forming a cycle of continuous improvement.

Sharing knowledge is of paramount importance to achieve good quality buildings. Intranets and databases are becoming common practice in large architecture firms and in-house personal levels of expertise in concept design, technical (including environmental) matters and diverse building types are shared between projects. They form the infrastructure of a rich knowledge base for all to use. Workshops at different stages of projects are used as a means to discuss key issues, aims and aspirations. However, there is little record of the decision-making process. Personal memories can be unreliable as they focus on individuals who do not always have continuous involvement in a project or process.

Guidance on the type of information to be collected, the methodology to be used and the appropriate time scales is required for feedback to be effective. Currently, the end of the defects liability period is seen as the most likely time such a study would take place, as designers need to revisit the building in any case. The first 12 months of operation have also been suggested as the time when some contractual obligation might be set to prove a building’s performance (Jaunzens et al., 2001).

Conclusions

Lessons from feedback studies were obtained and fed back to architects with encouraging results. Architects found the information presented relevant to their work. Their main interest in feedback was so they could improve future briefs, achieving better design solutions and checking the sustainability of designs.

The success of any feedback study relies on the quality of data gathered.

With a view to carrying out objective feedback in future, briefs should mention not only spatial design aspirations, but also the following:

- energy targets designated by fuel type
- management structures expected in operating the building
- degree of control and automatism
- information requirements at different stages: from simulations to commissioning and building logbook
- requirement for feedback itself

For the decision-making stages, it would be preferable to record design intentions and the expected performance of systems specified, and to monitor any changes of the design or construction.

The study showed that design decisions have an impact on the environmental performance of buildings, but their consequences are not necessarily considered fully during the project development. This results in missed opportunities (e.g. using the thermal mass in the museum to provide a better environmental control layer) or design changes (e.g. increased plan depth without natural daylight) that reduce the energy efficiency of buildings.

Advice on environmental issues therefore seems relevant throughout the whole project, from the very first design concept to final commissioning, and beyond into the building’s life in use, when actual performance efficiency becomes apparent. Architects need either to increase their awareness on such issues themselves or to seek expert advice as early as possible. Most significantly, architects will lack confidence of providing sustainable solutions if no practical corroboration can be made of their sustainability claims.

Figure 24 proposes a continuous loop of activities that should take place at each stage to promote ever-improving solutions. It starts with a feedback study of the type carried out for the case studies presented herein.

The success of any such continuous improvement programme relies on its capability to maintain the level of interest of all the participants on the process. As Bordass et al. (2001) put it:

from the client elaborating the brief to sustained management in use, a successful building needs the interest and the dedication of all the participants in the development.

For architects, this equates to recording the decisions they make clearly and a willingness to know the consequences of such decisions in practice.
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References

Figure 24 Schematic diagram of a continuous improvement programme for design. Key participants are highlighted in parentheses: De = designer, reflecting the person(s) within the firm in charge of the project; Exp = expert person(s) on the building type or technology; Cl = client; U = building user. The letters inside the circles refer to RIBA Plan of Work stages.

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Endnotes


2 The case study buildings by Reid Architecture had been in use for at least two years. All the data were collected as part of an MSc dissertation project (Carmona Andreu, 2002).

3 HOBO H8 Family of data loggers (available at http://www.onsetcomp.com).

4 Summer time monthly gas consumption of museum = 83 333 kWh. Estimated glass furnace annual gas consumption/m² = 83 333 kWh/month × 12 months/4286 m² (treated floor area of museum) = 233.32 kW h/m²/year.

5 Offices’ data were adjusted to account for weather, occupancy and special uses (computer room and catering) following the Energy Assessment Reporting Methodology (EARM) Stage 2 (Field et al., 1998).

6 The ECON 19 (2000) database contains data from 200 office buildings and includes both refurbished and newly built offices.

7 Further analysis followed EARM Stage 3, assessing electricity use from specification, drawings and observation during the building visit. However, no reconciliation was possible with typical day and night demands. Typical annual equivalent hours of full load operation were taken as 1000 hours for chillers and 3700 hours for pumps (DoE and Welsh Office, 2002, ADL2 Appendix G).

8 Questionnaires were distributed amongst all regular users of the buildings, which in the case of the museum excluded visitors.

9 The BUS benchmark gives the mean of the last 50 buildings surveyed using the questionnaire, e.g. Probe building studies, and therefore gives a comparison with ‘typical’ buildings.

10 Although Elizabeth Fry is not an office building, the published BUS survey on the Elizabeth Fry Probe concentrated on the responses of the office staff, which are therefore comparable with the BUS benchmark (Probe Team, 1998).

11 Stage M (Feedback) is no longer described in RIBA (1999) or RIBA (2000), but is described in Lupton (2000). Feedback activities are discussed by Halliday (2000, Stage L).