Eli Lilly Research Office Building

This document contains a Building Performance Evaluation report from the £8 million Building Performance Evaluation research programme funded by the Department of Business Innovation and Skills between 2010 and 2015. The report was originally published by InnovateUK and made available for public use via the building data exchange website hosted by InnovateUK until 2019. This website is now hosting the BPE reports as a research archive. As such, no support or further information on the reports are available from the host. However, further information may be available from the original project evaluator using the link below.

Innovate UK project number	450058
Project lead and author	AECOM
Report date	2013
InnovateUK Evaluator	Unknown (Contact via www.bpe-specialists.org.uk)

Building sector	**Location**	**Form of contract**	**Opened**
Offices	Windlesham.	Traditional	2012
Floor area	**Storeys**	**EPC / DEC**	**BREEAM rating**
Main building: 2150 m^2	2	B (46) / N/A	Excellent

Purpose of evaluation

The purpose of the BPE study intended to establish the robustness of the procurement process, evaluate changes that led to any discrepancy between as-designed and as-built, establish the performance of the research office building mixed-mode ventilation strategy, identify key issues with building systems and operations, evaluate the effects of build quality and operations on occupant thermal comfort and productivity, determine the energy and water consumption, and develop an improvement action plan to address and rectify any issues identified.

Design energy assessment	**In-use energy assessment**	**Electrical sub-meter breakdown**
No	Yes, but not reported	No

No energy data is reported from the CIBSE TM22 assessment beyond histograms.

The sub-metering configuration ensured an appropriate level of energy use breakdown such that different end-uses could be separately reviewed and analysed. However, not all energy uses were metered and not all meters were being recorded on the monitoring and targeting system.

Occupant survey	**Survey sample**	**Response rate**
BUS (type not reported)	Not reported	N/A

A BUS-based survey was carried out before the occupants designated move from their original building, the EMC, to the ROB. This survey was conducted to establish a baseline user satisfaction with their original workplace accommodation. A second survey was conducted in the new building.

The report carries no deep analysis of the occupant surveys, beyond stating that is was ‘BUS-based’.

Innovate UK is the new name for the Technology Strategy Board - the UK's innovation agency. Its role is to fund, support and connect innovative British businesses through a unique mix of people and programmes to accelerate sustainable economic growth.

For more information visit www.innovateuk.gov.uk

About this document:

This report, together with any associated files and appendices, has been submitted by the lead organisation named on the cover page under contract from the Technology Strategy Board as part of the Building Performance Evaluation (BPE) competition. Any views or opinions expressed by the organisation or any individual within this report are the views and opinions of that organisation or individual and do not necessarily reflect the views or opinions of the Technology Strategy Board.

This report template has been used by BPE teams to draw together the findings of the entire BPE process and to record findings and conclusions, as specified in the Building Performance Evaluation - Guidance for Project Execution (for domestic buildings) and the Building Performance Evaluation - Technical Guidance (for non-domestic buildings). It was designed to assist in prompting the project team to cover certain minimum specific aspects of the reporting process. Where further details were recorded in other reports it was expected these would be referred to in this document and included as appendices.

The reader should note that to in order to avoid issues relating to privacy and commercial sensitivity, some appendix documents are excluded from this public report.

Technology Strategy Board
Driving Innovation

Contents

Technology Strategy Board
Driving Innovation

1 Introduction and overview

This section of the report is an introduction to the scope of the BPE and includes a summary of the key facts, figures and findings

Eli Lilly has procured the construction of two buildings on the site of an old demolished asset. The planning application consisted of a 2400 m² general office building and a 2100 m² cafeteria/restaurant. This is part of a much larger development plan at the Lilly Research Centre at the Erl Wood Manor site in Windlesham.

The construction of the general office building, known as the Research Office Building (ROB), began January 2011 with design conception started in 2008. Figure 1 is a photograph of the completed ROB taken from its West elevation, where the main entrance is located.

Figure 1 Photograph of the finished ROB

The ROB features an innovative mixed-mode ventilation and space conditioning system, which had sparked the client's interest in its performance on thermal comfort and energy use in comparison to their other building stock in the site. The client has embarked on this experimental project to try to meet their aspiration for low energy buildings, in-line with the company's overarching environmental policy, and would like justification and evidence that the investment has paid off. This Building Performance Evaluation (BPE) project was set up to address this for the client.

The purpose of the BPE study is multi-faceted and intended to achieve the following:

- establish the robustness of the procurement process the ROB went through

- evaluate changes that led to discrepancy between as-designed and as-built building
- establish the performance of the ROB employed mixed-mode strategy
- identify key issues with building systems and operations
- evaluate the effects of build quality and operations on occupant thermal comfort, productivity and its energy and water use
- develop an improvement action plan to address and rectify the issues identified

The scope of the BPE Phase 1 study can be divided into several categories:

Stages	Task code	Task description
Commissioning	COM1	Design review covering the process of design, procurement and operation of the building
	COM2	Review of plans for commissioning
	COM3	Review of commissioning & testing management, planning, procedures and test documentation
HandOver	HO1	Review of Pre-Handover and Handover planning and procedure documentation
	HO3	Review of O&M manuals and documentation, and log book
Post Completion Monitoring	PCM1	Evaluation of ventilation system, heat pumps and BMS and controls
	PCM2	Metering of operational energy use of individual systems and large equipment
	PCM3	Evaluation of building fabric performance, including thermal imaging and air tightness test
	PCM4	Social evaluation of commissioning, handover and modifications stages
	PCM5	Initial Improvement Action Plan
Early Occupancy	OCC1	Review of tenant user guide and tenancy agreement, plus training
	OCC2	Review of thermal models and EPCs
	OCC3	Review of building sustainability performance
	OCC4	Monitoring of whole building energy and water consumption
	OCC5	TM22 assessment. Evaluate interactions between systems.
	OCC6	Monitoring and evaluation of rainwater harvesting system
	OCC7	Monitoring and evaluation of offices in use, including IT
	OCC8	Tenant social evaluation in previous building
	OCC9	Tenant social evaluation and building manager (Arup BUS)

Each of these tasks is accompanied by corresponding technical notes, which have been appended in the Appendix Section. These technical notes will be referenced in the relevant texts throughout this report. There will be a dedicated table at the end of each section to summarise the technical note referencing.

The following are the key facts about the ROB:

- The conception of the ROB was carried out using the traditional RIBA Stages procurement route
- A change in design and servicing scheme from a fully air-conditioned to a mixed-mode building was driven by the clients aspiration for a low energy building, and further motivated by the success of examples in a real life building presented to the client
- The mixed-mode strategy consists of the integration of Passivent's stack ventilation system and an innovative simultaneous heating-cooling and heat recovery VRF system from Mitsubishi via the control strategy developed by Severn Controls
- The ROB is currently lowly occupied, below its as-designed occupancy specification

Technology Strategy Board
Driving Innovation

The BPE project has highlighted the following key findings as summarised below:

- There have been issues with the building during its first year of operation, linked to problems in the construction process
- The BMS and controls of the building have been the main issue since handover and have led to problems with other related aspects of the building, in particular occupant complaints about being either too hot or too cold
- A considerable level of improvement has been introduced to the building during the course of the BPE project, some as a direct a result of the project discovery and intervention, which has led to improvements and will benefit the client in the long term. The simplest example was the energy use of a door air curtain that has now been stopped for normal circumstances as it was using a disproportionate amount of energy.
- The low occupancy in the building has influenced energy and water use, which are relatively low compared to benchmarks. However more could be being achieved.
- Going forward it is recommended that the water and energy use of systems is monitored at regular intervals as the building settles into normal operation, to ensure that the learning from this study is being best used to reduce operational energy and cost.

A full discussion of proposed future actions is given in Sections 8 and 9.

Further related details can be found in the following:

Appendix	Description
A1	COM1 - Design review covering the process of design, procurement and operation of the building

2 Details of the building, its design, and its delivery

This section summarises the building, its design and how it was delivered. It includes discussion on how well the design process has worked.

2.1 Building design

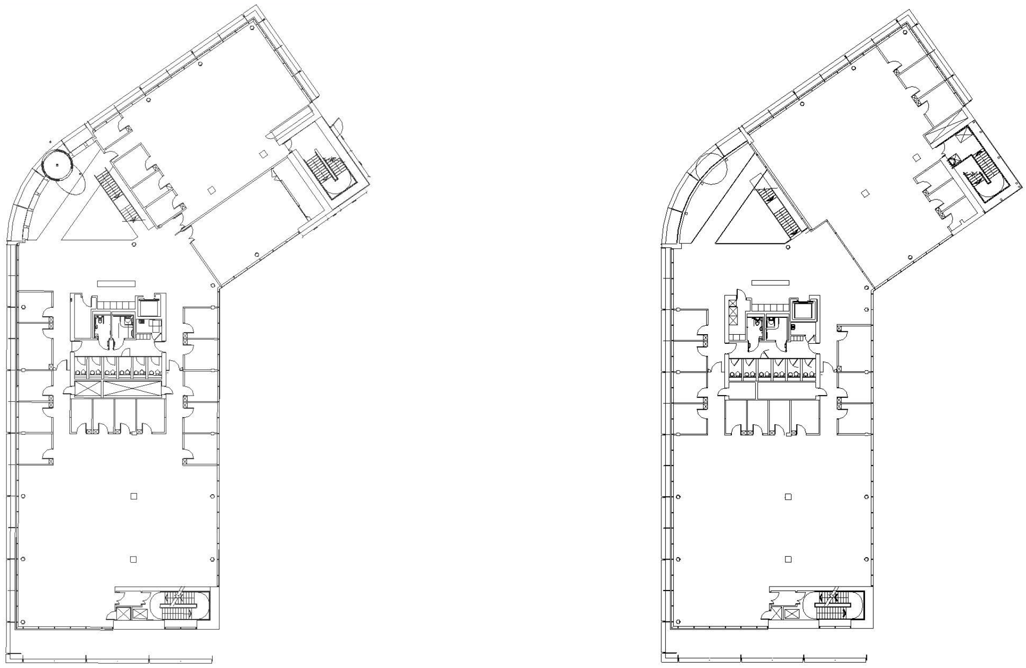
The Eli Lilly Research Office Building (ROB) completed in March 2012, is a 2-storey 2,150m² independent building constructed using a steel frame. In-keeping with the sustainable and low carbon design strategy, the building utilises form and orientation to try to achieve an environmentally low impact building. The external envelope consists of predominantly a curtain walling system with external overhangs incorporated onto the building facade to provide shading and limit unwanted solar gain. The building envelope has been designed to achieve a high thermal performance utilising lightweight external cladding and solar control glazing.

The building orientation as shown in Figure 2 further optimises on solar gain and overheating mitigation. Its narrow aspect ratio promotes the provision of good level of natural daylight into the internal spaces of the floor plates and complements the use of mixed-mode ventilation and conditioning strategy.

The ROB nestles within the green surroundings of the Lilly Erl Wood Manor site, with trees providing natural shading, access to fresh outside air and natural south-westerly breeze. The ROB has been constructed with an architecture which is consistent with the neighbouring EMC building and its build and form are sympathetic towards its ecological surrounding, helping to preserve a local bat colony. Access to the ROB is via footpath and there is a cycle storage facility in the vicinity, complemented by the provision of showering facility within the ROB.

Figure 2 The ROB building orientation at the Windlesham site

The ROB houses general open plan office spaces on both storeys with cellular office and meeting rooms mostly along its perimeter with some situated in its cores. Figure 3 shows the ROB floor layout for both levels. The ROB workplace design concept was modelled on Eli Lilly America's new workplace strategy (open plan office areas, focus booths etc), which placed focus on the users of the building.



Ground floor First floor

Figure 3 The ROB floor layout

The ROB accommodates desk-based staff most of who have been relocated from the adjacent EMC building. There is a significant number of contracted and travelling staff, which led to high fluctuation in building occupancy and a generally lightly occupied building. The initial aspiration was to accommodate new staff in the ROB; however, the recruitment move was downsized somewhat leading to a reduced staff allocation. The table below summarises the level of occupancy in the ROB.

Table 1 Occupancy level in the ROB

Description	Number of people
ROB design occupancy level	130
Actual allocated staff members	78
Daily average occupants in the building	40

The ROB was first conceived in a site-wide development master plan, during which it was expected to be fully air-conditioned. Further development of its design by subsequently appointed design team has led to the client deciding on the use of mixed-mode strategy to service the ROB with a chilled beam scheme coming in as a close second. Analysis carried out concluded that the mixed-mode strategy will help the client deliver the low energy building they wanted. Specifically, visits to similar real buildings have influenced the client's final decision to adopt this scheme for the ROB. This subsequently led to the procurement of a consortium of providers to deliver an integrated system whereby the mixed-mode ventilation system supplied by Passivent is linked with the VRF space conditioning system from Mitsubishi via control system developed by Severn Controls.

Essentially, there have been varying degrees of changes to the building throughout the design phase, whilst some elements have been preserved. The most significant change is a switch from a fully air conditioned to a mixed-mode servicing strategy, in-line with the client's aspiration for a low energy building.

The ROB's as-build Energy Performance Certificate (EPC) rating is 'B46'. Although a BREEAM assessment was not formally pursued, a pre-assessment was carried out by a trained assessor and an indicative rating of "Excellent" was achieved.

2.2 Project delivery

Malcolm Scrace, the Lilly's site project manager presented the client's brief to the design team detailing their aspiration and gave an overview of the overarching site development plan, which entails the construction of the ROB. The ROB has taken the traditional single stage RIBA design, procurement and construction route. The design team has been involved with the client since inception and at Stage H, assisted with the tender process, which led to the appointment of the main contractor as illustrated in Figure 4.

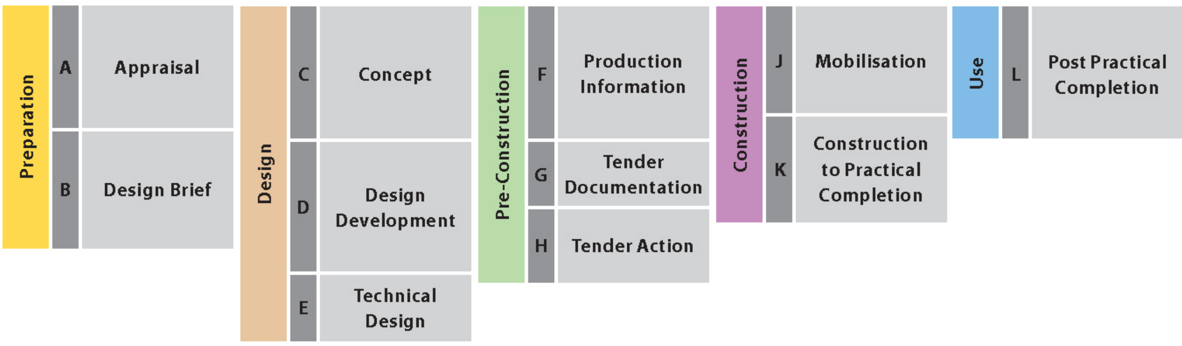


Figure 4 The traditional RIBA Stage design, procurement and construction route taken by the ROB

The main contractor, Miller Construction Group was selected based on cost and previous experiences with low energy buildings as indicated in their bid documents. The main contractor then recommended their choice for the main M&E contractor based on their past partnership and also their relevant experience in naturally ventilated buildings and construction in the pharmaceutical industry. Other suppliers and contractors have been chosen based on named-supplier for specific services already procured for other buildings at site. The chart in Figure 5 shows the main stakeholders involved in the delivery of the ROB. For more details regarding the tender and procurement process, please refer to Appendix A1 and A9.

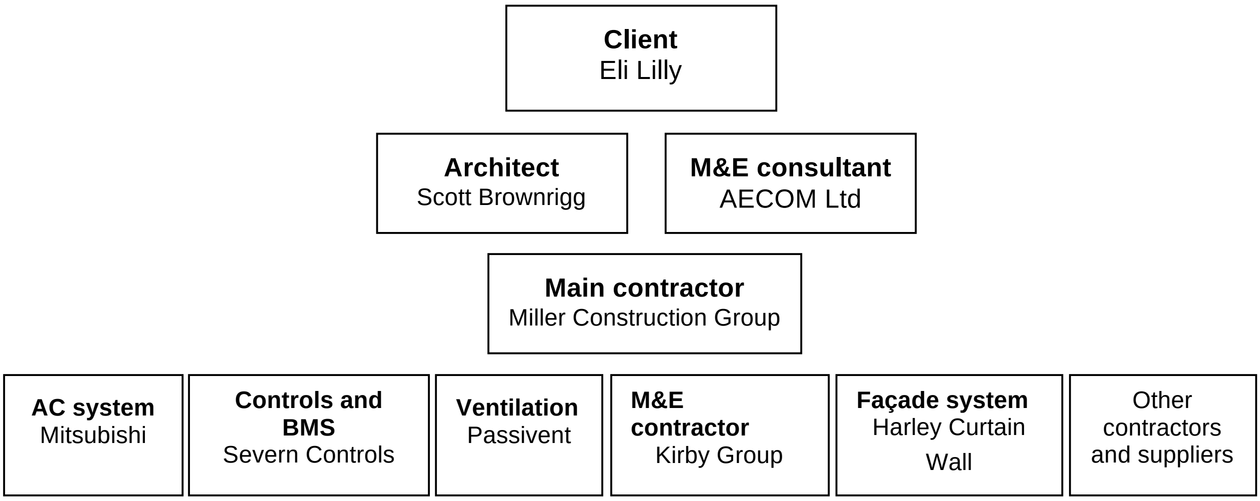


Figure 5 Chart of the main stakeholders involved in the delivery of the ROB

2.3 Conclusions and key findings for this section

The review of relevant documents and the outcome from stakeholder questionnaires and interviews have led to the following key findings:

<u>Procurement and construction phase</u>

- In general, the traditional RIBA Stage approach appears to have been robustly implemented
- The issue of whether the right staff with the appropriate skills as advertised by the contractors were actually on site and working on the project. The client felt that personnel at site did not necessarily understand what they were delivering in the context of the overall building design. This was somewhat inconsistent with what was advertised in the contractor's bid document, where the contractor has claimed expertise in low energy buildings
- Issues found include:
  - There was a delay to the start of work at site outside the Contractor's control involving ground preparation works, which had a considerable impact on their mobilisation at site and subsequently the deliverability of the project by the agreed date
  - There was an overall deficiency in coordination and planning for the construction work. This issue was raised by the client and the M&E consultant
  - A change to essentially all key members of the project team:
    - A change of both main contractor project manager and deputy project manager
    - A change of lead design engineer
    - A change of lead architect
  - The lack of good and consistent record-keeping and documentation
  - Slight deficiency in effective and adequate communication to all teams involved

- The main contractor felt that the designers have treated the build more like a design & build where there was no clear brief to follow. This project has a significant amount of Contractor Design Portion (CDP), which the client was not in favour off.
- The aftercare services by contractors have generally been good, with quick response to faults and defect reports. This was partly due to the M&E contractor being largely at site for refurbishment work on other buildings. However, response in resolving the building controls issue was slow at one period of time.

It seems likely that the approach to the Contractor Designed Portions in this project, particularly relating to the ventilation system, have resulted in the problems seen in early performance. For future projects much more careful identification and specification of these CDP elements must be made to avoid similar problems.

Commissioning and testing phase

- Inadequate time has been allocated for commissioning and testing, where work was carried out whilst the building was still being completed
- Failure to close off sections of the building has resulted in incomplete commissioning and unreliable test outcomes
- The building was handed over to the client with outstanding issues, mainly in relation to the BMS and control system
- The Operation and Maintenance (O&M) manual was delayed and incomplete despite being checked by the main contractor. In general, the O&M has irrelevant information; specifically, general product brochures and literature were included but did not necessarily relate to the actual product or model installed in the building. The quality and scarcity of information implies lapse of information during construction phase and the O&M will ultimately impact on the maintenance efforts of the building
- Electronic version of the O&M manual may seem a good idea at the start; however, the client has raised that this now comes with hidden costs when needing to update the manual with changes made to the building
- The main M&E contractor, Kirby felt that the building log-book should instead be completed by the M&E consultant and the architect

Further related details can be found in the following:

Appendix	Description
A1	COM1 - Design review covering the process of design, procurement and operation of the building
A2	COM2 - Review of plans for commissioning
A3	COM3 - Review of commissioning & testing management, planning, procedures and test documentation
A4	HO1 - Review of Pre-Handover and Handover planning and procedure documentation
A5	HO3 - Review of O&M manuals and documentation, and log book
A8	PCM3 - Evaluation of building fabric performance, including thermal imaging and air tightness test
A9	PCM4 - Social evaluation of commissioning, handover and modifications stages
A12	OCC2 - Review of thermal models and EPCs
A13	OCC3 - Review of building sustainability performance

3 Review of building services and energy systems.

This section describes the building services and energy systems, and identifies the key questions to be addressed later.

3.1 Energy systems in the ROB

The ROB is an all-electrical building with no provision of gas to the building. Space conditioning (heating and cooling) and the provision of hot water are through electrical means within the building using a VRF heat pump system.

The ROB also features water circuit trench heating for its atrium double height glazing and an electric air curtain along its main double-door entrance. Stairwell heating is through the use of direct electrical heaters. The building contains a dedicated Comms/IT room, which requires continuous cooling and a kitchenette on each floor in the core zone, which are served by a number of electrical appliances:

- Hot water dispenser
- Chilled water dispenser
- Refrigerator
- Freezer
- Dishwasher
- Vending machine
- Microwave machine

Within the office space, typical IT equipment lines the work desks such as desktop computers and laptops, all with dedicated monitor screens and docking stations. Printers, copiers and document shredding machines are located in the central core on both floors.

3.2 Ventilation system

The provision of fresh air into the ROB is carried out through a series of motorised façade louvres, which replace stale air exhausted through actuated dampers in the stack columns. On warm and still days, ventilation is enhanced through the use of booster fans within the stack columns. Figure 6 illustrates the mixed-mode ventilation strategy employed in the ROB.

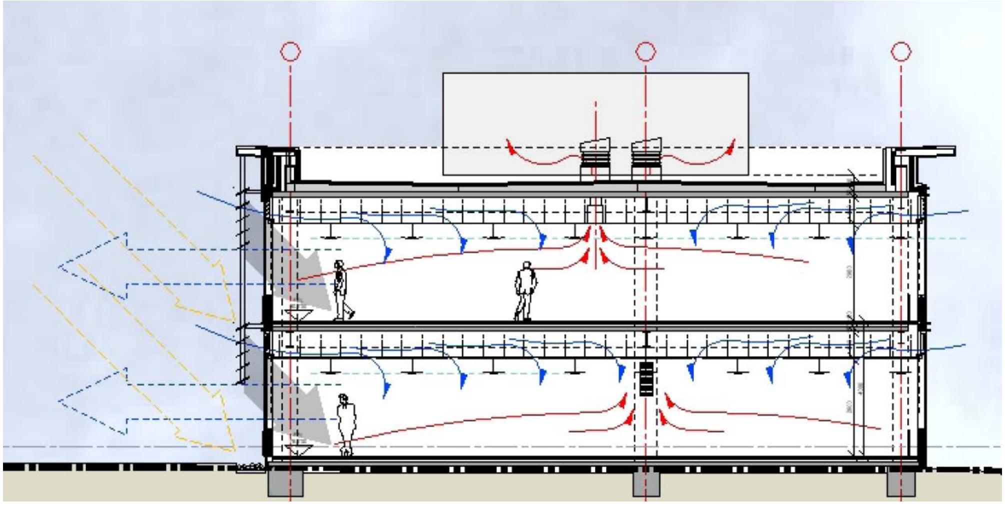


Figure 6 Illustration of the mixed-mode ventilation strategy employed in the ROB showing the expected exhaust and fresh air flow paths

Whilst predominantly mixed-mode, the ROB also has a series of mechanical extract system to ensure adequate provision of ventilation to its cellular and internal rooms. The small conference room is serviced by a small AHU for mechanical supply and extract.

3.3 Lighting system

The ROB has been specified with a high-standard of lighting using efficient luminaires and effective design of lighting controls. The overall lighting efficacy met and exceeded the applicable Building Regulations requirements. The ROB generally has good provision of natural daylight through its façade. Coupled with good design and implementation of occupant presence control and where possible daylight dimming, the energy associated with artificial lighting should be well-managed.

3.4 Air conditioning system

Based on the mixed-mode operation regime for the ROB, when external conditions are below 16°C and above 25°C, the building will revert to the use of mechanical means for provision of space heating and cooling, such that the building is not reliant on the ventilation alone to provide temperature control. The Mitsubishi Variable Refrigerant Flow (VRF) air source heat pump system has been installed in the ROB, in which multiple condenser units serving their respective zones in the building could provide simultaneous heating and cooling according to demand. The system also features the recovery of waste heat from the Comms/ICT room for space heating or to supplement the generation of hot water, where two dedicated heat pump boilers further boost the water to the required temperatures.

3.5 Rain water harvesting system

The rain water harvesting (RWH) system was proposed by the client and has been a feature in the ROB design from the start, as part of the overall site remit for water conservation. The installed RWH system collects rain run-offs from the building roof in a large buried storage tank for the provision of toilet flushing in the ROB as well as the planned future adjacent restaurant building. Any surplus run-offs are used for landscaping watering. This system is metered to ascertain the extent of water saving that can be achieved.

3.6 BMS and control system

The BMS and control system in the ROB is based on the TREND system installed and commissioned by the supplier, Severn Controls. This is in conjunction with the procurement of an integrated ventilation and air conditioning system. Previous examples of such integration have demonstrated successful implementation and this was a driver that influenced the client to commission such installation for the ROB.

3.7 Key findings for this section

A review of the features and systems in the ROB indicated the following were intended from the design:

- The use of mixed-mode ventilation strategy and therefore the associated systems should lead to a low energy building
- Being an all-electric building, the overall CO_2 emissions from the ROB could be higher than if it uses a fossil-fuel based source to meet its heating demand, however, the higher efficiency expected from the use of heat pump should mitigate this
- The rain water harvesting system should lead to a significant reduction in fresh water use
- The efficient lighting system installed in the ROB is expected to bring about significant savings in lighting energy
- The use of heat pumps, mixed-mode ventilation strategy, high efficiency lighting and a rain water harvesting system are features that are consistent with the client's sustainability remit and overarching site environmental policy.

The discussion of the findings of the review of these systems for energy and water use is in Sections 6 and 7. Further related details can be found in the following:

Appendix	Description
A6	PCM1 - Evaluation of ventilation system, heat pumps and BMS and controls
A7	PCM2 - Metering of operational energy use of individual systems and large equipment
A13	OCC3 - Review of building sustainability performance
A16	OCC6 - Monitoring and evaluation of rainwater harvesting system

4 Key findings from occupant survey

This section records a summary of what has been learnt from interviews with building users and the occupant survey.

4.1 Introduction

A building is needed to accommodate its occupants and protect them against the outside elements, whilst providing the necessary condition for thermal comfort and facilitating their function and productivity. It is essential to understand whether these objectives have been met and any necessary improvements are identified to ensure a building fit-for-purpose to its users. In this study, building user surveys have been carried out for:

- The designated users in their original building before the move to the ROB
- Occupants approximately one year after the move to the ROB

4.2 Occupants in their original building

At the start of the study, a BUS-based survey was carried out before the occupants designated move from their original building, the EMC, to the ROB. This survey was conducted to establish a baseline user satisfaction with their original workplace accommodation. Subsequently, this baseline will be used to identify the change presented by the ROB and to determine whether any improvement is genuine relative to the original building or have already been provided for in the original building, effectively meaning no real change.

The chart in Figure 7 below summarises the main outcome of the BUS carried out on the EMC building. For more details, please refer to report in appendix A18. In general, it can be seen that the occupants were reasonably satisfied with the accommodation provided by the EMC building. The EMC building is shown to be within the typical norm in comparison to the database averages and ranges.

However, there are minor shortfalls that came to light in some of the specific aspects surveyed. Some occupants highlighted undesirable disruption from internal noise and glare from artificial lighting. A proportion of the occupants also indicated that the building was slightly cold in the winter as well as the summer periods. There was a general dissatisfaction with the level of controls available to them for space conditioning set-point, lighting and ventilation.

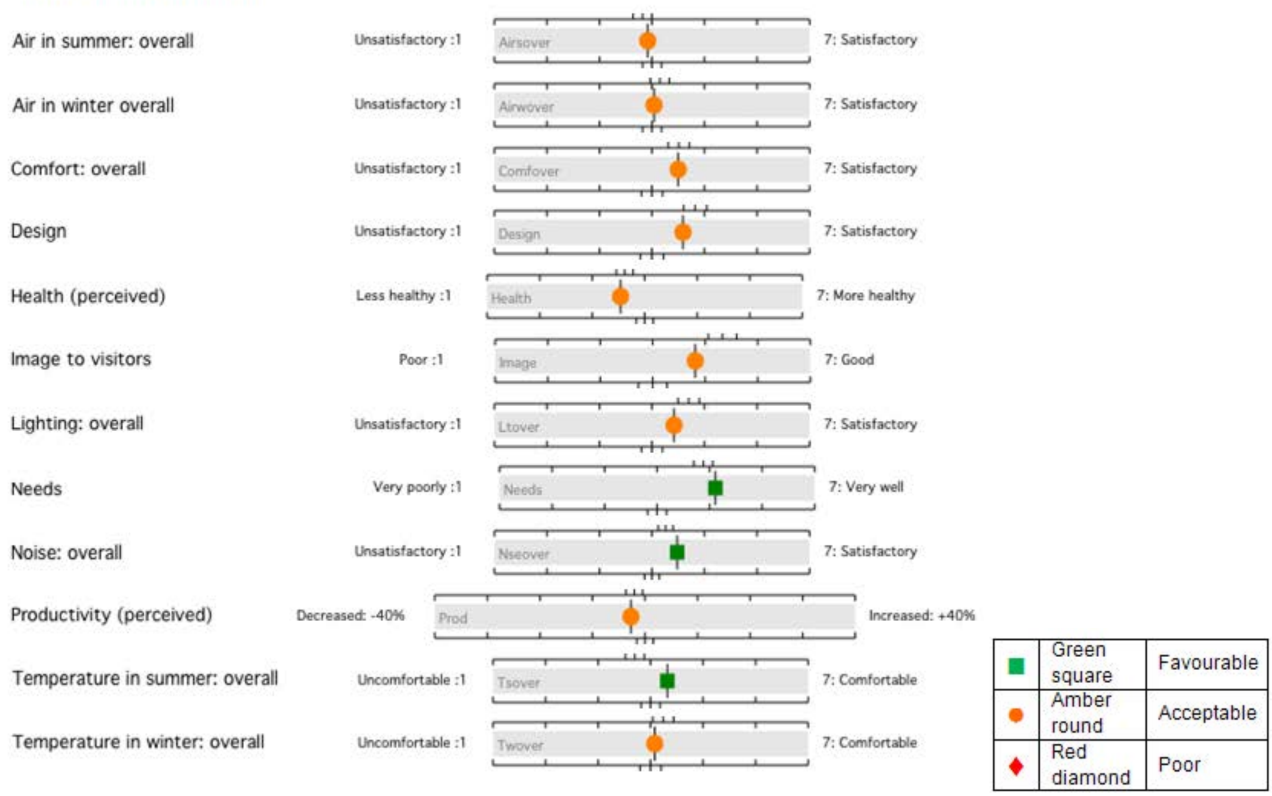


Figure 7 The overall summary from the BUS carried out for the EMC building

4.3 Occupants in the ROB

The BUS-based survey was again conducted for when the occupants from the EMC building have fully moved and settled into the ROB. Over the course of the study, there could be several additional occupants brought into the ROB from other buildings or newly recruited into the organisation. However, the majority would have responded to the survey with some relation to what they experienced in the previous building and what they would expect to see improved in the new building.

In general, the survey responses reflected dissatisfaction with aspects in the ROB consistent with the technical issues identified elsewhere in this report. These issues relate to the provision of ventilation and space conditioning, which at the early stages of post-handover have caused a significant amount of disruption to the occupants. In the many site visits during the study, the dissatisfaction of the occupants has already been made known to the building manager as well as the BPE project team. Figure 8 summarises the BUS output for the ROB showing the following perception by the occupants surveyed tabulated in Table 2. Please refer to the report in A19 for more details.

Table 2 Changes in occupant survey output between the EMC and the ROB for headline aspects in the buildings

Aspects surveyed	Original building - EMC	New building - ROB
General design and well-being	Acceptable	Acceptable, no change
Productivity	Acceptable	Poor, due to noise and comfort issues
Lighting	Acceptable	Favourable
Ventilation	Acceptable	Poor, due to noise and comfort issues
Space temperature/thermal comfort	Acceptable	Poor, due to noise and comfort issues

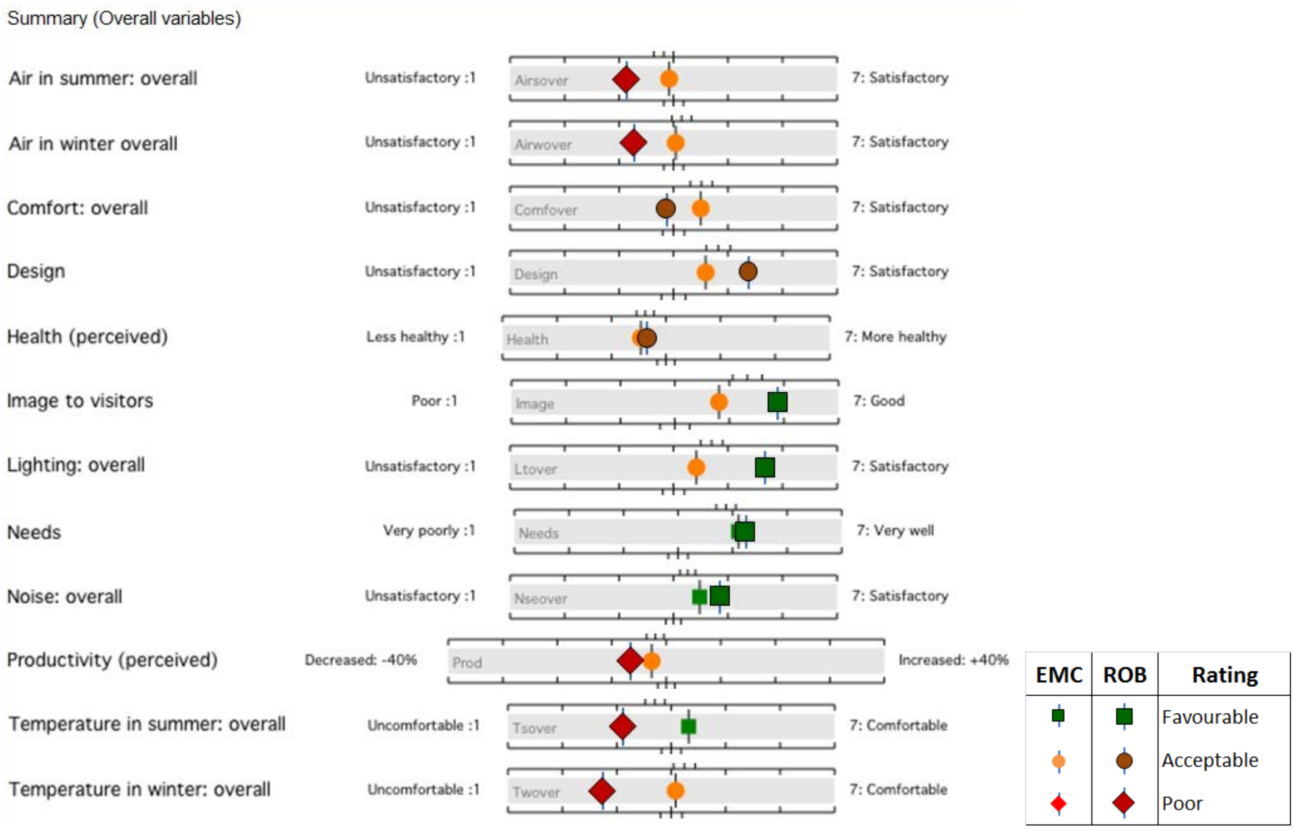


Figure 8: The overall summary from the BUS carried out for the ROB

Note: the larger symbols represent the ROB results

4.4 Client's own in-house workplace survey

The client conducts periodic in-house workplace survey for all the buildings on-site. As it was coming to a year of occupancy in the ROB, the estate management has launched a survey to gauge user satisfaction with the workplace setup. Details such as workplace atmosphere, work-desk and chair ergonomics, relevance of IT technology supplied to their work productivity and the usefulness of meeting rooms and other facilities were assessed. Unfortunately, the client has not made the outcome of their survey available for reporting here.

4.5 User training and building user guide

A comprehensive building user guide was produced by the estate management to disseminate useful and relevant information about the ROB to its users, specifically regarding the building layout, emergency route, details of the facilities available to them for work ergonomics, productivity and welfare. The guide highlights the types of facility for recycling and waste management around the building, which complements the site-wide awareness programme.

The guide includes a summary of the building's sustainability features such as the rain-water harvesting system. There is also a general illustration describing how the building works in terms of its ventilation and space conditioning, highlighting the difference from other buildings on site and in particular, the previous building they occupied.

As there are no specific building adjustment tasks available to users, such as opening louvres or windows in the ROB, no official user operational training was required. Also, as most staff members are on contract and constantly travelling, it has not been considered worthwhile to put in place formal training. Whilst the building user guide describes the building design and concept, it is believed that some form of introductory training and induction will raise awareness and describe to users of the uniqueness of the building they are occupying. This will help tailor the users' perception and acceptance of the differences experienced when using a mixed-mode building in contrast to their default air-conditioned workplace. This could then subsequently influence how users adapt to the building environment, understand how it should be used leading to less dissatisfaction with their workplace.

4.6 Conclusions and key findings for this section

The occupants in the ROB have mainly been relocated from their original EMC building. A survey carried out before the move to the ROB has indicated that the occupants were generally satisfied with the accommodation provided before. The move to the ROB has been largely challenging for the occupants in terms of adapting to the new servicing strategy employed. The issues with ventilation and air conditioning due to poor commissioning have affected occupants in various ways, causing disruption when remedial work needed to take place during working hours rather than after hours or the weekends. The mixed-mode ventilation in the ROB at early stage of occupancy has caused considerable thermal comfort issues leading to occupants having to shift work desks or resort to working from home. Whilst majority of the issues have since been resolved, the occupant dissatisfactions were reflected in the subsequent survey carried out. The building user guide was found to be comprehensive, which will be informative and useful to the occupants. Further related details can be found in the following:

Appendix	Description
A9	PCM4 - Social evaluation of commissioning, handover and modifications stages
A11	OCC1 - Review of tenant user guide and tenancy agreement, plus training
A18	OCC8 - Tenant social evaluation in previous building
A19	OCC9 - Tenant social evaluation and building manager (Arup BUS)

5 Details of aftercare, operation, maintenance & management

This section summarises the review of the handover, training and operation of the building.

5.1 Introduction

Upon handover, the ROB is being managed by the client's in-house building manager and the overall estate management team. The section summarises the level of training, aftercare and support the team received from the various contractors with regards to defects and issues with the operation of the building. It also highlights some of the aspect with maintenance and on-going problems.

5.2 Training and operations

During the commissioning phase, the building manager and the estate management team have been trained on the operations of the building. The client's team witnessed all system testing and received training on new systems such as the rain water harvesting system and the sprinkler system. Other training was for extensions to existing systems at site, for example lighting and fire alarm.

The estate management team have also been liaising with the BMS supplier from the start with regards to the controls setup and trouble-shooting and as a result were very hands-on and were involved as soon as they were able to. In general, the client felt that the training was useful but highlighted that there should be more training for operating the BMS as the system is new to the team. The study suggests that the operation training and information available on the BMS software interface may not be sufficient or in the right format to assist the building manager to operate the ROB effectively.

The client believed the documentation generated for the ROB in general is sufficient for the external maintenance contractor to carry out their work effectively. The periodic maintenance of the ROB rain water harvesting system, FCUs and condenser units are contracted to external suppliers.

5.3 Aftercare and maintenance

In general the aftercare services have been good and the client is satisfied with the response time and the outcome of the remedial work carried out by the main contractor (Miller Construction Group) and the M&E contractor (Kirby Group). Incidentally, Kirby are still on-site for refurbishment work in another building and this has helped facilitate a swifter response to issues reported in the ROB.

The client was also satisfied with the response by Passivent with regards to the enhanced ventilation booster fan problem, for which the supplier has agreed to a new fan type replacement at no cost to the client. The installation is currently planned but pending work on site.

However, the client has indicated that the level of service provided by the controls contractor has been unsatisfactory. The building was handed over to the client with various controls issues, which took considerable time to be resolved thereafter. There was a lack of urgency at one point where the contractor was not responsive for a period of time, although this has now improved.

The general maintenance of the ROB is normally carried out by the in-house team; however, specialist work has been contacted to external suppliers. The assessment of the building water consumption has highlighted a fault in one of the water meters, which was not picked up despite a recent maintenance visit. This emphasises the need for the client to fully understand specifically what elements are being serviced and maintained by the contractors when they were procured.

5.4 Conclusions and key findings for this section

In general, the study established that the client's estate management team is reasonably familiar with the ROB, its systems and its operation, with adequate understanding of the fundamental elements that make up the building. However, the client highlighted some issues with operating the BMS due to inadequate training and documentation for the new system employed at site, coupled with the ongoing unresolved issues. The availability of relevant information on the BMS to inform on building operation status and energy use would also be beneficial.

The client has found the training provided on the operation of the ROB to be generally useful. The estate management team has been largely proactive in their engagement with the suppliers and contractors on system training and knowledge transfer.

The client pointed out that the ROB will be a generally difficult building to maintain, especially with regards to its ventilation system. With its steel frame construction, the client felt that the design was not given sufficient consideration in terms of the practical accessibility for maintaining the louvre actuators. This will almost lead to tedious labour and high maintenance cost or possibly or the actuators possibly not getting maintained as scheduled or replaced in the future.

The separation of energy metering and building controls could have impeded a more integrated approach to effective running of the building by the owners, enabling direct reference to causality between building operation and energy use and occupant comfort. Any outcome of controls change and management is reviewed retrospectively from the meter data extracted from the M&T system.

Further related details can be found in the following:

Appendix	Description
A9	PCM4 - Social evaluation of commissioning, handover and modifications stages
A11	OCC1 - Review of tenant user guide and tenancy agreement, plus training

6 Energy use by source

6.1 Introduction

This section looks at the energy and water use by the ROB for the early periods of post-handover for up to approximately one year into its occupation. Energy and water use data recorded on the Metering & Targeting system have been used in the analysis in this section. The section summarises the energy break-down by end-use and highlights issues of excessive energy use through energy reconciliation using the CIBSE TM22 methodology and via comparison against corresponding benchmarks. The extent of water saving achieved by the rain water harvesting system was also assessed with comparison against the CIRIA benchmarked breakdown in water use in a typical office building.

6.2 Energy use

Metering of data started on the 1st of May 2012 in half-hourly intervals at the eSight Energy Metering & Targeting (M&T) infrastructure. Recorded energy can be accessed via a dedicated website and the client has full control over this access for energy use reviews and reporting. For the ROB, not all energy uses are metered and not all meters are being recorded on the M&T system. In spite of this, the majority of energy uses in the building are being captured by the current metering strategy, as shown in Figure 9. The sub-metering configuration ensures appropriate level of energy use breakdown such that different end-uses can be separately reviewed and analysed when required.

However, during the course of this study, it has been established that further breakdown of energy use will be beneficial in order to determine specifically energy use associated with the VRF condenser units. Along with other relevant information, this would enable the energy use for space conditioning (heating and cooling) and for hot water generation to be more accurately determined. Understandably, this may have cost implications where the typical process of value engineering would have reviewed this aspect and cut the metering strategy based on cost to the client.

Transformer T9

- T9-1-1 Ground floor lighting DB
- T9-1-2 Ground floor mechanical power DB
- T9-1-3 Ground floor power
- T9-1-4 Ground floor external lighting DB
- T9-1-5 First floor lighting DB
- T9-1-6 First floor mechanical power DB
- T9-1-7 First floor power
- T9-1-8 Zone 1 Mechanical DB
- T9-1-9 Zone 2 Mechanical DB
- T9-1-10 Zone 3 Mechanical DB
- T9-1-11 Roof lighting and power DB
- T9-1-12 Fire alarm panel plantroom
- T9-1-13 CCTV network switch
- T9-1-14 Lift supply
- T9-1-15 BMS panel electrical plantroom
- T9-1-16 100A autochangeover switch comms room
- T9-1-18 BMs panel GF mechanical riser

Figure 9 The extent of sub-metering available in the ROB. Pleases note that some meters are not being recorded on the M&T system and some minor energy uses are not metered.

For this study, the analysis of energy use by the ROB was based on the data extracted from the eSight Energy website between 1st May and 31st December 2012. Figure 10 shows the proportion of energy use in the ROB based on the major end-use categories for this period. A large proportion of energy use is shown to be associated with delivery of space conditioning (heating, cooling and fan energy).

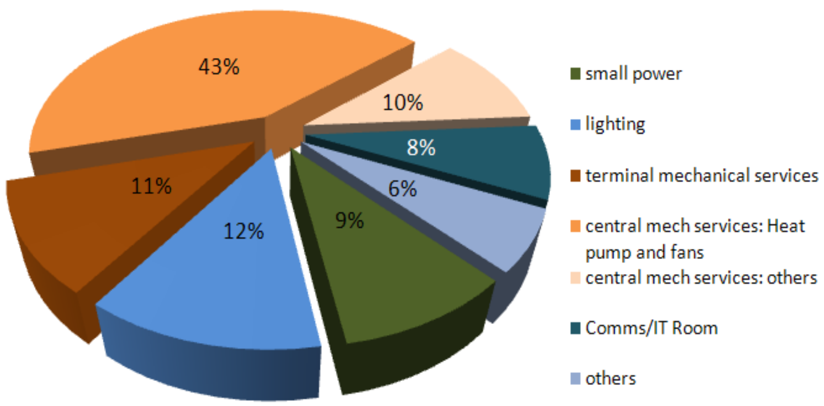


Figure 10breakdown of energy use in the ROB based on major end-use categories

The ROB's in-use energy was also compared against relevant benchmarks. The ROB as-built EPC model was used as an equivalent comparative benchmark although it is widely understood that the total energy (regulated and unregulated energy) estimated from such models is usually much less than the design and measured in-use energy. The ECON19 TYPE 2 office in the Good Practice scenario was also used as the closest building type match to the ROB. Figure 11 shows the comparison of total annual energy per unit floor area between the benchmarks as well as the comparison in energy use breakdown for small power, lighting and mechanical services (fan energy, condenser unit and pumps). It can be seen that small power energy use in the ROB is significantly low in comparison. This is most likely due to its low occupancy. Lighting energy appears to be relatively low, an attribute to its use of efficient lighting and good lighting controls, but also affected by low occupancy. It is encouraging that the lighting controls seem to be working, to take advantage of this low occupancy.

The energy use for mechanical services in the ROB is shown to be excessive in comparison to the benchmarks. This could be due to the control issues suffered throughout the period of the study since building handover, leading to the system switching between heating and cooling. This could also be affected by the low occupancy in the building, leading to low casual (passive) heating, which then requires additional active heating by the system. Regardless of the cause, this has led to the need for further investigation to the cause of such high energy use. It must be noted that no adjustment for low occupancy was carried out to the benchmarks for a fairer comparison as no corresponding occupancy data was available.

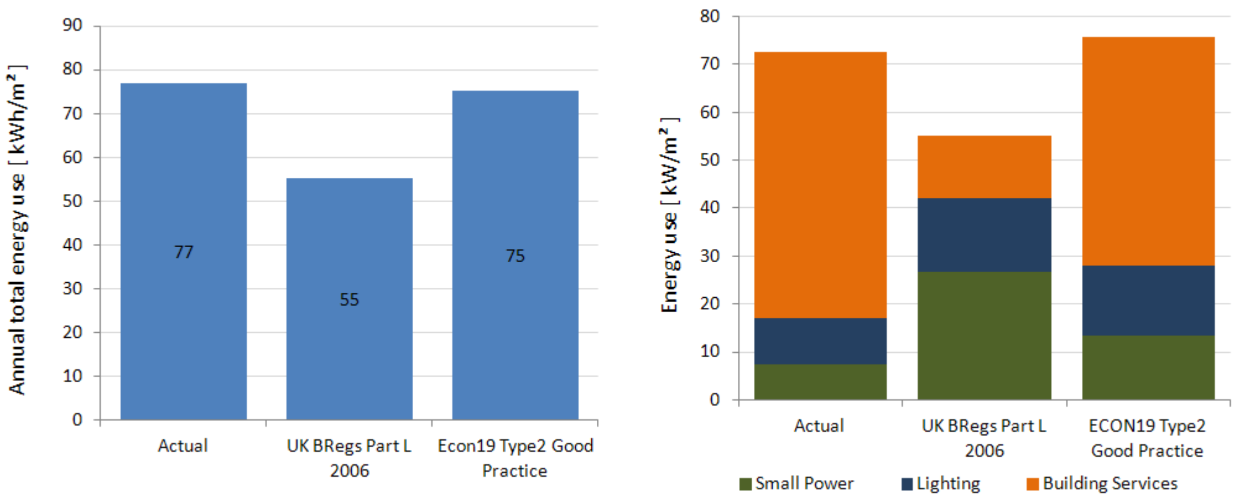


Figure 11 comparison of the ROB actual in-use energy against relevant benchmarks

6.3 TM22 assessment

The CIBSE TM22 assessment methodology was employed to facilitate the energy reconciliation between metered energy data and expected consumption by known energy systems in the building. The exercise demonstrated reasonably good accountability of all energy use in the building, which also helped to identify several avenues for potential energy saving. Figure 12 shows a chart comparing the CO_2 emission of the ROB actual in-use energy, broken down to the respective end-use categories, compared against its corresponding benchmarks.

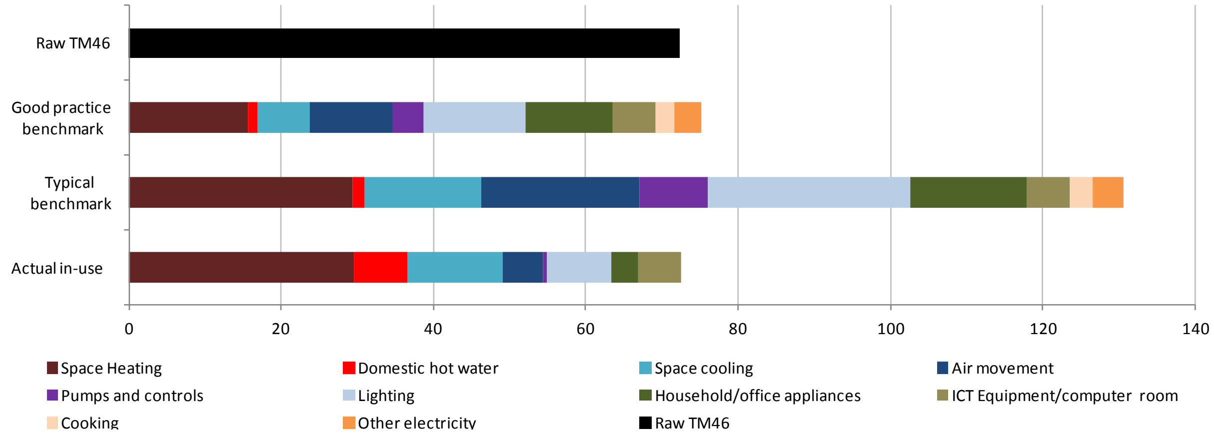


Figure 12: The ROB actual in-use breakdown of energy use by end-use categories, compared against its corresponding benchmarks

It can be seen that the ROB energy use for ventilation is much lower in comparison, an attribute to its mixed-mode strategy. Low energy use for small power was due to low occupancy and low energy use for lighting is a result of good lighting design and associated controls. The chart also highlights relatively high energy use for space heating, cooling and hot water, all with potential for further optimisation. Please refer to Appendix A14 and A15 for more information.

6.4 Water use

The use of mains water in the ROB is found to be significantly reduced due to the use of a rain water harvesting system to offset water use for toilet flushing. The water meter layout is as shown in Figure 13.

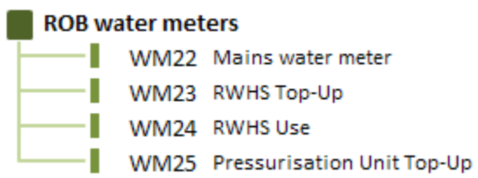


Figure 13: The ROB metering configuration for water use

Water use data downloaded from the M&T system has been plotted in the chart shown in Figure 14. The chart shows the amount of mains water saved each month as a result of rain water offset. However, an anomaly was discovered for December, which was later established to be a meter defect.

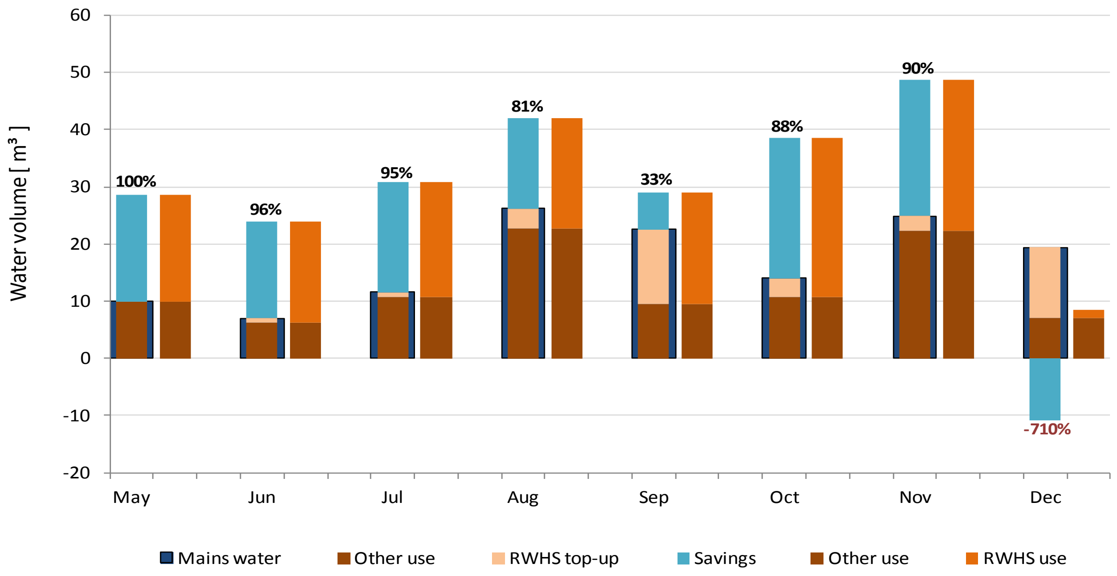


Figure 14: The ROB in-use water consumption. Note "RWHS use" meter defect in December

In summary, it has been demonstrated that the rain water harvesting system has been largely successful in the conservation of fresh water. However, it must be noted that both low occupancy in the ROB and high precipitation during this recorded period should be taken into account. Table 3 summarises the estimate of water saving in the ROB in comparison to the as-design consumption expectation and the CIRIA benchmark.

Table 3 Comparison of the ROB actual water use against as-designed expectation and the CIRIA benchmark

	Design [litre/person]	Actual [litre/person]	CIRIA benchmark [litre/person]	Savings against Design [%]	Difference against Benchmark [%]
Daily water demand for all purpose per person	40	22	16	44%	-39%
Main water used for flushing	12	6	10	50%	40%

6.5 Fabric performance and air tightness test

The build quality of the ROB has been highly regarded by the client. It is expected that this would lead to a minimal energy use associated with space heating. On paper, the ROB fabric performance exceeds the Building Regulations compliance limits complemented by a high-level of building air tightness. The validation of this aspect of the building has been carried out in the form of air tightness test during the commissioning phase and subsequently a thermographic survey was carried out exclusive to this study. Both assessments suggest that the ROB fabric is of high performance. The as-build air tightness for the ROB was registered at 4.98 m³/hr/m² @ 50Pa, which is slightly better than the as-design target. Equally, the performance of most as-built fabric surpasses the as-design specification and the thermographic images suggest no apparent deficiency in the fabric build quality.

6.6 Conclusions and key findings for this section

The high build quality suggests that ROB is a potentially efficient building to run in terms of energy use. However, control issues have caused some excessive consumption, certainly during the early stages of post-handover when remedial works were still being carried out on some major issues related to the ventilation and air conditioning system. The study has also identified several areas for potential energy savings, which will be explored by the client outside the study.

The low occupancy in the ROB below the expected design capacity has had an impact on the energy use, in particular in relation to space conditioning and small power. This is such that whilst the ROB compared well against its corresponding benchmarks due to its low energy design, the low occupancy is a contributing factor, which ultimately may require adjustments for a fairer comparison.

The low occupancy coupled with periods of high precipitation also led to a notably high percentage of water savings through the rain water harvesting system, which need to be taken into account for a fairer reflection of system performance.

Further related details can be found in the following:

Appendix	Description
A7	PCM2 - Metering of operational energy use of individual systems and large equipment
A8	PCM3 - Evaluation of building fabric performance, including thermal imaging and air tightness test
A14	OCC4 - Monitoring of whole building energy and water consumption
A15	OCC5 - TM22 assessment. Evaluate interactions between systems.
A16	OCC6 - Monitoring and evaluation of rainwater harvesting system
A17	OCC7 - Monitoring and evaluation of offices in use, including IT

7 Technical Issues

7.1 Introduction

During the course of this study, various technical issues have been identified, which are either independent or inter-linked to other issues in the building. This section highlights the main issues in the ROB that impact on occupant thermal comfort and energy use.

7.2 BMS and controls

During the commissioning and testing phase, issues with control implementation began to emerge. The need for control algorithms proprietary to the servicing strategy specified for the ROB has led to unexpected complications. Issues were mainly related to the difficulty Severn Controls encountered when interpreting the control strategy specification produced by the M&E consultant and this remained largely unresolved upon handover. During the course of the study, Severn Controls have been slow in the remedial work.

Towards the tail-end of the study, recorded BMS data revealed poor control of the façade louvres. Whilst some are not operating, others are not modulating based on CO_2 levels but rather operate with a large extent of opening and closing, hence causing the dumping of cold outside air into the building. Other issues identified and are currently being investigated are:

- Extended fan coil unit running hours in most zones
- Rapidly switching fan coil unit controls, which could potentially lead to premature wear and energy wastage
- Unnecessary trench heating operations
- Poor louvre controls

7.3 Ventilation

With regards to the ventilation system the following issues have been uncovered:

- Localised stuffiness in certain part of the office
- Sudden ingress of cold air led to alternate cold and hot dumping from the ceiling diffusers causing occupant discomfort and leading to occupants needing to move desk-space or resort to working from home
- Acoustic problems associated with axial fans being used as a booster fans in the stack columns
- Turn-down of booster fan speed led to ineffective provision of enhanced ventilation in the stack columns

The causes of ventilation issues have been identified and remedial works are as follow:

- Ineffective provision of enhanced ventilation was due to an unsuitable axial fan being used. Replacement with low speed, quiet sweep fans has been proposed by Passivent at no cost to the client.
- Localised stuffiness and sudden ingress of cold air was due to poor louvre controls, which will be rectified by Severn Controls.

7.4 Air heating / cooling system

The space temperature in the building was initially inferred using the FCU return air temperature, which generated significant control issues, in particular for the mixed-mode strategy employed in the ROB. The controls were reconfigured to use sensors within the office space for a more accurate indication of space temperature.

The poor louvre controls, which allow the sudden ingress of large amounts of cold air has caused cold dumping into the internal spaces on many occasions. This in turn forced subsequent requirements for heating by FCUs in response to a sudden drop in space temperature due to the cold dumping. Related controls issues are being investigated by Severn Controls to try to smooth this process out.

Air distribution has been problematic at the start of building occupancy due to insufficient air throw from the slot diffusers. Adjustment to allow high flow rate during heating mode and low flow rate during cooling mode has largely resolved the issue, which improved space air ventilation as well as space conditioning. There are still minor problems with air throw at some perimeter zones, where the cooling effect of the glazing window has manifested in a slight down-draught that caused occupant discomfort. Whilst the client indicated that they are now unsure of the rationale behind the decision to use slot diffusers in the design scheme, it has been established that it is likely due to the recommendation by the architects in the effort to preserve a clean and minimalist ceiling aesthetics where the ventilation slots could be hidden amongst the ceiling tile seams.

7.5 Metering

The Metering and Targeting (M&T) of the ROB energy and water use has been implemented on the eSight Energy system. The building BMS consequently holds no energy data, thus preventing a straightforward analysis of the corresponding building system performance and execution of energy audits. Despite this, the M&T strategy allowed for adequate breakdown of energy use. There were some issues found in the study, which include:

- Labelling ambiguities, which caused confusion until they were resolved
- Incorrect multiplication factor used, which led to incorrect metering of water consumption
- Incorrect reading on the main electricity meter due to zero current reading on one of the three phases

These have now been resolved.

7.6 Air curtain

It has been highlighted that whilst controlled on a time-clock basis and to operate when the external temperature is less than 16°C and internal space temperature is less than 21°C, the main entrance door air curtain appeared to be running continuously. Its estimated typical energy use is approximately 80% of other use for the floor terminal mechanical services as illustrated by Figure 15. The remainder of the energy use is due to FCUs fan energy. The client has since switched off the air curtain and is awaiting a modification to its operation regime to be derived and implemented.

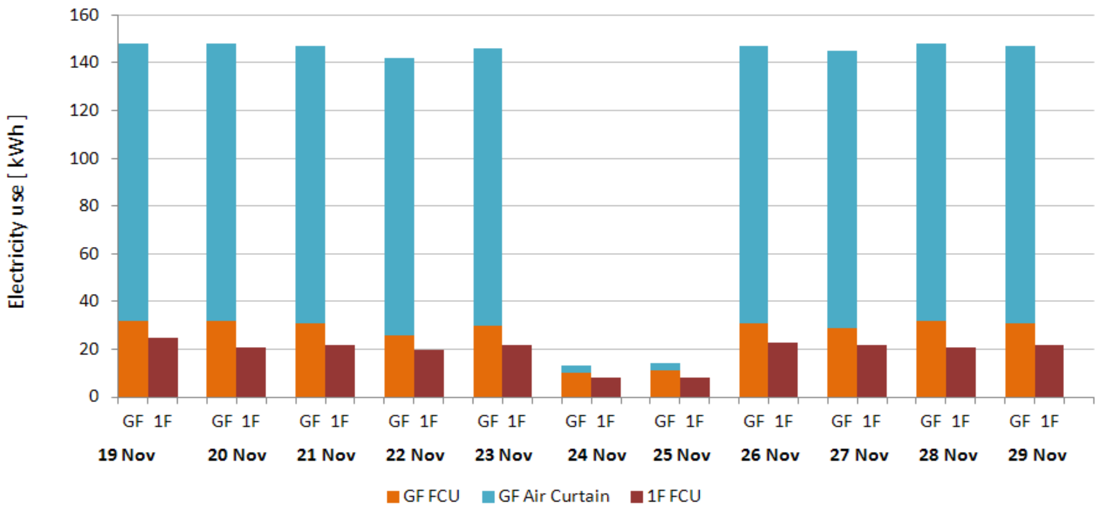


Figure 15: Energy use by the entrance door air curtain compared to fan energy by FCU on both ground and first floor

7.7 Trench heating

Whilst it appeared to be operating according to design intent, closer inspection of the trench heating suggested that its operation could be optimised for energy saving. The trench heater has been programmed to run based on a time-clock for each zone and when the outside temperature drops below 5°C to mitigate any potential down-draught and risk of condensation on the atrium double-height glazing, as shown in Figure 16. This may not be necessary when the internal space temperature is relatively high. Further investigation into this potential energy saving measure is required beyond the timeframe of this study.

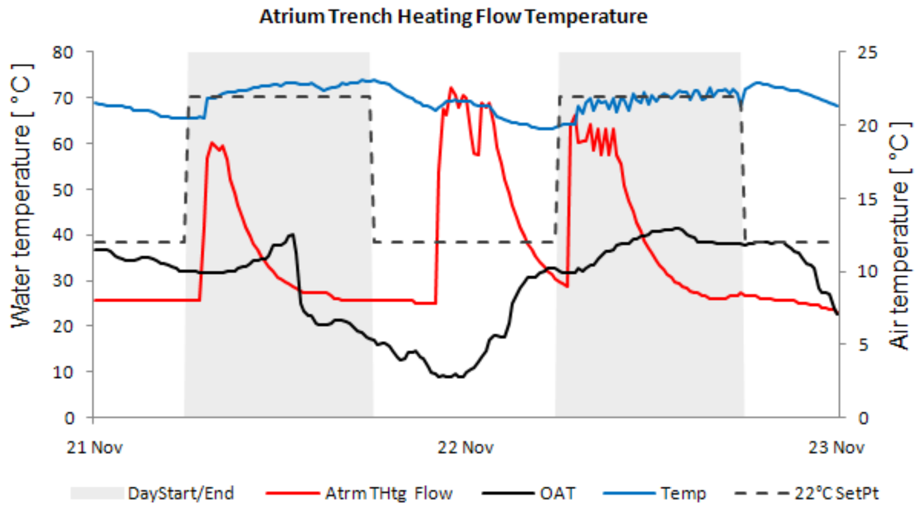


Figure 16: The atrium trench heating operation based on zonal time-clock and external temperature

7.8 Conclusions and key findings for this section

Whilst a range of technical issues were discovered post-handover, directly and indirectly as a result of carrying out this study, the majority of them are inter-linked and can be sourced back to the issues with controls. Specifically, the louvre controls have led to issues associated with ventilation and space conditioning, leading to effects on occupant comfort and energy use.

Further related details can be found in the following:

Appendix	Description
A6	PCM1 - Evaluation of ventilation system, heat pumps and BMS and controls
A7	PCM2 - Metering of operational energy use of individual systems and large equipment
A8	PCM3 - Evaluation of building fabric performance, including thermal imaging and air tightness test

8 Key messages for the client, owner and occupier

8.1 Key messages: technical

In section 3.7, the following key design issues were raised, and these are discussed in turn:

1. The use of mixed-mode ventilation strategy and therefore the associated systems should lead to a low energy building

   It is not certain that this has been effective; the building compares very well against benchmarks, but is lightly occupied. In general the users are content, but initial problems with control of heating / comfort cooling meant that concerns were raised. A review after a further year should resolve whether the mixed mode solution has been a success.

2. Being an all-electric building, the overall CO_2 emissions from the ROB could be higher than if it uses a fossil-fuel based source to meet its heating demand; however, the higher efficiency expected from the use of heat pump should mitigate this

   The energy use is relatively low, but the CO_2 emissions were not helped by the excessive use of the heated door curtain. The BMS and other systems did not allow measurement of the performance of the heat pump, so this query could not be fully addressed.

3. The rain water harvesting system should lead to a significant reduction in fresh water use

   The rain water harvesting system was able to deliver nearly all of the water used for the toilets, assisted by low occupancy and high rainfall in the study period.

4. The efficient lighting system installed in the ROB is expected to bring about significant savings in lighting energy

   The lighting energy use is low compared to benchmarks, indicating a good solution with efficient luminaires and effective lighting controls, which resulted in energy use that corresponds to low occupancy.

5. The use of heat pumps, mixed-mode ventilation strategy, high efficiency lighting and a rain water harvesting system are features that are consistent with the client's sustainability remit and overarching site environmental policy.

   Overall the building, now that improvements have been made to controls and the air curtain, is generally meeting the aspirations set for it.

8.2 Key messages: process

Drawing from the findings established in this study, there are a set of key messages specifically for the client/owner and indirectly for the occupiers of the building:

- Before embarking on a building project, does the client know what they want?
- At any point in a building project, does the client know what they are paying for and getting?
- Is the building being designed and built to cater to the client's and the users' requirement and functions?
- Compile a tighter and more prescriptive set of Employer's Requirements (ERs) to make specific requirements clear
- Consider performance-based contracts where appropriate
- During the procurement and tender process, the client needs to ensure they can appropriately evaluate the contractors, knowing the criteria on which the appointment of suitable contractors are based on
- Understand exactly what services each contractor is providing
- Commissioning and testing is critical, therefore it is essential to allow adequate time and resources in the programme
- Commissioning of the whole building system must be made a requirement, as well as the individual components.
- Whilst Value Engineering / cost cutting may make sense, do not deploy this on the BMS and controls without taking great care to ensure vital functionality is not lost
- Plan to include soft-landings and seasonal commissioning in the contract
- The client needs to understand that they have a role in understanding how the building works. Hence, it is essential to ensure a proper handover between staff members taking over the responsibility of managing the building

8.3 Key messages: Impact of the project

During the course of the project, the following have changed and improved in the ROB:

- Use of dedicated temperature sensors at work-plane for better conditioning controls
- FCU and diffuser adjustment led to better heat and coolth distribution
- Action to replace booster fans for more effective enhanced ventilation is underway
- Identification of faults in façade louvre controls, which is currently being investigated by the controls supplier
- Discovery of faults in the water meters despite recent maintenance work, leading to rectification
- Rectification of the Metering & Targeting website data multiplication, incorrect main meter reading and labelling issues
- Identification of the air curtain as a major and wasteful energy use on the ground floor
- Discovery of some FCUs running after-hours causing energy waste, for which the controls are currently being investigated
- Development of skills within the project team, to be applied on other projects

Further related details can be found in the following:

Appendix	Description
A9	PCM4 - Social evaluation of commissioning, handover and modifications stages
A10	PCM5 - Initial Improvement Action Plan

9 Wider lessons

9.1 Introduction

Dissemination workshops with AECOM's in-house design teams were carried out where the findings and outcome from the study were presented specifically to the design team directly involved in the project and to the wider group. Discussions with the team members on the findings and relating them back to the company's processes have managed to establish the following feedback.

9.2 Lessons learned from the BPE project

The BPE project has highlighted several aspects of a building project, which require closer attention, more accountability and a feedback mechanism for continuous improvement. These aspects relate to the:

- procurement process
- commissioning and testing
- building BMS and controls
- energy and water Metering &Targeting (M&T) infrastructure and data acquisition
- training and building operations manuals

It has been acknowledged in the dissemination workshop that the current procurement process meant that designers and consultants normally 'half-specify' the design (through RIBA Stage D, E) and thereafter leaving the other contractors to derive the details and then formulate the actual construction of the elements of the building. This leads to work separation, risking the loss of an understanding of the overall design scheme and resulting in the lack of integration of the design intent for the building. There are normally insufficient details and guidance produced at Stage D/E to effectively inform or support design intent throughout the rest of the project.

It was also highlighted that the term 'or equivalent product' has been too loosely and frequently used in design specification such that it exposes the project to uncontrolled variability in product procurement, which can be incompatible in terms of integration with the overall building system. This can be further exacerbated by the lack of good understanding of the mission critical element of a specific product and as a result, an unsuitable equivalent product was procured solely to meet a cost-effectiveness remit.

The client has pointed out that a change of project team members during the course of the project has had a detrimental impact on its smooth running. The client expected a more seamless transition of staff change, which would mitigate information and knowledge loss on the project, particularly when it involved critical roles such as the project manager, lead architect and lead design engineer.

The client has also indicated that they were not in favour of the extent of Contractor Design Portion (CDP) imposed upon the main contractor, which in their view has somewhat compromised the quality of work and ultimately the delivery.

In a more general sense, the project team at AECOM has leant a great deal from taking part in the project. This is already helping with other project work through the involvement of the four staff involved. In particular Michael Lim has assisted with two projects funded by the TSB 'Invest in Innovative Refurbishment' project, as an external evaluator.

9.3 What AECOM will do differently

Through the dissemination workshop, the design teams have expressed the need to consider and implement the following:

- Formulate a commissioning 'proving' and verification process
- Procurement of a company (AECOM) approved/preferred BMS supplier
- Video-record future building user training sessions conducted by the contractors
- More prescriptive training content to be included in the tender documents, such as:
    - Protocol on plant/system operation
    - Instruction to carry out system parameter change/adjustment
    - Energy saving options in building and system operation
- Specify client member of staff to attend training and ensure competency in building operation
- Offer Soft-landings and Building Performance Evaluation (BPE) services to clients as an inclusive package
- Ensure the procurement of an 'equivalent product' is bounded by specific operation or technical criteria
- Continue to develop expertise in BPE, including through sharing experience between those involved through quarterly meetings, and developing our offer further

9.4 How will the design and delivery of future buildings be improved

In order to improve the design and the delivery of future buildings, the following should be considered:

- Procurement of the right project team members
- Ensure that the contractors have the right teams with the appropriate skills and competence (as offered to the client during the tender process) at site and actively working on the project
- Better building user guide
- User-oriented training
- Introduce seasonal commissioning and soft-landings
- Improve handover process for change of members of the project team
- The use of Soft Landing as a set of aftercare principles to ensure that all of the issues highlighted are properly monitored and addressed

9.5 What will Lilly (the client) do differently

The client has indicated the following as what they will do differently as a result of the ROB:

- Reconsider their site-wide plan to move to a new control system and reverting back to using the site-default system from Honeywell. The installation and commissioning of the control system in the ROB has given the client very little confidence about the prospect of moving to a new system, which essentially has not been delivered to expectation by the supplier
- Unsure as to whether mixed-mode strategy should be further adopted in any further new buildings on site
- The low occupancy has not allowed for a true test of the ROB servicing scheme, hence the client will give time to determine whether the strategy employed in the ROB has delivered to their energy and environmental aspirations
- Further monitoring of the performance of the ROB will help the client assess the true return in their investment

9.6 Dissemination

Several avenues for dissemination are underway, these include tasks already done:

- Client presentation
- Dissemination workshop with design team
- Publication on CarbonBuzz
- Input to CarbonBuzz: Andrew Cripps is the AECOM lead on CarbonBuzz, and learning from this and other projects, has been helping to inform the development of CarbonBuzz

We are also planning

- CPDs to colleagues, including away from base office
- Strengthening of AECOM BPE network
- Paper (conference – target CIBSE Technical symposium) publication - probably drawing on common strands within our projects
- Offer to trade press if client is in agreement
- BPE case study

9.7 Conclusions

This study has found that the Eli Lilly Research Office Building is performing well in general, but not quite as well as hoped for. Improvements have been made during the study period to the control of heating, cooling and ventilation, and so it is hoped that the building will settle down to a better long term performance. Lilly are encouraged to continue the process of monitoring the building to achieve ongoing improvements.

Undoubtedly the issues highlighted in the study around controls and systems not working well together are not new to many in the industry, and came as no surprise to the audience when we have fed back to colleagues. However, the concern is that there is no sign of improvement.

Both AECOM and Lilly have identified areas for different action in future. For AECOM, we are also combining these with findings from other TSB BPE projects, to inform a wider set of possible changes. These would relate to the way in which we develop Employer's Requirements, and details of our specifications, to help ensure the most likely achievement of a successful project. AECOM are also seeking to make the assessment and management of operational performance a part of more of our design projects.