PROBE STRATEGIC REVIEW 1999

FINAL REPORT 1: Review of the Probe process

A confidential report to DETR

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REPORT 1: Review of the Probe process

Final report to DETR

by

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Executive Summary

From 1995 to 1998, the Probe project (Post-occupancy Review Of Buildings and their Engineering) undertook and individually published surveys of sixteen recently-completed buildings, together with a range of introductory and overview reports. The project was jointly funded by Building Services Journal (BSJ) and DETR, under their Partners in Technology programme. A further Probe project has recently been approved under DETR's Partners in Innovation scheme.

This report outlines the techniques used to set up, undertake and report the projects, and to turn the results into readable articles in BSJ. It looks at the nine key steps of the process from inception to production of the published article; and including the core technical and energy surveys, occupant surveys and air leakage pressure tests. It outlines how each was undertaken; how they were honed to permit robust and insightful results to be obtained with a limited budget; and how they might be further improved in consistency, quality and cost-effectiveness of post-occupancy surveys in future.

The Probe process was pioneered and developed by highly experienced surveyors. As it matures it needs to become more standardised, lending itself better to procedures that could be documented and followed by other suitably qualified professionals given appropriate training and possibly accreditation. This would allow Probe-like POEs to become a mainstream activity for the UK property industry, with consequent improvements in building performance, occupant satisfaction (and hence productivity), environmental impact and energy efficiency.

A standard resource pack to document the appraisal and performance data on the building is potentially a powerful concept that might become a standard good practice tool for facilities managers. It has many potential characteristics of the building log book, which many people have suggested might be introduced within the new Building Regulations.

The Probe process and the articles in BSJ have captured the interest of the building services industry. It is now vital to secure the full potential benefits from feedback by engaging all the other main players in the UK building industry. There are many lessons here that can be exploited both for undertaking all types of post occupancy evaluation or feedback exercises for the benefit of the occupier, the client, the designer; and for the industry as a whole to learn from the results. The need for such feedback has become particularly important with the Egan initiative to improve the performance of the building industry and its products; the Kyoto protocol to reduce greenhouse gas emissions; and other drivers to improve technical, economic and environmental performance, together with occupant satisfaction and productivity.

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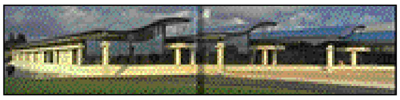
#1 TAN Tanfield House

#2 ALD 1 Aldermanbury Square

#3 C&G Cheltenham and Gloucester

#4 DMQ De Montfort Queen's Building

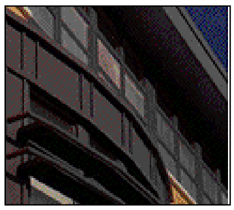


#5 C&W Cable and Wireless

Probe 1 and 2 buildings with article sequence numbers

#6 WMC Woodhouse Medical Centre

#7 HFS Homeowner's Friendly Society



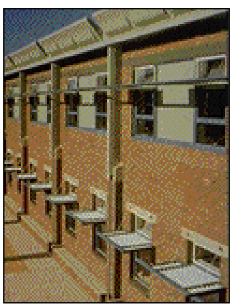
#8 APU Anglia Polytechnic University Queen's Building

#11 CAB John Cabot CTC

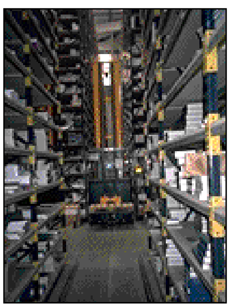
#12 RMC Rotherham Magistrates' Courts

#13 CAF Charities Aid Foundation

#14 FRY The Elizabeth Fry Building



#16 MBO Marston Books Office



#16 MBW Marston Books Warehouse

#17 CRS Co-operative Retail Society

#18 POR The Portland Building

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1. Introduction

1.1 Background and Objectives

Probe has been internationally acknowledged as a successful way of undertaking and reporting post-occupancy evaluations (POEs) of buildings quickly and reliably. The relatively small budgets for the survey team - typically 20 person-days per building from inception of project to completion of the technical report - have encouraged improvements in efficiency and productivity. The public exposure of the results has also required the Probe team to maintain diligent standards of quality control.

This is a review of the researchers' experience of the project, with all its opportunities and pitfalls. It:

- explains the techniques, especially how they have been honed to permit robust results to be obtained with limited resources;
- considers how the approach could be further improved for future application;
- identifies which aspects might be usefully be applied to general building POEs for designers, occupiers or researchers (e.g. BRECSU case studies); and
- explores how such techniques might be packaged.

Ultimately we think that post-occupancy evaluation and benchmarking should become a standard follow-up to the design and construction of all new buildings, and the alteration and enhancement of existing buildings. The lessons learned from Probe may help to identify how these ends can be met more effectively and efficiently. Appendix A gives a full list of Probe publications.

1.2 The history of the method

1.2.1 The process for Probe 1

The original purpose of Probe was to provide lively, informative reports in Building Services Journal (BSJ) on the actual performance of recently occupied buildings of sufficient potential interest to the readership to have been written-up in the Journal at the time of their completion. It was intended to stimulate building services engineers (and other design professionals) to develop better designs, with the benefit of the feedback obtained.

This ambitious objective could only be achieved if the methods used to produce the reports had sufficient rigour and credibility. Since Probe was intended to provide feedback and not to develop new analysis tools, the methods employed needed to be standardised, and make use of existing techniques and benchmarks where possible.

The original proposal therefore incorporated two existing tools:

- The occupant survey method developed by Building Use Studies (BUS©) to gauge the levels of occupant satisfaction with internal conditions, their control and management.
- The Energy Assessment and Reporting Method (EARM™) in the form of the prototype Office Assessment Method (OAM) for the analysis of energy use in each building.

Both had the benefit of a long and respectable pedigree. The BUS method, and critically the questions on the 2-page questionnaire developed for Probe, had evolved from studies undertaken by BUS to investigate sick building syndrome during the 1980s. These were subsequently reviewed and developed by BUS under contract to BRE, and incorporated in standard procedures[1]. The EARM™ OAM was derived from early analysis work by the London Energy Group, developed and implemented in Excel spreadsheets by LEG's ex-chairman and Probe team member Bill Bordass when undertaking office energy surveys and case studies, and completed by contractors to BRE as part of two projects under DETR's EnREI and PiT programmes. It has just been published in CIBSE's Technical Memorandum TM22 and also makes extensive use of related energy performance indicators such as those published in DETR's ECON 19[2].

The process employed on the first eight buildings has already been documented for the Probe 1 review conference[3] in February 1997, reproduced in Appendix B. The flowchart in Figure 1.1 illustrates the systematic approach of the technical review, how the occupant survey and energy analysis were incorporated, the roles of the team members, and other details.

The original project budget for Probe 1 did not permit the OAM technique to be applied in full, and BUS occupant surveys were only planned for two or three buildings. However, once the project was approved, the team argued that the value of the exercise would be limited unless such methods were used routinely and consistently. For the first Probe building (Tanfield House), the team therefore decided to attempt to use both the OAM and a much-shortened version of the BUS occupant survey. When the outcome proved successful, additional funding was secured to enable these techniques to be used on all the buildings.

1.2.2 Availability of background information for Probe 1

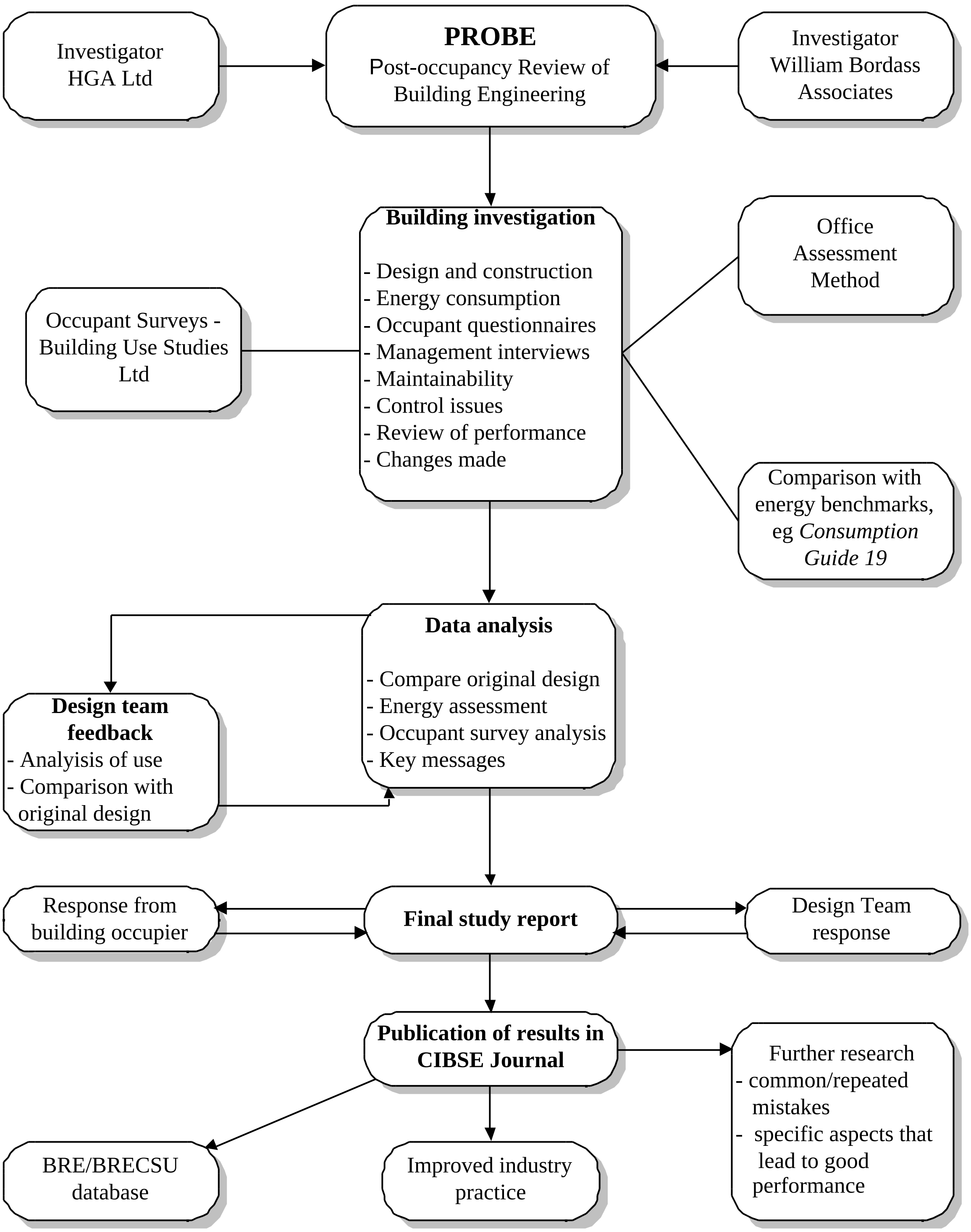
To streamline the POE procedure, one needs as much information as possible before going to the building. Armed with some understanding of the project, A4 copies of floor plans for making notes on, and if possible some knowledge of the pattern of operation of the building and its level of energy use, the first visit can be much more efficient and effective.

For Probe 1, it was first assumed that the original article in BSJ and the associated project files would afford sufficient background on the building and its services. WBA's experience with BRECSU office case studies and other projects, however, indicated that a preliminary questionnaire improved the speed and efficiency of initial data collection. The standard of completion of the questionnaire also turned out to be a useful indicator of the information and co-operation likely to be obtained from the building's management: organisations not able to fill in a questionnaire after three reminders were unlikely to provide adequate support to a surveyor, or to be running an energy-efficient building!

For the first Probe (Tanfield House), only energy data were requested before the first visit, and the team took outline questionnaire forms including a laptop-based version to test their utility in structuring the survey process. Here they found that:

- The information from BSJ files was comprehensive and helpful. However, experience with later Probes revealed that the original reviewer of Tanfield had been unusually thorough in his record keeping. All the original files were then lost when BSJ's archives were destroyed by the Docklands bomb.
- The management provided all the information requested quickly, efficiently and comprehensively from their computers, files and archives
- The engineering staff were also diligent in collecting new data for us, for example, on plant ratings and utilisation, water and energy consumption, steam use and BMS trend logging.

FIGURE 1.1 Outline of the process used in Probe 1



On the Tanfield visit, the information on the building, its use and its systems arrived so rapidly and from so many directions that any attempt to force it into the standard form required by hand or computer-implemented questionnaires was impractical. The Probe team therefore decided that a special initial questionnaire would not be necessary and that a computer-based site data collection process would not be practical. Some information was however collected before and during site visits to subsequent buildings on the draft EARM-OAM forms then available.

While most of the Probe 1 buildings did supply good background information, there were a few problems and ad hoc questionnaires were sometimes used, as follows:

- One Aldermanbury Square. Data were not readily to hand, but this was thought to be because the building was speculative and had been empty for more than a year before being occupied.
- Cheltenham & Gloucester. The building's management and the corporate energy team were good at providing the required information.
- de Montfort had been subject to independent monitoring. This and a range of articles and papers on the design provided substantial background details.
- The main contact at Cable & Wireless was via the Clerk of Works, who was more familiar with the structure of the building than its operation and servicing, for which ad hoc preliminary questionnaires had to be used. It is usually best to have initial contact with a senior member of the occupier's staff, and one who has the authority to get things done and to approve the final article.
- Woodhouse Medical Centre was a small, relatively simple building for which information was easily collected on site.
- At HFS, the time for the survey was very limited. WBA therefore used a standard questionnaire of their own.
- APU had been independently monitored by a researcher who was still on site, and so did not receive and had less need of a preliminary questionnaire.

1.2.3 Revisions to initial data collection for Probe 2

Several significant improvements were made to the process:

1. To avoid the difficulties encountered in obtaining basic background data for some of the Probe 1 buildings, a pre-visit questionnaire (PVQ) was routinely used in Probe 2. This was developed from previous questionnaires which had been designed and used by team members; and was comprehensive, clearly structured and attractively laid out.
2. Problems with airtightness had been found in several Probe 1 buildings, affecting occupant comfort and energy performance. Team members could detect problems using smoke pencils; and HFS had already been pressure-tested when it had proved difficult to maintain the desired environmental conditions. BRE, BSRIA and CIBSE had already been drawing attention to such problems. Probe 2 offered the opportunity to benchmark performance of the buildings surveyed, and raise awareness across the building services industry. Seven of the eight Probe 2 buildings were pressure tested by either BSRIA or BRE, again using established techniques. At CAF, the occupiers were unable to obtain permission from their landlord.
3. Widespread concern about growing water use in the UK, reinforced by the shortages in the dry weather of 1995 and 1996, led to water usage efficiency being included. Here Probe hoped to raise awareness of water consumption, benchmarks, and improved metering amongst designers and managers of buildings.
4. A subtle change was made to the meaning of the Probe acronym, from Post-occupancy Review Of Building Engineering, to Post-occupancy Review Of Buildings and their Engineering. Probe 1 had actually done this anyway, but explicit recognition of the change helped to engage a wider audience; and articles about and referring to Probe have appeared in the architectural and facilities management press.

1.3 Audience for this review

There is a big difference between reporting feedback in the public domain for a wider readership and identifying specific aspects of the performance of a certain building for the building occupier and/or its design team. The main thrust of the analysis may be similar, but the presentation, delivery and follow-up of the findings will be different.

Probe 1 and 2 were intended to give feedback to the design community. The reported findings were thus more of general interest than of specific use to the building occupier – who will often require more detailed and "tactical" advice. For example, pointing out that a design detail such as a window opening mechanism does not suit users is of little practical use to the occupier (who probably knows this already and may or may not have been able to do anything about it) but is very useful feedback to designers of future buildings. The occupier or user is more interested in effective intervention and coping strategies in the circumstances; while the designer wants to know how to produce effective results within constraints both seen and unseen. This difference is addressed in sections 4 and 5, which discuss the applicability of the Probe process to POEs with a variety of different objectives.

2. Overview of the Probe 2 process

2.1 The existing stages

The nine key stages of the Probe process and their component parts are listed in Table 2.1, which also identifies the team member responsible for each. The stages are roughly chronological, although the order of completing EARM, the occupant survey and the pressure test can vary.

2.2 Helpful and difficult experiences during each study

For each of these nine key stages, Table 2.2 identifies those study buildings in which the required tasks proved either particularly easy or particularly difficult. Table 2.3 lists things which went particularly well, and those which caused particular difficulties in each of these stages.

TABLE 2.1 The nine key stages of the Probe process

Stage	Activity	By whom
1.	Access for Probe study	BSJ
2.	The pre-visit questionnaire (PVQ) · Issue to host and seek return prior to first site visit	HG or WBA
3.	The first site visit · Pre-visit assessment (Equivalent to EARM Stage 1) · Seek approval for occupant survey questions and provide point of contact for BUS liaison. Consider best way of sampling occupants and whether additional questions should be added on special features of the building or its operation. · Seek approval for other tests - e.g. pressure test. · Review data from the first site visit - usually includes analysis of utility bills and half-hourly data if available. · Write descriptive sections of the draft final report	HG or WBA
4.	The second site visit · Prepare pre-visit check list of gaps in knowledge, etc. · Organise appointments with necessary host staff · Site visit structured around check list · Review of second site visit data - which usually includes production of stage 3 EARM	HG and WBA
5.	The BUS Occupant Survey · Confirm arrangements and samples to be taken · Adapt questionnaire if necessary and seek approval · Prepare questionnaires, etc. · Undertake survey · Enter and analyse data · Produce draft occupant survey report for comment by Probe team · Complete report	BUS
6.	Use of EARM · Build up Stage 3 analysis spreadsheet · Seek additional data (e.g. on second site visit) · Produce final electricity breakdown and graphics	HG or WBA
7.	The pressure test · Obtain pre-test information (access details, scaled elevations, etc.) · Agree programme with host and attendance during unoccupied periods (nights and weekends) · On -site test · Report results	BRE
8.	The Probe report · Write draft technical report · Produce final occupant survey report and integrate key points into technical report · Issue draft report, occupant survey report and EARM stage 3 spreadsheet and graphs to host for comment · Manage comments from host and Probe team · Write executive summary (surrogate article). This was tried for the last building in Probe 2 – the Portland Building	HG or WBA
9.	BSJ Probe article · Produce draft article · Issue draft article to Probe Team and building M&E designers for comment, and to building host for comment and approval to publish. · Incorporate comments into final article · Prepare diagrams for article in parallel · Incorporate designer feedback into final article · Publish article	BSJ

TABLE 2.2 Study buildings notable for being particularly easy or difficult for each of the nine stages of the process

Stage		Especially helpful	Particularly difficult
1.	Access for Probe study	TAN: Enthusiastic and knowledgeable owner-occupier. MBO: Good support from occupier and landlord.	C&W: Initial contact via Clerk of Works, not occupiers. CAF: Landlord less interested than the occupier.
2.	The PVQ (or equivalent by interview)	TAN: Really good data in BSJ files and from host. C&G: Knowledgeable site staff. MBO: Base data collected by HG for previous ETSU project.	ALD: Some information patchy in this speculative building. Original BSJ article less comprehensive than most (due to focus on ice storage). CRS: took a long time to complete PVQ.
3.	The first site visit	TAN: Alan Jerome who had procured and was now responsible for managing the building. FRY: Enthusiastic contact in host's estates department CAF: Tenant had arranged for landlord and maintenance contractor to be present.	POR: Support from estates department was limited (as had been their involvement during the design of the building), so site surveys started alone, or with caretaker. Fortunately a knowledgeable teaching staff member came forward and provided considerable assistance. CAF: this proved to be the sole audience the landlord and maintenance contractor were prepared to give. Not possible to extract maximum value on this single occasion owing to information overload, and lack of awareness at the time that this would be the only opportunity for contact.
4.	The second site visit	TAN: the site engineers had assembled vast amounts of good data in response to our initial queries. FRY: accompanied by knowledgeable elec engineer all day. HFS: Hot weather permitted plant to be checked and electrical consumption measured on a design day.	POR: accompanied by porter CAF: access not permitted by landlord to plant rooms and maintenance contractor's data and meter readings. Needed to arrange for host to seek and take additional readings.
5.	The BUS Occupant Survey	Occupant surveys were successfully completed on all 15 sites.	FRY: Owing to survey fatigue, a departmental secretary insisted on distributing and collecting the questionnaires herself, rather than allowing BUS to do it. Response rates were still good! C&G: did not permit productivity question (pity: as on the basis of the other data the results are thought likely to have been good)
6.	Use of EARM	C&G: central energy management group provided comprehensive energy data on disc which was a delight to analyse comprehensively.	ALD: HG first building, WBA didn't visit it, HG focused on ice storage. C&W: could not reconcile electricity spreadsheet; gas consumption unfathomable without fortuitous manual meter readings by maintenance staff
7.	The Pressure Test	FRY: were able to compare handover test result with occupied test result.	POR: blocking displacement vents in lecture theatre, loss of pressure for reasons unclear RMC: only part of building could be tested and envelope area difficult to calculate. CAF: Not permitted. All: BRE & BSRIA use different standard for air leakage index. Concern about relevant area measurement.
8.	The Probe report	HFS: Relatively small building. Quite efficiently produced as the last project in Probe 1 without the additional burdens of Probe 2 (e.g. more tasks, more severe QA, poorer energy data).	CAF: Took a long time to verify facts and write a fair report in the absence of supporting information from the landlord and maintenance contractor. MBO: Essentially describing two distinctly different buildings. MBW: Little information on gas consumption, particularly in cold weather when the majority of the warehouse's gas consumption occurs.
9.	BSJ Probe article	TAN: Pilot study with additional time available for analysis and presentation. POR: Executive summary smoothed article production	APU: major controversy about fairness of findings. C&W: Missing data. Limited occupier support as the host had given the responsibility for liaison with Probe to their clerk of works, who knew much more about the building than the occupier. FRY: Termodeck advert placed at the end of the article brought its objectivity into question.

TABLE 2.3 Aspects of each study notable as being particularly helpful or difficult

Short name	Especially helpful	Particularly difficult
Tanfield	Excellent information from hosts on procurement method, energy consumption, and data from BEMS. Good reference file in BSJ archives.	The first Probe and a large building a long way away.
Aldermanbury	Completion of a satisfactory Probe would not have been possible without the original Building Services Article.	Lack of clear information in this speculative building. Ice storage proved difficult to analyse and stole time from other activities.
C&G	Good initial support from facilities and energy management team. Excellent energy data including half-hourly metering.	FM staff patience began to wear thin on the second visit, making detailed analysis of computer room cooling systems difficult. Canary Wharf bomb destroyed Building Services archive material for this and subsequent Probe 1s.
de Montfort	HG familiarity with building from other projects and site visits. Loughborough student helped with energy data collection	Integration of independently monitored data owing to differences in conventions and cross-checking procedures.
C&W	Liaison with Clerk of Works enabled more information on construction and handover to be gleaned than usual.	CoW less aware of building services and requirements and comments of building occupants. Lack of sub-metering for three separate facilities on site (teaching, leisure centre with swimming pool and residential). Gas meter faulty. Uncertain power of telecom transmitter. Architects were unhappy that the low-energy claims were not supported by the measured data.
Woodhouse	Sub-meters for both gas and electricity for each of the 3 practices. Enthusiasm for low energy design from original procurer. Small size enabled single site visit.	
HFS	Assistance given in checking system operation via the BMS. Electrician in attendance for spot metering and demand profile recording by team.	Interpreting performance correctly (resolved by identification of previous air leakage survey and use of portable electrical demand profile recorder on second visit to provide checks).
APU	EC 2000 monitoring provided evidence survey would not have uncovered other than indirectly through occupant survey comments, e.g. night venting not working. Research student undertaking the monitoring knew more about energy aspects of building than Estates Division staff.	Changes in construction (design and build) and use from design intent. Reporting occupant survey with two different groups of building users: staff (some in spaces originally intended for students) and students (small numbers). Limited support from Estates Division. Designers unhappy with the way in which Probe had reported the project.
Cabot	Very helpful administrative manager.	Occupant numbers increasing annually with new class intakes meant we were not looking at past building performance with full complement of staff and students.
RMC	Chief engineer helpful.	Many constituencies of building users: not all could be included in occupant surveys. Admin/facilities manager knew relatively little about the building or its services; delegated liaison with Probe to engineers.
CAF	Support from the occupier and architect.	Developer and maintenance contractor not able to provide the time and information necessary to support the investigation. This increased the riskiness of the survey and the time taken to obtain robust results.
Elizabeth Fry	Estates Manager’s intimate knowledge of building and its services. Databuild energy monitoring report provided corroboration for EARM analysis, as well as evidence for how Termodeck was operating.	Ensuring independent reporting for one of the UK’s most heavily analysed buildings. Some inconsistencies in energy end-use attribution between monitoring and Probe’s EARM™ procedures.
MB Office	Good support from the occupier, developer and designers. Performance data available from BRECSU-sponsored monitoring.	Lack of gas consumption data and of sub-metering for the offices. Delayed installation of the new office sub-metering the landlord kindly provided following our requests.
MB Warehouse	Good support from the occupier, developer and designers.	Essentially a completely different building requiring separate analysis: this made Marston (office and warehouse) the most labour-intensive Probe of all.
CRS	Support from facilities manager, maintenance contractor and electrician.	Missing data. Presence of designer during first site visit reinforced Probe team view that this is typically inappropriate.
Portland	Highly insightful tour of building from aware and enthusiastic lecturer.	No reliable electricity consumption data for building. Meter found to be faulty. Probe had to extrapolate annual consumption from two weeks of new data, using EARM™-OAM reconciliation technique.

3. Review and improvement of key elements

3.1 Access for Probe study

3.1.1 Review

The vital first step for a Probe is to obtain permission from the occupier, who occasionally also needs to consult other parties including landlords, corporate management, and property, estates and maintenance departments. Access to the Probe buildings was generally easier than researchers normally find with independent surveys, a particular surprise since the results were to be published. A critical benefit was the previous publication of an article in BSJ and the rapport which this had created between the occupier and the publisher. In a confirmation letter, the publisher also sends the names and telephone numbers of contacts at two or three buildings which have already had Probes. This also gave reassurance about the value and relative smoothness of the process. In spite of this, several buildings did not wish to have a Probe. Of those that initially agreed, four subsequently withdrew: Perronet Thompson School, Western Morning News, Powergen and The Ark.

There was sometimes a long lead time between BSJ contact and the Probe team's follow-up: this was usually inevitable as approval could be slow and – if not forthcoming – time had to be available to find substitutes and complete a Probe in time to meet BSJ's publication schedule. Note that Probe's initial contact – and indeed the site visits - were always arranged with the occupier client and not the designers, who would otherwise have been keen to accompany the surveyors and would inevitably have imposed their own agendas and reduced the surveyors' opportunities for contact and frank discussion with the occupants themselves.

3.1.2 Possible improvements to access procedures

Two options could be considered:

1. A more standardised approach by BSJ, handing over the contact to the survey team only when the terms of engagement were agreed in writing and the PVQ could be sent. While this would make best use of BSJ's established contact, it might create expectations (not least about when the survey will start) which cannot be fulfilled by the Probe survey team. The occupier will also tend to identify increasingly closely with BSJ, which could reduce the survey team's authority and access to information. There could also be an awkward handover phase when occupiers first fully appreciate the ramifications of their commitment, for example with the PVQ or the first team visit. If the occupier were then to pull out, the abortive effort would be significant.

2. Make better use of long lead times, e.g. by setting up mechanisms to collect better quality energy and water data, possibly with an early first visit (especially if this can be combined with another trip) as to date hosts have rarely started to do much before a face to face meeting. A long gap to the main survey period might then make data collection more efficient; but there is a danger of loss in enthusiasm and impetus. This approach might not necessarily require a third visit, at least for smaller or simpler buildings.

3.2 The Pre-visit questionnaire (PVQ)

3.2.1 Review

The Probe 2 PVQ gives a professional impression and demonstrates to the host that a thorough investigation is in hand. It can extract much upfront information before the first visit and provides a useful structure for the initial interview on this visit. In practice, the Probe team only rarely received a completed PVQ prior to the first visit and copies of bills or plans only at C&G and HFS. Even a partially completed PVQ is very useful: it prepares the occupier for the process, and allows the Probe team to be firm in what they need to see and take away on this visit, or have sent through quickly afterwards. Occupiers, forewarned by the PVQ, have usually been good at this, and more responsive to pressure on missing items.

The PVQ should not be sent until the host has committed in writing to the Probe survey. Otherwise, the detail of the questions may frighten them off, typically because they fear that such a detailed study will take too much of their time (or possibly reveal shortcomings in the way they do their job).

In practice, we think most hosts have found the Probe surveys less troublesome than they feared, though it would be worth interviewing them on this. The PVQ takes no more than 30 minutes to fill in. The time to provide the supporting information varies more depending on the hosts' command of the information: while a few can immediately open a physical or electronic file of energy data, some need to have a lengthy correspondence with their accounts departments, who almost invariably fail to send the right material the first time.

Table 3.1 documents the quality of the information received from each Probe building host in terms of the PVQ completeness and the fuel consumption data availability. It shows that most Probe 2 hosts completed their PVQs reasonably. The availability of energy data is discussed further in sections 3.3.2 and 3.6.3.

TABLE 3.1 Quality of PVQ return and fuel consumption data for each building

Building	PVQ quality	Electricity consumption data			Gas consumption data		
	5=good 1=poor	Initial quality	Difficulty of obtaining	Final quality	Initial quality	Difficulty of obtaining	Final quality
Tanfield	NA	Good	None	Good	Fair	Small	Good
Alderman bury	NA	Very good	Low	Good	Good	Low	Good
C&G	NA	Excellent	None	Excellent	Very poor	High	Fair
de Montfort	NA	Good	None	Good	Fair	Low	Reason able
C&W	NA	Low	High	Reasonable	Very poor (wrong)	Very high	Good
Wood house	NA	Good	Low	Good	Good	Low	Good
HFS	3	Good	Low	Good	Good	Low	Good
APU	NA	Reasonable	Low	Good	Reasonable	Low	Good
Cabot	3	Good	Low	Good	Good	Low	Good
RMC	2	Good	Low	Good	Good	Low	Good
CAF	3	Poor	High	Good	Very poor	High	Fair
Elizabeth Fry	4	Excellent (manual readings)	Low	Excellent	Excellent (manual readings)	Low	Excellent
MB Office	4	Not submetered	High: new meter	Good	Not submetered	High: Meters added	Fair
MB Warehouse	4	Not submetered	High	Good	Not submetered	High, not enough winter data	Poor for climate correction
CRS	5	Low	High	Good	Low	High	Good
Portland	4	Not separately metered	High	Very poor (only two weeks)	Low	High	Good

3.2.2 Possible improvements

The PVQ used in Probe 2 works well where details of the building are already available to the survey team, as when the building has been written up in BSJ. Nevertheless, one could consider possible improvements to the form and the procedures for liaison with the host, seeking a higher return rate and enough data to produce at least an EARM Stage 1 assessment before the first site visit.

An alternative would be to reduce the data requested initially to drawings (e.g. to calculate envelope area), floor area and utility bills. However, this has several drawbacks:

- The host would not have seen the PVQ and realised the scope of the survey operation intended.
- On the first visit the survey team might well find it much more difficult to extract the data requested in the PVQ.
- The full PVQ is a good standard source of reference information (e.g. for the current technical review). The fact that different cells have been completed by different people at different times also brings the whole survey experience back to life. An electronic version might not have this advantage.

It may be too optimistic to expect a fully completed PVQ before the visit. On the other hand, in collecting information for initial screening of buildings for office case studies for BRECSU, WBA used a precursor to the PVQ and sought the return of completed forms, because visits to all the candidate buildings were simply not affordable; and in any event not very helpful without the associated technical, operational and energy data. A completion rate of about 60% was obtained (including attached fuel bills or summaries), most arriving within five weeks of identifying the contact and obtaining approval to send the questionnaire.

Using a similar approach in Probe would require perhaps the following steps:

1. **BSJ initial contact procedure** would state clearly that the terms of engagement required the PVQ data upfront (as well as support on site).
2. **Probe surveyor** to telephone to introduce themselves, confirm who to send the PVQ to, and discuss the timetable for its return and site visits.
3. **Pencil in as much as possible** on the PVQ before sending it off.
4. **After 1 week** ring to make sure the contact has got and understands it. Request data in ten days time (or other agreed date if this is impossible).
5. **After 3 weeks** (if necessary) ring and ask if all is well. Allow another ten days.
6. **After 5 weeks** (if necessary) ring and ask if all is well. Offer help if required.
7. **If they are in real trouble,** offer to fill it in with them during the first visit, but request them to have copies of fuel bills, design data, plans, and O&M manuals to hand.

For buildings not previously reviewed in BSJ, one must collect the standard information BSJ gets on its building visits. The host will usually be able to provide floor plans and a summary of occupant numbers and their activities. If hosts are paying for a survey (not being subjected to an independent operation such as the Probes to date), they may well also put in effort to obtain additional briefing information.

If the data is not forthcoming, the survey team may need an extra preliminary day on site visit rather than to export a major data gathering activity onto the occupant. It may also be necessary to contact the designers for design intent, technical details of the building and its services, and other items such as procurement route, cost level, and any unusual requirements or difficulties. The final decision on an extra site visit will depend on the anticipated success of remote information retrieval, the size and complexity of the building and of course whether the host is prepared to pay.

Ideally a pre-visit assessment (equivalent to at least an EARM Stage 1) would be made using information provided along with the PVQ. This allows a running start to the first visit, with eyes opened and hunches formed, particularly in respect of unexpectedly high or low energy consumption. However, it is not worth too much time unless the available data are known to be reasonably reliable.

3.3 The first site visit

3.3.1 Review

The first site visit is usually by two members of the technical survey team. They collect as much information as possible about the building, its operation and any problems experienced since occupation. The day includes a structured interview with the senior contact using the PVQ, an accompanied walk-round of the building (with copies of small-scale floor plans, e.g. fire drawings where possible) and informal discussion with operations and other staff encountered.

They also review the available records of plant and equipment including specifications, operating descriptions, maintenance manuals, O&M inventories, office equipment inventories, commissioning records, BMS time schedules, BMS trend logs, submeter readings etc. is also made. Where possible information is photocopied on the spot or borrowed, and data on-screen noted down or sometimes printed out. Any missing detail (plant ratings, number and type of office equipment etc.) will need to be collected by the host, or by the surveyors on the second site visit.

During the building walk-round spot measurements are taken. Equipment normally carried includes:

- True power meter
- Light meter
- Temperature probe for measuring air and surface temperatures, often with RH indicator
- Smoke pencils
- Good quality compact, automatic zoom cameras for prints and slides. SLRs are too cumbersome.

Sometimes hot wire and vane anemometers, moisture meters, and electrical demand profile recorders are also used. Temperature and RH logging has not been undertaken by Probe, but results from the BMS or independent surveys have sometimes been available. BUS use an electronic camera to illustrate its reports. The images are excellent for scene-setting but lack the resolution for BSJ publication and some technical purposes.

Other objectives for the first site visit are to outline and seek approval for the occupant survey questions; to begin to identify the sample of occupants to be included; and to establish a point of direct contact for BUS. Approval is also sought for the pressure test, and for any additional activities by in-house or maintenance staff (e.g. meter reading and BMS trend logging). At CRS the host also paid for ten days of chiller electrical load monitoring, and at MBS/MBO the landlord installed and paid for extra gas and electricity meters to enable consumption by office and the warehouse to be separated.

Structuring the information-gathering to mesh neatly with the input needs of standard assessment methods has proved difficult. The current site procedure consists of collecting photocopies, recording other data in notebooks, and taking photographs where permitted. Back in the office, key points are summarised in typed site visit notes, and numbers are entered into spreadsheets: both are circulated – now by email - to the other members of the Probe team.

3.3.2 Review of first site visit data

This usually starts with analysis of utility bills and half-hourly electricity consumption data, if available. There is often a time consuming chase for energy data not handed over on the site visit (see Table 3.1); this may require contacts with utilities and/or bureau services. The Probe experience, particularly in Probe 2, has underlined the poor level of energy reporting currently practised by the typical building owner or occupier. It has also found a wide range of bill formats, information content and half-hourly data presented by each utility, which stop a single standard analysis package being used effectively. For ease of analysis, should utilities be required to provide consumption and billing data in an industry standard format? This would also improve competition as comparison between suppliers would be simpler. This issue is reviewed in more detail in section 3.6.3.

As much as possible of the descriptive content of the final report is written now: the skeleton on which more interesting flesh can be added later. This draft is a valuable overview for Probe team members who have not been to the building; exposes gaps in the verbal and numerical arguments; and helps to generate checklist items for the second visit. Section 3.8.2 reviews ideas about improving the procedures for generating the final report of the study.

3.3.3 Possible improvements to the initial visit and review

To achieve a viable balance between quality and budget, Probe tries to do only two site technical visits. This was not always possible, for example:

- CRS had one extra visit, nominally to verify arrangements for the chiller sub-metering. This was also a very useful introduction to a large and relatively complex building.
- Marston Book Services had two preliminary visits: one to identify the need for sub-metering; and one to check the new meters and agree data collection with the host.
- Marston also needed a fifth visit at the end to resolve uncertainties and obtain the host's advance approval to the preliminary findings (final production was on a tight programme and the senior host contact was going to be away when the proofs of BSJ article were to be submitted).

On the critical site visits, the survey team has a lot to do in a very limited time. Hosts are also constrained by the normal pressures of their jobs, so sometimes meetings have been delayed or curtailed, and escorts have had to rush off to deal with emergencies. Opportunism is therefore essential if one is to extract the most relevant information in the time available, and to adapt rapidly to disruptions in the intended programme.

In theory a more structured method for the first visit might help, perhaps with a subjective review in the morning and objective measurement in the afternoon. However, time constraints make this more difficult the larger and more complex the building; and it has often been difficult to visit specialised areas (e.g. computer rooms) more than once. The host may also find it impossible to fit in with the survey team's agenda. Nevertheless, the following structure for the day would be worth aiming for:

A. In the morning:

- Discuss operational aspects with senior staff and complete the PVQ. For successful progress, it has been important for the Probe surveyors to meet and establish a good rapport with a relatively senior (or at least influential) member of the host organisation, preferably at the beginning of the first visit. This meeting needs to outline the Probe process and timetable, including arrangements to review and approve the draft article before publication.
- Tour of building, plant rooms, etc
- Where permitted, lots of indoor photos including typical fittings, unusual equipment, etc using slide and digital cameras. 35 mm slides are needed for publication and some presentations. Digital images permits instant quality checks and easy transmission of images via email and web pages.

B. In the afternoon:

- Measure key variables needed for the HVAC, lighting and office equipment tree diagrams
- Temporary installation of 1-channel dataloggers to measure key variable or unknown energy use and operating times of equipment (e.g. on/off times of lights or pumps, variable speed fan power measurement, office equipment power and usage). These can be picked up on the second visit.
- Review of BMS time schedules and key control setpoints; output of trend logs of sample variables, where available.
- Review of O&M manuals including a list of plant ratings and commissioning figures, if available.

The emphasis on systematic measurement would allow the survey team to be supported by less senior staff in the afternoon. It is nevertheless important to avoid too regimented an approach; not to stifle informal discussions with a variety of staff (many important observations and leads have come from off-the-cuff comments); and to allow the survey team to be opportunistic in rapidly seeking out items of particular interest (plus the standard information required for the EARM end-use breakdown).

Palmtop computers with handwriting recognition could replace pen and paper – but they would need to deal with information in a combination of written, graphic and tabular form. Another possibility is voice recording and transcription. On past experience, this has been very labour-intensive back at the office, though voice recognition technology may now be changing things. It might also be possible to organise the visit with one person asking the questions and the other taking all the notes – perhaps onto a computer – but even this is likely to deny some of the richness of the information provided.

3.4 The second site visit

3.4.1 Review

Probe has usually been able to collect the required information in two site visits, because both are by two experienced surveyors who know what leads to follow through, which searching questions to ask and how to distinguish wheat from chaff. The approach is also iterative: the team seeks as much relevant information as possible in the time available, to identify what gaps need to be filled next and the extent to which this is likely to be possible.

The second technical visit is by the principal technical surveyor for the job (who was also on the first visit) and – for quality control - a second surveyor who has not. The survey team takes a fresh look at the building, and addresses specific queries. Before going, the team has drawn up a comprehensive checklist of actions to be taken and questions to be resolved, and has fixed appointments with the host staff who can deliver the required information. A few queries inevitably arise after the second visit, but these can usually be dealt with by telephone.

The second walk-round can be a bit repetitive for the principal surveyor, but fills-in important gaps. By now the host appreciates the value of the exercise and the quality of the service, is usually more open generally, and can react to preliminary results (especially if occupant survey information is also available by now). Extra value is added through second opinions and follow-up by the second surveyor, who has read the background information and often done some calculations. The second surveyor, being new to the building, can also open up matters which may have overlooked or not clear the first time. Sometimes the host's responses on the two visits differ (e.g. different staff may have different perspectives or interpretations): this then triggers further investigation by the team.

3.4.2 Possible improvements

Difficulties can arise on the second visit if the right people do not appear, for example:

- Someone expected has not been available, or has had to go to a meeting. To be fair, this has usually happened on dates which were not the host's first choice, but were needed for the Probe team to satisfy BSJ's production demands (e.g. at POR).
- Facilities and maintenance staff have emergencies (on and off-site) which naturally take priority.
- Problems with attendance, particularly by electricians to assist with power measurements. This can be difficult to guarantee, especially where there are no permanent on-site staff; or where in-house or contract maintenance electricians are on call.
- Sometimes it has proved awkward to get back into tenanted areas, secure areas such as computer suites, and occasionally even plant rooms.

These difficulties can perhaps be reduced by longer lead times and better managed site visit preparation. But the unexpected can still happen. The best remedy would be more time on site.

Another frequent dilemma is to balance the effectively social demands to discuss and review things with the hosts (and build up the working relationship) and the technical demands to review previous information and collect more. This might be improved with clearer agendas for the visit; but on the other hand the social side is vital in ensuring smooth progress towards a published Probe report.

On the energy side, a lot could be learnt from being in the building at night, to identify whether plant switches off to programme, and what lights and office equipment are left on. In the office case studies for BRECSU, WBA frequently undertook 2-day detailed survey visits with an overnight stay, where the survey could continue until 9 or 10 PM, sometimes with an additional inspection in the early hours to check what lights had been left on. Such extended surveys have not been affordable on Probe. Light loggers might displace some of this human input, but can only provide spot checks, rather than a view of the whole building. Increases in building security over the past few years have also made night visits more difficult. Indeed, occupants are tending to require visitors to be accompanied more, particularly in special areas and plant rooms. Few Probe visits have included unaccompanied surveying, except in public areas and in some general offices.

3.5 The BUS Occupant Survey

3.5.1 Review

To make the BUS occupant survey affordable in Probe, it was trimmed from 8 to 2 pages. The questionnaire now includes 24 environmental comfort questions, 10 on personal control and a further 17 on background information, health, productivity, response times, design and needs:

- Permanent office staff are sampled, sometimes supplemented by a shorter questionnaire for other users, typically students and visitors; and more unusually magistrates at RMC.
- Sample sizes are normally 100-125 (the full population is sampled if less than this). If the sample size falls below about 10% of the permanent office staff, a bigger sample will be used.
- The questionnaire form is designed to look appealing. Respondents can immediately see that it is easy to fill in, normally taking less than five minutes.
- Most of the questions are seven-point "Gregory" scales with tick-boxes.
- The questionnaire is normally handed out by a researcher in the morning of the survey day and collected in the afternoon. It is printed on two separate A4 pages – or people may not realise that they should turn over - and vivid in colour so the collector can find it easily amongst other papers.
- Data are manually transferred from the filled-in questionnaire to standard data files in Excel spreadsheets (for ease of transfer between different computer systems). Web – i.e. HTML - versions with automatic data input via email have been tested but have been ruled out owing to lower response rates and some staff not having easy access to or familiarity with computers. Scanning data capture has also been abandoned because a) questionnaire batches are not large enough for real economies of scale and b) comments are difficult to manage efficiently.
- Data are transferred from Excel into statistical packages for analysis (StatView version 5 is currently used).

These techniques guarantee response rates of over 80% in every case and well above 90% in most. It is important to have high response rates to avoid any suspicions about the statistical validity of the results and to permit analyses of sub-samples (e.g. between people who do and do not have window seats). In the detailed survey reports, significance tests are used on all variables. Significance levels are not reported in BSJ because few people understand them; but where written comments (e.g. high or low) are included, they are only made for items which are statistically significant.

If the occupant survey is on the day of the second technical visit, technical and occupant survey team members can share their views of the building with each other and with the host. For operational reasons this has happened in fewer than half of the buildings: it does also reduce the time available for the technical survey.

In most BUS post-occupancy studies, the questionnaire survey is followed up a week later by focus groups, so a richer picture can be obtained and fed into the final report. For cost and scheduling reasons, this has not been possible in Probe. Instead, BUS aims to have a structured discussion with occupants and management at the time of the visit,. These findings are added to the conclusions, for example the managing director of Marston Book Services offered a most useful insight into their working ethos as a company.

The occupant survey may raise other issues which need to be brought to the attention of management (e.g. duty of care). A feedback seminar with management and staff is the best place for this, but again not affordable in Probe. We have considered asking the occupiers to fund feedback seminars, but decided against this on the grounds of possible conflicts of interest and difficulties in maintaining objectivity. As in the technical surveys, the tight budget and focus on the public domain publication outputs has meant that the Probe team cannot deliver as much value as they would like to the hosts.

Owing to the tight Probe programme, sometimes the occupant survey report is complete only a few days before the final deadline for submission to BSJ: data for BSJ’s graphics are usually on the critical path. The most pressed was the occupant survey of the Portland Building, which took four days from start to finish!

3.5.2 Possible improvements to the occupant survey

The BUS/Probe questionnaire has achieved an economical compromise between the needs of respondents, data management, data analysis, statistical validity and question-answering ability. Supplementary questions are sometimes used, but pages are reflowed so that the questionnaire is never more than two pages long. New questions have been trialled in non-Probe studies (as on "importance" of particular issues, for instance) but not yet incorporated. Any change to the questionnaire is treated circumspectly, as it can have potentially serious implications for cost, quality, consistency and comparability. For example benchmarks may cease to be available or need rework; and information collected from large numbers of previous surveys but not yet fully analysed may lose its value if a question is changed or abandoned.

One hidden cost in Probe has concerned the "handing" of scales. In Probe data files, variables are encoded both in BUS/Probe format and, for certain questions, in BRE format[4]. In earlier versions of the BUS questionnaire used by BRE, certain scales were reversed by BRE to suit their own data management conventions (e.g. from 1 = uncomfortable to 7 = comfortable to 1 = comfortable to 7 = uncomfortable). These seemingly trivial changes create obvious potential for confusion, but BRE did not want to change back. At the beginning of Probe 1, BUS tried changing their own handing for compatibility with the BRE scales, but this introduces major incompatibilities with their previous reports, benchmarks and databases. So BUS datafiles now include variables encoded both as BUS-handed and as BRE-handed to make sure that a third-party analysing the data does not confuse the scales.

Even tiny changes in handing and nomenclature quickly increase the likelihood of mistakes and inefficiency, especially when the number of buildings is large. To give an idea of the data management issues involved, the single meta-level data file for all Probe buildings (including other buildings in the BUS data set) now has 210 variable fields. A data file for a single building has 77 variable fields and there are over 80 building files of this type. Any change to a scale, question or handing potentially involves changes to up to 80 files!

Data management and maintenance issues should not be underestimated. For a single Probe occupant study, about 40% of the resource available is spent on fieldwork, 40% on data input and analysis, and 20% on the occupant survey report (usually about 10 pages of text and 25 pages of graphs and tables). Most of the meta-level activity (e.g. testing buildings against benchmarks and maintaining the benchmark data file) is not covered by the Probe survey budget and is an extra cost to Building Use Studies.

Data handling and management becomes more important as the number of buildings increases. Investigators should consider the point at which their study changes from being a pilot or "one-off" to a benchmarking exercise. If a series of buildings is planned - as in Probe - it may be advisable to use databases for basic data entry and analysis; and in initial reports to make use of simple statistics like means and variances, which are easily calculated by databases. The up-front cost of preparing a suitable database may be about five days, but the time saving later may be much greater, especially as the number of buildings increases. This may be especially helpful for quality control, because at present the time spent rectifying mistakes often exceeds that for analysis.

Statistical graphics are also a major area for development. As the number of buildings increases, the amount of information that needs to be put on one chart may become unacceptably large. Probe is currently experimenting with web-enabled graphics for occupant survey statistics which show building scores, dataset distributions, and descriptive statistics and histograms for individual buildings. Each graphic contains about 50 sub-graphics which are available to the user on request (i.e. by clicking a datapoint or image in a web browser). Pictures of buildings are also included. A demonstration is available on www.usablebuildings.co.uk.

3.6 The energy assessment method

3.6.1 Review

The Energy Assessment and Reporting Methodology (EARM) office assessment method (OAM) has proved very effective in improving the speed, accuracy and consistency of energy surveys, and has allowed rapid results to be obtained in a way not previously thought possible. However, the original three-stage, iterative, paper-based approach proved cumbersome for the Probe surveys and too time-consuming in relation to the limited budget available. In Probe 1, BRECSU provided a special budget to use and assess the EARM Office Assessment Method, (OAM) and a report[5] on this was submitted.

A particular problem was the manual recording of background information on the building (which Probe records elsewhere in any event). This required double-or triple-entry of data on the way through the three stages of the OAM assessment; manual or separate spreadsheet calculation of some data, and difficulty in making corrections. The second stage assessment was also of limited relevance: the third stage was most useful for Probe and could normally be undertaken immediately after the first. Although initially developed for offices, the Probe team found they could also use OAM principles and techniques effectively on the other building types studied.

In Probe 2, where completion of the OAM forms was not separately funded, the Probe team found it most efficient to jump straight to the OAM Stage 3 spreadsheet, which allows a model of electricity consumption by end uses to be built up and reconciled with fuel bill data. All the Stage 1 steps were also taken but not formally recorded in the paper forms.

3.6.2 Possible improvements to the energy assessment

In an ideal Probe, it would be helpful to have a draft of OAM Stage 3 completed before the second site visit. In Probe, HGa have rarely found this possible. WBA (who initiated some of the techniques now incorporated into EARM) have found it easier – and most helpful - to produce approximate estimates immediately after the first visit; and sometimes even makes a first attempt beforehand using the published data.

EARM OAM has recently been implemented in Microsoft Excel workbook form as part of CIBSE Technical Memorandum 22[6]. Now the final TM22 is available, Probe should aim to adopt it for reasons of discipline and uniformity. Pilot tests indicate that it could bring significant efficiency and productivity gains over the paper-based version. Double-entry of information is virtually eliminated; and calculations, consistency checks and benchmark comparisons are also done automatically and presented consistently. EARM workbook output might now form part of the standard Probe report - with a corresponding reduction in the main report text describing energy use (see section 3.8.2).

CIBSE TM22 project also includes preliminary versions of EARM workbooks for banks and estate agencies, hotels and mixed-use (industrial/office) buildings. The underlying technique is however similar for all building types, though the standard end-uses and benchmarks change. WBA has recently used the TM22 OAM workbook with ad hoc modifications to analyse energy data for a sports centre with swimming pool and for laboratories; and managed to do so quickly and effectively.

A valuable feature of the new EARM workbook is its accuracy checks. These are partly numerical based on consistency and orders of magnitude, and partly the surveyor's own assessment of the quality and relevance of the input data in relation to stated accuracy guidelines. They also permit surveyors to enter provisional data which they know to be rough; and reach rapid initial estimates, whilst flagging-up input figures which will need re-visiting. Our initial tests suggest that this feature offers potentially major improvements in short-term speed and longer-term accuracy.

The new EARM workbooks also generate automatically "tree diagram" benchmarks for system capacity, efficiency, operating hours and control and management factors. The Probe team thinks that these could greatly improve the language of energy target-setting, assessment and reporting at all stages of a project from briefing onwards. This is discussed further in the Probe Technical Review[7] and Strategic Overview[8]. We had hoped to use tree diagrams in the second half of Probe 2, following the publication of the 1998 version of ECON19, but were held back by the lack of a suitable spreadsheet and the editorial space tree diagrams take up. For Probe 3 we hope it may be possible to develop a compact graphic to summarise tree diagram information.

The correct balance between accuracy and cost (resources) needs to be established in order to decide between the use of spot checks, short term monitoring and long term monitoring. Typically, the Probe team attempt to apply the 80/20 Pareto rule - capturing the 80% of the data that can be collected with 20% of the effort and making professional judgements for the remaining 20%. One advantage of the EARM Stage 3 reconciliation method – and one which demonstrates surprisingly more power hands-on than one would expect before one uses it – is how this iterative technique forces the surveyor towards seeking more information on the larger items with the greater margins of error. However, its power does depend somewhat on the experience of the user in determining default values and likely ranges of variation. Clearer expression, development and review of the associated rule systems would be highly desirable. This will itself be aided by clearer expression and continued development of the tree diagram approach and the associated numerical values commonly obtained for different equipment and systems in different contexts.

3.6.3 Fuel consumption data

A critical input, which falls outside of the formal EARM stages, is obtaining and analysing utility usage to provide accurate input data to the auditing process. The absolute minimum requirement is two firm (i.e. not estimated) meter readings close to 12 months apart. These have come from a number of sources including monthly or quarterly invoices, site meter reading records, or directly from suppliers on paper or electronically. Ideally monthly records of electricity and gas consumption need to be analysed to establish the pattern of seasonal consumption. In practice, this has often proved difficult, especially with gas readings, many of which tend to be estimated (on the smaller sites some electricity bills were also estimated). Larger sites with half-hourly electricity metering nearly always have good monthly bill data. Full half-hourly records are often available, though in practice the authority for third parties such as the Probe team to access them can be hard to get in time.

Ideally, consumption statistics would be input to standard spreadsheet or proprietary utility analysis software for systematic analysis of monthly data. However the format, information content (day/night/STOD) and units used in bills varies from one supplier and contract to another. The number of meters can also vary, as can the end-uses and their seasonal patterns of demand. In practice it has been easiest to take previous spreadsheets and to tailor them nearly every time to accommodate the monthly consumption inputs for a particular site. For quality assurance purposes, the spreadsheet recalculates the total invoice value of each bill from the meter readings and other tariff data, and check that this agrees with the actual value entered manually from the invoice.

In Probe:

1. Availability of monthly gas data during the later stages of Probe 1 and most of Probe 2 was often appalling. Firm readings were very irregular: on one site the supplier had not read the meter for 2 years. Curiously, on some sites where the supplier had estimated the reading, it was sometimes possible – though with administrative difficulty - to get additional firm readings from Transco.
2. Gas billing may be improving, particularly for larger sites with modem links to Transco or the gas supplier, ensuring monthly or more regular firm readings, but no Probe 2 buildings had yet got this.
3. More and more sites have half-hourly electricity meters with direct links to the supplier. Information on electricity consumption can therefore be excellent. However, the invoices may simply state the monthly consumption for each tariff - not all include the meter readings from which you can check the consumption; or interpolate where bills are missing from the records.

Presentation of half-hourly meter readings (and the associated computer data files) also varies from supplier to supplier. The minimum standard is a text file with the data for a whole month, with a 48 field record for each day. It can take time to get this across into a spreadsheet in which the data can be analysed. One simple solution is to present a week’s worth of daily profiles on the same chart, including the weekend, preferably for summer and winter periods and including bank holidays to enable a spot check of demands and actual hours of operation.

It could make sense for the Regulators to issue edicts for more consistent billing information, fewer estimated readings, and possibly some statutory reporting to customers of their energy consumption trends and profiles. A few suppliers already provide printed thumbnail daily profiles for a whole month on one or two sheets of A4 (in addition to the raw data). These are easy to review individually but comparisons between different days can be difficult.

All Probe buildings have been gas heated, often with many estimated readings, so the patterns of consumption have been hard to analyse. For a few buildings it has been possible to establish the profiles of monthly gas consumption against monthly degree days for the location and make an assessment of control and baseload non-heating usage. For most, it has only been possible to state an annual gas consumption, estimate the climate-dependent proportion and normalise this for total annual degree days.

Degree days have been taken from the bi-monthly DETR Energy Management Journal, but these data are at best 2 months old and sometimes 4. It is also annoying that complete annual tables are no longer provided (the Probe team maintains its own spreadsheet) and that the 20-year norms are now updated on a rolling basis and so wander around, instead of providing fixed reference standards, only revised at wide intervals, say 5 to 10 years.

3.7 The Pressure Test

3.7.1 Review

Air leakage is one aspect of building performance that can be measured objectively, thereby providing incontrovertible proof of the quality of the fabric details. This is salutary for architects not accustomed to their designs receiving such a direct quantitative analysis – particularly as (in common with most UK buildings) many Probe pressure test results were poor, even sometimes for buildings which claimed to be tight. The test is time consuming and can be difficult for the host because it has to be done out of hours (e.g. on a Sunday) and typically overruns its scheduled time. Nevertheless, the pressure tests were generally popular with building occupiers.

Currently, only two organisations in the UK (BRE and BSRIA) provide a pressure testing for large non-domestic buildings. Both organisations appear to be stretched to meet currently rising demand, so it was difficult for both us and them to arrange the testing of the Probe 2 buildings to meet the tight publication deadlines. As a result, the full pressure test report usually arrived long after the article had been published; and sometimes included minor corrections to the preliminary draft on which the article had been based. To calculate envelope area, the pressure testers also required scaled elevations and roof plans. These were seldom immediately accessible from the occupiers of the building (who tend to work with floor plans), and often were only produced at the time of the test.

3.7.2 Possible improvements to the pressure tests

Pressure tests have been really useful in Probe 2. They have helped to improve the awareness of the building industry and its clients of the performance of a specific building, and to make more real (and hence accessible) the body of research by BRE, BSRIA and others. Since the tests of the Probe 2 buildings have revealed generally woeful performance, it would be desirable for them to continue. However, they are expensive and time consuming.

Probe also revealed some apparent inconsistencies in the current pressure test procedures and reporting conventions:

- Should leakage rates be expressed at a pressure of 50 or 25 Pa?
- Does the building envelope area include the ground floor? Should raised and suspended floors be treated differently from those at grade? What about basements?
- How should buildings with mechanical ventilation openings be prepared for the test?

It would be helpful for BRE and BSRIA to publish, perhaps jointly, a definitive technical guide to pressure testing non-domestic buildings, with associated standards for measurement and reporting.

3.8 The technical report

3.8.1 Review

The Probe technical report is a comprehensive and rigorous compilation of the findings, with:

- A 20-30 page main report with sections on Introduction, Building assessment, Air infiltration, O&M and energy management, Energy and water consumption, Post occupancy evaluation and Overview
- EARM spreadsheets and graphics
- Occupant survey
- Pressure test report

This report has three objectives:

- To provide all the information BSJ needs to produce the Probe article
- To enable the host to check for any errors in the Probe team's descriptions, analyses or interpretations.
- To underpin the information and opinions expressed in the Probe articles, and as a record for subsequent reviews (such as this); and if there happened to be any disputes (for example with the design team) regarding the fairness and accuracy of the published article.

In practice most hosts have been more concerned about the content of the article and given less priority to checking the draft report (which is more detailed, candid and confidential and will never see the light of day).

This main report is time consuming to produce, absorbing typically one-third of the budget for an output which is never finalised and is not an official deliverable for the project, although the more dynamic hosts may put it to good use. Whilst writing the reports we are torn between the need to provide background contextual description, actual assessment, technical detail, or plain English descriptions. It is also difficult to know whether to focus on:

- specific aspects of the building, which may be particularly important to the occupants, but which if troublesome – even if this is typical or better – may lead to talk of blame; or
- the light these throw onto more general issues for the industry – perhaps vaguer but more important in helping the industry and its clients to bring about useful change.

Within the time available for a Probe survey, it has not been possible to compare and contrast as much as the survey team would have liked from a professional point of view. The emphasis on public domain output has also made it impossible to offer the host clear remedies to problems encountered.

3.8.2 Improvements to the Probe technical report

A detailed technical document of some kind is essential, to present the facts and opinions which underlie the published article. However, at present there may be too much duplication, for example the occupant survey is presented in full, in longer extracts in the technical report and condensed in the article. This feels inefficient (though it may not be) and the host can be confused.

The problems arise from:

- Difficulties in applying a completely systematic approach to technical data collection owing to its diversity. (NB: the occupant survey can be standardised more rigorously because the process and the questionnaire input forms are standard and completely under the control of the team).
- The multiple audiences of the public, BSJ and the host.
- The difficulty of going straight from the surveys to a published article in which some critical messages may be uncomfortable for its designers or managers. Clear supporting arguments must demonstrate that any conclusions have been reached fairly and objectively.
- The need to maintain the professional standards and reputations of the Probe team and its constituent individuals and companies. A single false move could destroy all this!

A solution is for the main technical output to be in the form of a systematic resource pack, including:

- Background papers on the building e.g. the original BSJ article.
- A4 or folded A3 copies of key plans, elevations, schematics etc.
- Completed PVQ.
- Occupant survey report (as at present)
- Pressure test report (as at present)
- Completed EARM workbook.
- Input data forms: schedules of equipment, commissioning records, occupancy schedules, fuel use statistics etc. Probe already uses scratch versions of these and it might be possible to standardise them further; though complete standardisation has proved elusive.
- Visual record e.g. photographs and/or images on CD
- Full text statements covering:
  1. Building description and assessment (avoiding duplication with EARM forms)
  2. Services description and assessment
  3. O&M and energy management
  4. Key messages for public.
  5. Key issues for host.
  6. Miscellaneous (to catch issues not covered elsewhere).

Options for converting the resource pack into the completed Probe article are reviewed below.

3.9 The BSJ Probe article

3.9.1 Review

The Probe team currently issue the technical report to BSJ, who produce a draft article. This ensures that the report content receives a journalistic eye, but contextual data and strategic general messages can sometimes be lost. The draft article is then issued to the Probe Team, building host and building M&E designers for comment, usually in parallel over typically no more than two or three days. Despite good intentions, the completion of each Probe study is driven by BSJ's publication deadline. Although in principle there is no reason whatsoever why a study cannot be completed well in advance, without the imperative of such a deadline, other work receives a higher priority; and there are also more facts to check.

The graphics in the article are generated by a separate department of the Builder Group (and sometimes outsourced by them) and have seldom been available in time to be reviewed. Simple but potentially critical typographical errors can then appear in the final copy. This is frustrating for the Probe team, given their painstaking approach to quality control, particularly when DETR's Chief Scientist picked on one such error at a conference presentation, and said that studies like Probe must be meticulous in avoiding mistakes!

The arrangement for obtaining feedback from the designers (usually the services engineers but occasionally the architects) has worked well and proved invaluable. Occasionally the draft article has changed after going to the designers (as at CRS and APU), which has led to some inconsistency between the feedback and the final article. This is undesirable, but occasionally inevitable with the pressure of publication deadlines. However, few people other than those directly involved probably notice.

There has been inevitable tension between the Probe survey team's desire for rigour, fairness, objectivity, professional independence and technical quality; and BSJ's need for a good, readable article to meet their space limitations, production schedule and audience preferences. Areas of difficulty have included:

- A densely-written main technical report of typically 10,000 words (excluding appendices) is difficult and time-consuming for BSJ (under pressure from publication deadlines) to edit down to the 4000 words or less available for the article.
- This process can inevitably lead to a drift in emphasis from the survey team's point of view: sometimes BSJ's drafts have "talked up" (or down) aspects more than the survey team considered justified. There is a tendency – again for journalistic interest – for BSJ to focus more on technical issues specific to the building, whilst the Probe team seeks to identify more strategic and process-related issues, using the building to illuminate the state of the industry and help to establish future priorities.
- The danger of creating situations in which parties involved with the building may feel that they may have been made to look incompetent – and are then likely to complain and question the techniques and competence of the Probe team.
- The use that other journalists make of the output. For example, an article "Winners and Losers" in *Building* – in the same group as BSJ, but editorially completely independent – gratuitously sensationalised Probe's findings. Third parties are of course free to draw what conclusions they like from published information, they must not be given hostages to fortune.

Because the Probe survey team is seen as the authors of Probe articles, and therefore to be blamed for any ruffled feathers, it has been wary of handing full editorial control to BSJ,. Quite reasonably BSJ has been equally unwilling to relinquish its control. The outcome has often been somewhat uneasy, with both parties hoping to achieve something acceptable without upsetting the applecart. In this, BSJ's standards and their responsiveness to the comments by the survey team have been second to none – as evidenced by the reputation of Probe; and the fact that it has managed to maintain a series of fifteen published survey reports (a world first, so we understand; and something which other countries have been surprised that we have been able to do). It has also just secured DETR funding for a third series. Every single survey so far which has progressed beyond the initial visit stage has proceeded to publication. Sadly, one did lead to a threat of legal action.

Overall, the tension inevitable in such a project has been coped with remarkably well. Indeed, this very tension may have created the unprecedented interest in the Probe project and thus so directly served the aims of the ultimate client. DETR's agenda effectively embraces both the Probe team's objective to provide suitable steers to the industry and BSJ's *raison d'être* to engage the attention of its readership - and it is human nature for critiques of one's peers to be read more avidly than generic messages (especially if they are misconstrued as platitudes).

3.9.2 Possible improvements to creating the article from the survey material

Three options could be considered:

1. The Probe team write the draft article and draw attention to points they think particularly important for the building concerned; and in relation to other Probe buildings and to other sources. This would greatly reduce BSJ's editing task and consequently the commenting by the Probe team on the draft article. This was tried in a stripped-down form on the last of the Probe 2 buildings (Portland). Two Probe 1 reports (Tanfield and HFS) were also more of this style. BSJ would only refer to the resource pack for quantitative information (e.g. energy and occupant survey statistics for their graphics) and supporting data on issues they found interesting or puzzling.
2. The Probe team write an outline only of the points they regard as particularly important, and BSJ assemble the article from this and the resource pack.
3. BSJ produce the draft article directly from the resource pack, leaving sufficient time for comment from all parties (the Probe Team, building host and building M&E designers).

Option 1 would allow the Probe team to apply their perspective (both of the building itself and how it fits into its various contexts) to the source material. BSJ can then undertake a level of editing normal to a submitted technical article, and would not need to trawl through a lot of technical data – though they would have it as background.

Option 3 seems unlikely to work as well. It would require a level of insight into the technical data which would probably be unavailable to anyone not personally involved in the survey and in the production of the technical report. The article production might either:

- become a somewhat routine technical operation on the resource pack which did not pick up some of the richness potentially available from the surveyors' experiences;
- generate many ad hoc queries from the journalists to the survey team, wasting time for both;
- require the survey team have to provide an over-complete set of information and opinions to inspire and inform the journalist, taking more time than Option 1; or
- lead to a final article which was professionally compromising for the survey team.

The Probe survey team are also experts and interpreters – able to draw strategic and detailed conclusions, which can then be enhanced by the professional skills of a journalist. BSJ themselves has found it difficult to extract the key messages from a large Probe technical report in the time available for editing; and the proposed resource pack might well be yet more difficult to interpret.

The draft article from Option 3 might easily provoke quite a lot of debate. The survey team would require at least two weeks to comment , and not until then could a revised draft go on to the host and the designers. This could be labour intensive and relatively unproductive for everybody.

Although it involves more upfront work, Option 1 would help to avoid unprogrammed and possibly stressful and abortive work downstream. If the Probe study could be programmed well in advance of the publication deadline (for example by being one building ahead) then the stress due to time constraints would be avoided (but the impact on budget might be more severe).

Option 2 offers a possible compromise, with the opportunity of productivity gains and more scope for journalistic flair. Subject to BSJ's comments, we suggest that it is tested at the start of Probe 3.

The Probe article's format and content was discussed at a designer feedback seminar on Probe 2 in January 1999[9]. Overall, the response was that Probe articles are well read, with particular interest in the key design lessons at the end. The value for young engineers was emphasised: experience of real projects is normally slow, and Probe articles represent a way of accelerating up the learning curve. Some people thought six pages were too long and difficult to digest in the limited time engineers have to read magazines; but nevertheless Probe was one of the first things they turned to. They also recognised quality and detail would be lost if articles were significantly reduced in length.

The seminar went to suggest long lists of new material it would like to see incorporated, including:

- Transport use and emissions
- Capital and maintenance costs
- BREEAM implementation in the as-built design
- Embodied energy
- Clearer relationships between any modelling predictions used in the design (dynamic thermal computer modelling, CFD, etc.) and the performance of the completed building.

Many of these wishes implied major new effort and revealed that the commentators did not appreciate Probe's severe time and cost restrictions. The Probe team suggested tackling some of these in a simple manner; perhaps by selecting one issue particularly relevant to a specific building and dealing with it in a special box in the Journal article.

A fresh presentation format for Probe 3 might consider including more boxes (as used at present for the pressure test results), for example for the occupant survey results and for the energy consumption analysis with tree diagrams. A more compartmentalised layout could also permit a more direct transition from the proposed resource pack to the final copy.

Although the Probe project has demonstrably caught the attention of a much wider constituency than the building services industry at which it is primarily targeted, further widening of the audience has been suggested by other professions, other journalists and DETR.

Examples of specific comments made about the articles in include:

- FACILITIES MANAGER: “The reports are aimed rather too directly at building services professionals – they’re over my head, which is a pity and a missed opportunity.”
- SENIOR ARCHITECT “I know a bit about Probe and I think is marvellous, but I don’t regularly see BSJ. You engineers are way ahead of us on feedback: please now tell us the lessons are, and help us to go about getting our own.”
- JOURNALIST “On the issue of why architects are not much interested:

  too few of the right questions posed about design and especially about work

  inappropriate writing up

  buildings that, mostly, architects are glad they didn't design"

The focus on services engineers is inevitable: the project was set up with BSJ as the partner; BSJ is the principal organ for the delivery of its messages; and the buildings studied have had to be featured in BSJ before. Nevertheless, this issue will need to be addressed seriously if Probe is to make a real impact.

4. POE issues for Designers

To date Probe has provided feedback to the building services community (especially designers) about how recently completed buildings - mostly with some innovative aspects of environmental control - have performed in use. It has reviewed many aspects of the operation of the building, but has focused on technical performance, energy efficiency and sustainability - partly influenced by government policy and its funding criteria. In Probe 3, the team hopes to incorporate the improvements proposed in section 3, subject to time and budget constraints.

The Probe experience could also help to ring routine feedback into the briefing, design, construction, completion, operation, use and alteration of buildings[a]. In spite of clear needs, feedback is not a standard part of the design service. For example, a feedback Stage M is included in the current version of the RIBA Plan of Work (published in 1973), but was omitted from the 1992 Standard Form of Agreement (SFA) for the Appointment of an Architect, apparently due to the potential impact on PI insurance. However, the RIBA Guide to the SFA[10] includes the following statement:

> *"Feedback, the last stage (M) in the RIBA's model Plan of Work, is an important but often neglected element of a commission. Much can be gained from revisiting completed projects, and the client may also benefit from your findings now that the building is in use. Even if you are not appointed for stage M services, it can be valuable to keep in touch with the project.*
>
> *It is all too easy to get dragged into providing services as a matter of good will after the project has been completed. Remember that Architects are not obliged to provide their professional services free."*

Probe has helped to expose the market to the idea of such feedback, to permit professionals to admit and openly discuss shortcomings in systems and in-use performance; to increase familiarity with energy and occupant satisfaction benchmarks; and to streamline the techniques of collecting and presenting information.

Feedback, of course, should occur at all stages of a process, viz reference[11]. However, key conclusions[b] from the Probe project to date underline the need for the conditions of engagement for designers to include formally a feedback stage after practical completion (when it can be naively assumed that their job is complete and they should go away).

A post occupancy review period of 12-24 months, built into the terms of appointment of the design team and the contractor, could offer huge potential benefits. In this "sea trials" period, unexpected difficulties in systems behaviour and alterations in occupant requirements can be rapidly identified and dealt with. This would improve occupant satisfaction, environmental performance and value added and provide useful feedback to the building team for future projects. The need for and value of such a radical revision of current procedures has been demonstrated in Probe. In many buildings, a successful handover is difficult to achieve, with occupants not really ready to take control, designers under pressure to move on to the next project, and contractual arrangements that seem to make it particularly difficult to identify and resolve teething problems during the first year's "defects liability period". The industry does not yet seem to have adapted to the change this century from a new

---

[a] The Probe perspective can also help to broaden the Egan initiative to improve the construction industry, extending it from its initial emphasis on products and process to improving in-use performance: for individuals, organisations, society and the environment. Many strategic and detailed issues arising from Probe are also highly relevant to improving the upstream process, as is discussed in the three other reports in this series.

[b] For example:

- The degree to which seemingly minor items, for example airtightness or controls interfaces, vastly affect the performance and functionality of a design.
- The ease with which buildings and occupant requirements can drift apart.
- The importance of the building managers understanding the design intentions for the building and its services – and the designers understanding the occupants' requirements, perspectives and constraints.
- The need to counteract ever-growing technical and behavioural complexity with more usability and manageability for occupants and owners, especially with respect to basic human requirements like comfort, safety, and health; and with knock-on benefits for productivity, sustainability and energy efficiency.
- The importance of controls and controllability for users.

building being largely a static object (the hardware, in a computer analogy) practically complete when physically complete; to a dynamic system which needs to be proved functionally and operationally (again in the computer analogy: systems, applications, communications and diagnostic software).

The format and techniques for a design feedback procedure could adopt some techniques from the Probe process. Some parallels are explored in Table 4.1.

TABLE 4.1 Some issues for designer feedback POEs

Step	Probe	Designer feedback
0	Not present	Preparing for the new post-occupancy feedback stage: to avoid there being too much wisdom after the event and not enough beforehand. This could include, for example, the designers setting up a stage 3 spreadsheet which summarised the elements of the predicted energy consumption in a form which was readily compatible with in-use data. Incorporating past feedback during briefing, design, specification, construction, completion and commissioning. Reviewing the design as it progresses (creating its own internal feedback) and reality-checking against past experiences.
1	Access for study and meetings	Built into original brief and terms of appointment.
2	PVQ	Only applicable to collecting information on the way the occupant has started to use the building (which may well differ from anyone's intentions at the design stage).
3 & 4	Site visits	Perhaps four meetings over 2 years post handover (say at, 3, 6, 12 and 24 months). Each meeting to be structured by a simple check list.
5	Occupant survey	Typically undertaken in time for a report to the third meeting. Results to be presented and any responses required to be agreed at this meeting.
6	EARM	Fuel bill review completed prior to each post handover meeting. Review of stage 3 spreadsheet set up by the designers and left with the building occupier. More detailed analysis could be undertaken if required, or if energy targets were being missed.
7	Pressure test	Built into original brief and conducted before Certificate of Practical Completion signed.
8	Probe report	Replaced by minutes of post handover meetings. These would incorporate normal lists of actions for various parties and attachments such as graphs of monthly gas and electricity consumption or other parameters proposed for special monitoring.
9	Probe article	Generally not applicable, but standard methods of linking generically-interesting feedback into company and industry data must be considered.

5. POE issues for Occupiers

A POE for an occupier or owner of an existing building might be commissioned for a variety of reasons, including:

- Management desire to improve environmental and energy performance.
- Response to general or specific occupant dissatisfaction or complaints, especially concerning basic comfort, health or safety issues.
- Worries about performance in use from a facility management perspective, perhaps including space efficiency, functional performance and occupant satisfaction.
- Concerns about the building not meeting its original brief or performance specification.
- Ongoing programme of monitoring and benchmarking either by the building owners or the design team.
- Assessment of current situation, performance, perceptions and priorities before alteration, refurbishment or new construction. This would improve understanding of priorities for the network, pitfalls to be avoided, and establish benchmarks against which the success of the new work could be assessed.

The particular reason for the POE will determine its specific focus, but some procedures will be similar to the Probe approach. The scope of the investigation may range from what can be achieved from a single day site visit through to a comprehensive survey, with the detail achievable from such input depending on the size and complexity of the buildings being studied. Table 5.1 outlines possible issues in POEs for occupiers, and the parallels with the Probe procedure.

Table 5.1 POE issues for a building owner or occupier

Step	Probe process	POE for building occupier/owner
1	Seek and obtain access for study	Invitation by the host assures motivation, but hosts may also have difficulty dealing with unwelcome findings. Host requirements may differ from POE study team who may wish, say, to take samples in a different way, or to ask different questions for consistency with their databases and benchmarks. POEs may also wish to include space utilisation, cost and some aspects of aesthetic performance as well as those areas covered by Probe. These can considerably raise the level of difficulty of the project.
2	PVQ	A Probe-like PVQ could be very helpful. The current PVQ is largely technical and operational. Some PVQs may also need to ask preliminary questions about occupant satisfaction. A detailed POE, particularly of a larger or more complex building, may need a preliminary visit to make contact and collect this information. Client will often want an initial meeting in any event. For a minimal POE, it will be practically essential to receive a completed PVQ with energy data and floor plans prior to the sole site visit.
3	First site visit	As Probe, but more work will often be required on confirming the detailed nature of a building, its services and how it is operated (in Probe, much of this has been available in the original BSJ article on the building). For minimal POEs, this might be the only site visit, and it will be crucial to ensure the required host staff are available to the POE team. However, for thoroughness, two separate visits are always better: on the first visit, data flows in so rapidly, and from so many directions, that one needs time to take stock and will always miss some features which on further consideration turn out to be important. Checklist approach to ensure that essential minimum information is not overlooked. Occupants may be looking for immediate advice on how they stand in relation to peers and benchmarks; whether they have specific problems or benefits, and what they have scope to do without too much cost or difficulty.
4	Second site visit	More emphasis on looking for measures to be recommended to host rather than examining the extent of compliance with design intent, as in Probe.
5	Occupant survey	Sometimes perceived as an optional extra dependent on POE objectives, although in practice the occupant survey may often be the driver. Sometimes supplemented by extra questions on workplace performance (e.g. cleaning, fitness for purpose), costs-in-use, space utilisation as well as basic comfort issues. Occupant surveys often try to cover too much, often leading to lengthy questionnaires, low response rates and protracted data analysis. Focus groups are often a good supplement to a basic questionnaire, especially if retrospective work is being carried out on briefing, design process and design quality. The constraints of Probe have encouraged a wide-ranging occupant survey to be undertaken, analysed, reported and benchmarked much more quickly and cheaply than was possible beforehand.
6	EARM	Extent of EARM analysis will range from: · For minimal POEs: Stage 1 with some initial tree diagram analysis for typical systems, for example perhaps office lighting and main air conditioning fans. · For a comprehensive POE with emphasis on energy efficiency: the full stage 3 analysis
7	Pressure test	Optional extra. Few occupiers would probably want to pay for a routine pressure test, but if an airtightness problem was identified (through complaints, high fuel consumption or smoke pencil tests) then it would become a higher priority,
8	Report	Report should include benchmark comparisons but then focus on site specific measures that can be undertaken by host. Measures will typically be split into no, low and medium cost categories. Report unlikely to go beyond approximate estimates (e.g. budget prices from suppliers) of the likely capital costs, energy savings and energy cost savings for each measure. Detailed specification of measures and tendering for such work would be a separate exercise following review of POE by host. Length and detail of report will depend on the extent of survey. The resource pack plus summary report format looks promising.
9	Probe article	No, but reporting of key findings and benchmark figures to a national clearinghouse and database would provide added value and would allow (for example) the government to keep better tabs on energy performance statistics for statistical and regulatory purposes.

ENDNOTE

The team has considered possible aspects which may have helped Probe to be successful. These are outlined below, with star ratings in terms of their importance.

Presence of:

**** Initial BSJ article about building, vital in establishing initial relationship and fact gathering and entrée to building.
**** Established, robust base techniques for measurements and monitoring giving believable data and permitting secondary analysis.
**** Scheduled public domain outputs in BSJ.
**** Experienced and committed research team who work well together with no learning curve, well-known to the industry, with no hidden agendas.
**** Commitment, responsiveness and confidentiality of BSJ editorial staff.
*** Empirical (“need to have and efficient and useful to do”), not theoretical (“nice to have whatever the cost and difficulty”) approach to the further refinement of techniques
*** Conjecture test using benchmarked case studies rather than hypotheses synthesised by analysis of statistical data.
** Tight project management and ability to work to strict deadlines.
** Restricted budgets, meaning that methods had to be efficient and turnover fast.
** Timeliness - people are now more receptive to feedback, POEs and benchmarking than they were when Probe started.
** Support - key people now support Probe, increasingly making success self-fulfilling.

Absence of:

**** Major litigious disputes (but only just!).
*** Buildings / designs / images linked to / associated with big name designer or corporate PR.
*** Aesthetic assessment – a minefield.
*** Linkage to academic research agendas, allowing studies to be focused on the buildings concerned and the articles in BSJ.
*** Need for statistical validation for exceptions detected (both good and bad) for which the causes are clearly demonstrable and replicable.
** Cost studies - very difficult to carry out effectively.

APPENDIX A

COMPLETE LIST OF PROBE SERIES PAPERS IN BUILDING SERVICES JOURNAL (BSJ) AND THE PROBE 1 CONFERENCE

PROBE 1 BUILDING SURVEYS

P0 P Ruyssevelt, W Bordass and R Bunn
Probe - Post-occupancy review of building engineering, BSJ 14-16 (July 1995).
P1 W Bordass and A Leaman, Probe 1: Tanfield House, BSJ 38-41 (September 1995)
P2 M Standeven, R Cohen and W Bordass
Probe 2: 1 Aldermanbury Square, BSJ 29-33 (December 1995)
P3 M Standeven, R Cohen and W Bordass,
Probe 3: Cheltenham & Gloucester Chief Office, BSJ 31-34 (February 1996).
P4 R Asbridge and R Cohen
Probe 4: Queens Building, de Montfort University, BSJ 35-41 (April 1996).
P5 M Standeven and R Cohen, Probe 5: Cable & Wireless College, BSJ 35-39 (June 1996).
P6 M Standeven, R Cohen and A Leaman
Probe 6: Woodhouse Medical Centre, BSJ 35-39 (August 1996)
P7 W Bordass, A Leaman and J Field
Probe 7: Homeowners Friendly Society, BSJ 39-43 (October 1996).
P8 R Cohen, A Leaman, D Robinson and M Standeven
Probe 8: Queens Building, Anglia Polytechnic University, BSJ, 27-31 (December 1996).

PROBE 1 FINAL CONFERENCE

(Buildings in Use 1997, February 1997, papers available from CIBSE)
PC1 R Cohen, P Ruyssevelt, M Standeven, W Bordass and A Leaman
The Probe Method of Investigation.
PC2 W Bordass, R Cohen and M Standeven, Technical Review: Probe Office Buildings.
PC3 R Cohen, M Standeven and W Bordass, Technical Review: Probe Non-office Buildings.
PC4 A Leaman, W Bordass, R Cohen and M Standeven, The Probe Occupant Surveys.
PC5 W Bordass and A Leaman, From Feedback to Strategy.
PC6 R Bunn, Real World Solutions, BSJ 27-32 (April 1997).

PROBE 2 BUILDING SURVEYS

P11 M Standeven, R Cohen, W Bordass and A Leaman
Probe 11: John Cabot City Technology College, BSJ 37-42 (October 1997).
P12 M Standeven, R Cohen, W Bordass and A Leaman
Probe 12: Rotherham Magistrates Court, BSJ 25-30 (Dec 1997).
P13 M Standeven, R Cohen, W Bordass and A Leaman
Probe 13: Charities Aid Foundation, BSJ 33-39 (February 1998).
P14 M Standeven, R Cohen, W Bordass and A Leaman
Probe 14: Elizabeth Fry Building, BSJ 37-41 (April 1998).
P16 W Bordass, R Cohen, A Leaman and M Standeven
Probe 16: Marston Book Services, BSJ 27-32 (August 1998).
P17 W Bordass, R Cohen, A Leaman and M Standeven
Probe 17: Co-operative Retail Services HQ, BSJ 37-42 (Oct 1998).
P18 W Bordass, R Cohen, A Leaman and M Standeven
Probe 18: Portland Building, BSJ 35-40 (January 1999).

PROBE REVIEW ARTICLES IN BUILDING SERVICES JOURNAL (BSJ)

P9 W Bordass, R Cohen and M Standeven
Probe 9: Energy and Engineering Technical Review, BSJ, 37-41 (April 1997).
P10 A Leaman, Probe 10: Occupancy Survey Analysis, BSJ, 37-41 (May 1997).
P15 A Leaman and W Bordass
Probe 15: Productivity in buildings: The Killer Variables, BSJ, 41-43 (June 1998).
P15A R Bunn, Probe feedback, BSJ 44 (June 1998).
P19 Probe 19: Designer feedback, BSJ 35-38 (March 1999).

APPENDIX B

THE PROBE METHOD OF INVESTIGATION

This paper on Probe was given to the Probe Conference, Buildings in Use 1997
Commonwealth Institute, London, March 1997
Sponsors: BRECSU, Building Services Journal and CIBSE

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1 INTRODUCTION

1.01 Few people would question the educational value of structured feedback from occupied buildings. Such information is vital to help new buildings meet client and user expectations, particularly given the heightened interest in health and welfare of building occupants. Reader research by the *CIBSE Journal* has revealed that the services industry is crying out for such information. A two-year research project to bring CIBSE Journal readers up to date on how buildings featured previously in the magazine have actually performed in practice is being undertaken with support from the DoE's Construction Sponsorship Directorate under its Partners in Technology programme. The PROBE (Post-occupancy Review Of Building Engineering) project is a joint initiative between the CIBSE Journal, HGa Consulting Engineers, William Bordass Associates (WBA) and Building Use Studies Ltd (BUS).

1.02 HGa and WBA undertake the main investigations and co-ordinate inputs from other investigators, particularly occupant surveys by BUS. Articles based on the PROBE reports appear at two month intervals in the CIBSE Journal. As the PROBE studies are of buildings analysed by the *CIBSE Journal* at the time of completion, readers can compare performance in use with the original design objectives. The overall aim of the exercise is to provide designers with evidence of the success or otherwise of the performance of particular designs in practice with a view to improving the standard of future designs.

1.03 The buildings studied by PROBE range from air conditioned and non-air conditioned offices to teaching facilities and a health care centre. All buildings studied have been occupied for at least two years but for no more than seven years. This allows sufficient time for the youngest buildings to have settled down and for any initial problems to have been ironed out, while the upper limit rules out buildings which are no longer of topical interest.

1.04 This paper describes the method of investigation employed in the PROBE studies and provides a commentary on its application in practice.

2 SCOPE OF EACH INVESTIGATION

2.01 Figure 1 shows how each PROBE investigation is carried out. The aim of each assessment is to cover a full range of post-occupancy issues:

- design and construction, in particular any innovative features, both technical and in terms of client requirement;
- design integration;
- the effectiveness of the procurement;
- methods of construction, installation, and setting to work;
- initial occupation of the building and, in particular, testing, commissioning, handover, fit-out and move-in;
- any unexpected requirements, changes and teething problems.

2.02 In practice, it has sometimes proved difficult to identify client procurement methods either because individuals are no longer around or where the building was speculative.

2.03 User issues receive particular attention, specifically how occupants and management perceive the building as a whole, its engineering systems, and levels of occupant comfort, productivity and well-being.

2.04 PROBE also tries to unravel how the buildings and their services are being operated, controlled and maintained. Have the intentions of the client and the designers been achieved; have there been any management problems or effects on running costs and system reliability; and if so have they been resolved?

2.05 Analysis of energy performance forms a major part of the work, as do the control, management, durability and maintenance requirements of the building services. Where possible these are compared with occupant expectations, design intentions and good practice benchmarks, for example Energy Consumption Guide 19 for offices [1]. As the project has progressed new benchmarks have been established which may be useful to other investigators. Some of these benchmarks are discussed in [2]

2.06 Changes to the building, its services and occupancy levels including any alterations, extensions, replacements, and internal reorganisation are examined. The reasons for any changes are sought and compared with expectation in the brief and provision in the design.

2.07 At the conclusion of each study, the investigators identify the key messages and compare each building's performance with similar buildings and current best practice in energy performance and occupant satisfaction. These are intended to assist engineers, architects and their clients to build upon the good features, to avoid those that have proved unhelpful and to improve upon those which show potential for further development.

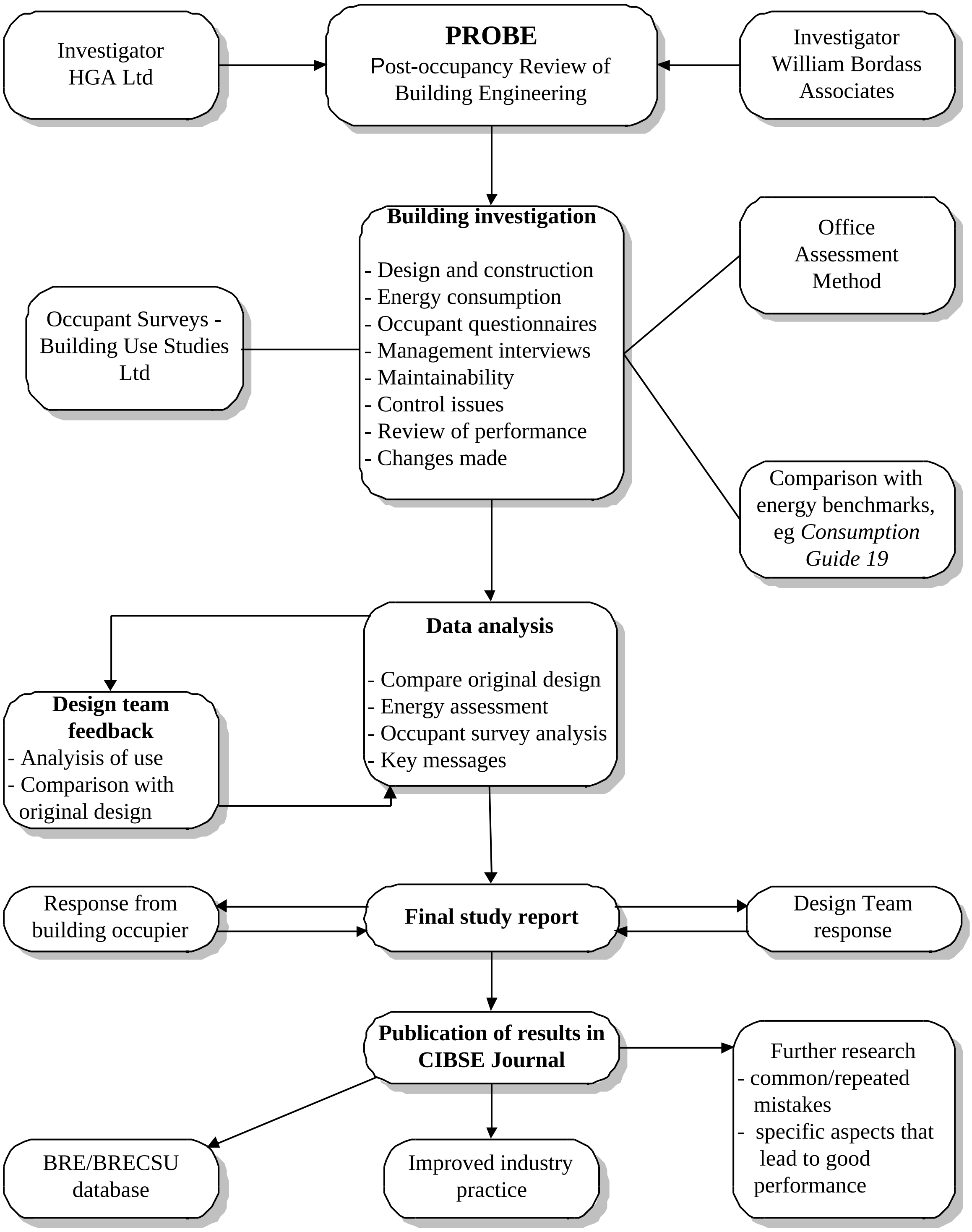

Figure 1 PROBE Investigative Method

3 STUDY PROCEDURE

3.01 When a suitable building has been identified and approval obtained from the occupier, the investigators study the building's original design intent, particularly any background material used in preparing the first building analysis article. The building manager is then requested to supply any missing information and identify any changes to the building, its use and equipment that may have occurred since completion.

3.02 Energy data in the form of utility bills, manual meter readings or electronic data from a BEMS is requested at this stage.

3.03 Facilities managers are also asked to annotate the earlier CIBSE Journal article which describes the building, adding their comments based upon today's perspective, and identifying what they regard as major strengths and weaknesses of the building and its services.

3.04 Ideally once this preliminary material has been received and reviewed, the investigators visit the building and apply a range of proven energy reporting and assessment procedures. They also carry out structured interviews with those responsible for managing the building and maintaining its services and brief BUS on any special requirements for the occupant questionnaires. This usually takes two people one day on site, plus one or two return visits depending upon the size and complexity of the building. The detailed nature of the surveys and the type of information sought by the survey team has surprised some of the building managers. In some cases it has not been possible to obtain all the information required in the time available.

4 SURVEY METHODS

4.01 Survey forms and procedures are standardised as far as possible, and this has been easiest for offices. In other buildings, PROBE had to adapt the office method and to seek appropriate benchmarks and research tools for the sector.

4.02 Under the DoE's Energy-Related Environmental Issues (EnREI) research programme, BRE has been developing a prototype procedure for collecting, assessing and reporting energy use in occupied non-domestic buildings, the Energy Assessment and Reporting Methodology (EARM) [3].

4.03 Table 1 demonstrates the modular basis of EARM, which can be tailored to fit a particular building and the level and extent of an energy survey. Essentially the research principles enable:

- a detailed assessment of energy use;
- a level of accuracy to be established;
- apportionment between end uses;
- indices for comparison with sector norms.

4.04 A prototype application of EARM has already been developed called the Office Assessment Method (OAM). This in turn was developed from procedures used in energy case studies of offices by Consultants working for the Building Research Energy Conservation Support Unit (BRECSU). Described in figure 2, OAM differs from most methods as it is iterative and contains in-built quality checks. Users are directed towards collecting only the information they really need for the purpose in hand. This helps to improve speed, accuracy, consistency, and productivity. There are plans to produce a CIBSE Applications Manual on the OAM.

Table 1: Investigation stages, modules and quality criteria of the EARM		
Stage		Tick box if required
1	Building performance analysis using simple energy consumption indices	
1A	Assess accuracy of data and analysis	
1B	Assess the need for further investigation	
2	Preliminary explanation of performance	
2A	Develop normalised performance indices	
2B	Analysis of building fabric systems and operation	
2C	Analysis of detailed energy consumption records	
2D	Preliminary assessment of energy by end-use	
2E	Assess accuracy of data and analysis	
2F	Assess the need for further explanation	
3A	Confirm critical building data	
3B	Calculate energy consumption by end-use and reconcile against metered data	
3C	Explain energy end-use consumptions	
3D	Assess accuracy of data and analysis	
3E	Assess the need for further investigation	

4.05 Most of the offices within PROBE have been analysed through all three stages of the OAM. The stage 3B method of detailed reconciliation of metered energy use against end-use has been employed to calculate the breakdown of electricity consumption in all the buildings.

4.06 The PROBE project has piloted the Office Assessment Method, particularly on air conditioned offices. Application of OAM to the PROBE project has been supported by funding from BRECSU and a report has been produced providing feedback on its use in practice.

4.07 Occupant Questionnaires are used to determine levels of user satisfaction and to compare them with BUS's national benchmarks. To ensure a significant sample of users are surveyed at least 100 completed questionnaires are sought in each building.

4.08 Response rates of typically 90% or more have been achieved by handing out questionnaires in the morning and collecting them at an agreed time in the afternoon, with a second collection for any stragglers.

4.09 Considerable effort has resulted in an agreed short, standard and modular questionnaire which is being employed on PROBE. This has been developed from questionnaires already used by BUS [4] and BRE [5]. In some buildings a second questionnaire developed by UMIST [6] has also been distributed. The occupancy survey has been very successful in quantifying the subjective assessment of each building and it is hoped it will become an acceptable add-on module to the OAM for wider use.

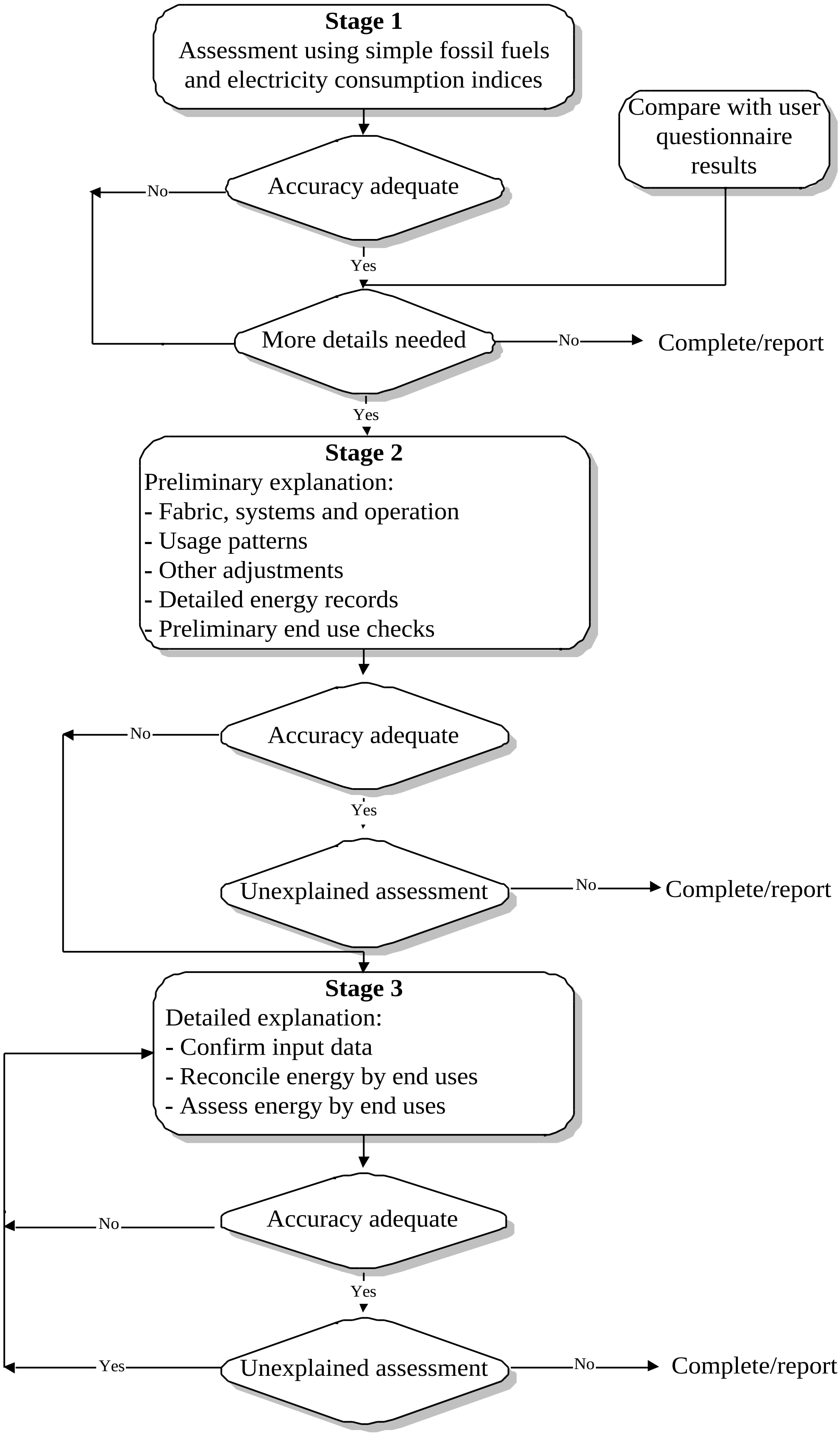

Figure 2 The Structure of the Office Assessment Method (OAM)

5 PROBE BUILDINGS

5.01 The first group of PROBE investigations (PROBE 1) involved the eight buildings set out in the table 2 below. The buildings comprise four air conditioned offices, two university buildings, a training college and a medical centre.

Table 2 PROBE Buildings Investigated

Building	Type	Article date
Tanfield House	Headquarters office building	September 1995
Aldermanbury Square	Speculative office building	December 1995
Cheltenham & Gloucester Chief Office	Headquarters office building	February 1996
Queen's Building DeMontfort University	Academic teaching building	April 1996
Cable & Wireless Training College	Residential training centre	June 1996
Woodhouse Medical Centre	Doctors and Dentist Surgery	August 1996
Gardener House (HFS)	Headquarters office building	October 1996
Queens Building, Anglia Polytechnic	Learning Resource Centre	December 1996

A further phase of PROBE (PROBE 2) is due to start in April 1997.

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7 REFERENCES FOR APPENDIX B

1. Energy Consumption Guide 19, Energy Efficiency in Offices, A Technical Guide for Owners and single tenants, UK Energy Efficiency Office (October 1991)

2. Bordass W T, Cohen R R and Standeven M A, Technical Review: Probe Office Buildings, Buildings in Use 97, CIBSE Conference (25 February 1997).

3. Field J W, Jones P G, Bordass W T and Grigg P F comparing non domestic buildings and their Energy Use. CIBSE National Conference Proceedings, Brighton, UK Volume I 203-207 (2-4 October 1994).

4. Leaman A J, User Satisfaction, in David G, Gray J, Kernaton D, Isanes N and McIndoe G, Building Evaluation Techniques. McGraw - Hill (1996).

5. Raw G J, A questionnaire studies of sick Building syndrome. BRE TC Report TC 6/95 (January 1995)

6. Levermore, G J, Occupants Assessments of Indoor Environment, questionnaire and rating score method, BSERT 15(2) and 113-118, 1994.

APPENDIX C

REFERENCES FOR REPORT 1
Review of the Probe Process

[1] G J Raw, *A questionnaire for studies of sick building syndrome,* BRE Report TC 6/95 (January 1995).

[2] Energy Consumption Guide 19, *Energy Use in Offices,* BRECSU for DETR, (February 1998).

[3] *Buildings in Use '97, Results from the Probe Research Project,* CIBSE (February 1997).

[4] As proposed, for example, in Reference 1.

[5] *Use of EARM OAM in Probe*, HGa report to BRECSU, (January 1997).

[6] CIBSE Technical Memorandum 22: *Energy Assessment and Reporting Methodology: Office Assessment Method*, CIBSE (1999)

[7] Probe Review 1999 *Report 2, Technical Review,* The Probe Team (1999)

[8] Probe Review 1999 *Report 4, Strategic Conclusions*, The Probe Team (1999)

[9] *Probe 19: Designer Feedback",* Building Services (March 1999).

[10] *A Guide to the Standard Form of Agreement for the Appointment of an Architect*, RIBA Publications (1992).

[11] G L Race et al, *Application Guide AG21/98, Feedback for better building services design,* BSRIA (1998).