Bourne Hill Council Offices

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	450113
Project lead and author	Wiltshire Council and the Centre for Sustainable Energy
Report date	2014
InnovateUK Evaluator	Tom Kordel (Contact via www.bpe-specialists.org.uk)

Building sector	Location	Form of contract	Opened
Offices	Salisbury	Traditional	2010

Floor area (GIA)	Storeys	EPC / DEC 2013	BREEAM rating
1498 m^2 & 2357 m^2	Various	B (50) / D (86)	Excellent

Purpose of evaluation

The offices at Bourne Hill underwent major refurbishment, including repairing and improving the existing Grade II listed building (1498 m^2), and the construction of a large modern extension (2357 m^2). The aim of this study was to review the energy performance and occupant satisfaction of the buildings in use and to compare the results to both standard industry benchmarks and the calculations made during design. The study also aimed to determine the extent to which the performance of high-specification Grade II* protected building can be achieved with a tight budget.

Design energy assessment	In-use energy assessment	Electrical sub-meter breakdown
No	Yes	Partial

Estimated electricity use: 78.1 kWh/m^2 per annum; thermal (gas): 86.8 kWh/m^2 per annum. Due to the questionable accuracy of the electricity sub-meters and missing data for some loads, all individual items were simply assigned to the mains electricity meter. While it was not possible to use data from the heat meters to accurately separate out energy used for space heating in the old and new parts of the building, along with energy used for water heating, it was possible to estimate the split between space and water heating based on the amount of gas consumed during the warmest months of the year when it was assumed that little, if any, space heating was required.

Occupant survey	Survey sample	Response rate
BUS, xx	111 of 300	37%

Although only 11 occupants located within the original building completed a survey form, their responses were considered sufficiently different to warrant separate analysis from those completed by staff located in the new extension. The data were therefore analysed separately. Overall, the results suggest that Bourne Hill did not perform well in terms of delivering a comfortable working environment. On critical measures of comfort in both summer and winter conditions the occupants typically felt somewhat uncomfortable. On virtually every measure the old part of the building was considered a more comfortable environment.

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.

The Technology Strategy Board is an executive non- departmental public body sponsored by the Department for Business, Innovation and Skills, and is incorporated by Royal Charter in England and Wales with company number RC000818. Registered office: North Star House, North Star Avenue, Swindon SN2 1UE.

Contents

1 Introduction and overview ... 3
2 Details of the building, its design, and its delivery ... 6
2.1 A description of the building ... 6
2.2 Summary of design, construction and handover processes ... 8
3 Review of building services and energy systems. ... 10
3.1 Heating ... 10
3.2 Ventilation ... 11
3.3 Lighting ... 11
3.4 Rainwater harvesting ... 12
3.5 Energy-consuming equipment ... 12
3.6 Systems for energy monitoring and management ... 12
4 Key findings from occupant survey ... 14
4.1 BUS survey results ... 14
4.2 Conclusions ... 17
5 Details of aftercare, operation, maintenance & management ... 19
5.1 Energy management at a strategic level ... 20
6 Energy use by source ... 23
6.1 Methodology ... 23
6.2 Energy performance as measured through formal certification procedures ... 24
6.3 TM22 analysis and results ... 25
6.4 A closer look at gas consumption ... 32
6.5 A closer look at electricity consumption ... 36
6.6 A comparison to other case studies ... 39
7 Technical Issues ... 41
7.1 The performance of the building fabric ... 41
7.2 The performance of the building services ... 43
8 Key messages for the client, owner and occupier ... 45
9 Wider lessons ... 48

1 Introduction and overview

Technology Strategy Board guidance on section requirements:	This section of the report should be an introduction to the scope of the BPE and will include a summary of the key facts, figures and findings. Only the basic facts etc should be included here – most detailed information will be contained in the body of this report and stored in other documents/data storage areas.

This report summarises the work carried out at Wiltshire Council's Bourne Hill offices as part of the Technology Strategy Board's Building Performance Evaluation programme. The offices at Bourne Hill in Salisbury underwent a period of major refurbishment prior to occupation in late 2010, which included both work to repair and improve the existing Grade II* listed building (1498m^2), and the construction of a large modern extension (2357m^2). Bourne Hill predominantly provides office accommodation, with registry office facilities and a public reception also found on the ground floor. The aim of this study was to review the performance of the building in use and to compare the results of this analysis to both standard industry benchmarks and to the predicted performance of the building as calculated during its design.

Bourne Hill is an award-winning office building, with the project having won a number of prizes including the British Council for Offices regional 'Office Building of the Year' accolade, as well as a RIBA South West and Wessex regional award and the Society of Chief Architects of Local Authorities 'Civic Building of the Year' 2011 title. This case study provides a rare opportunity to study a building that combines an existing, highly protected heritage building with a new, innovative and modern building. Whilst similar studies have generally focused either on the brand new or on the old, it is not often that one building can provide both.


Figure 1: (Left) Photograph of the existing listed building and the new extension
Figure 2: (Right) Photograph of the new extension

The original research questions defined for this study were as follows:

- How much does the occupants view on their working environment and comfort levels vary between those in the new part and those in the old?
- What was the primary reason for the poor Display Energy Certificate (DEC) rating in 2011?
- To what extent can you balance high-spec building performance with prudent costings in a Grade II* protected building?

- To what extent does the heritage element of the building 'bring down' the performance of the new part?
- How successful are the innovative passive features of the extension in keeping energy consumption low and providing a comfortable working environment for occupants?
- How does Wiltshire Council's flexible working policy affect the consumption of energy on its estate?

It is hoped that the findings of this study can be used to influence future decision making within the Council and to feed into the national debate on providing modern building environments for today's workforce. In particular, the study will have a direct impact on upcoming Council developments as part of its current Transformation Programme. The study will create, inform and improve current policies, procedures and practices for design and development as well as for maintenance and operation at the Council.

The work carried out under this study included a review of the available design documentation; a survey of building occupants; the procurement of a thermographic survey; the setting up of additional monitoring equipment for measuring heat and internal office conditions; and the analysis of data, amongst other activities. Unfortunately, the analysis contained in this report has been severely restricted due to a lack of good quality data. Bourne Hill has two separate (pre-existing) systems on site for the collection and storage of information related to the functioning of the building. Internal temperature and CO_2 data, external weather data and information relating to the effective functioning of the building services is collated via the BMS, whilst electricity sub-metering data is stored on a piece of equipment called the 'Schneider unit', which utilises 'ION' logging software. The complexity and lack of usability of both of these systems has meant that accessing the logged data has been particularly difficult and extremely time consuming. In turn, this has led to problems and delays in identifying faults within the systems, some of which are still to be rectified. The importance of having monitoring equipment that is easy to use and that is properly set up in line with user requirements is one of the most important key messages from this project.

The results of the Building User Survey suggested that despite the building appearing to be working well, the occupants are still marginally dissatisfied with the working environment that the building provides. Separate discussions with Bourne Hill Staff (for example, during the workshops held as part of this project), however, indicate a more balanced view. The BUS results showed a marked difference in the responses of staff based in the two different parts of the building, with those situated within the original building generally appearing to be more content than those within the extension. A number of possible reasons for this are put forward within this report. These include the higher level of user control over heating and ventilation systems in the existing building; the similarity of the environment to that experienced in the offices in which staff were located prior to council unification; and/or the technical issues within the extension that may be leading to particularly uncomfortable or overly-variable temperature and ventilation levels.

In summary, this study finds that the building services and energy systems of the Bourne Hill offices are performing broadly in line with expectations in terms of energy consumption. There had been initial concerns from the Council about the difference between the poor rating it had received in the 2011 Display Energy Certificate (DEC) compared to the higher rating attained in the Energy Performance Certificate (EPC). This was found, however, to be primarily the result of miscommunication between those who designed the building and those who operated it. A closer look at the two certificates showed that they were in fact representing different parts of the building. The EPC only covered the modern extension and, unlike the DEC, did not take into account the impact of the older part of the building. Prior to this project, the DECs indicated that the building was performing better than standard in-use benchmarks in terms of electricity consumption, but generally worse in terms of space heating and hot water. As a direct result of this work, changes have been made to the hot water settings within the building and this has had a significant impact on recorded consumption levels. Bourne Hill is now also though to be performing better than typical benchmark figures for gas consumption, however without being able to split the gas consumption between the two parts of the building, it is still difficult to be sure exactly to what extent the heritage element has had an impact on the overall performance of the building or how well the passive elements of the building are performing. The TM22 analysis suggests that the relatively low level of electricity usage may primarily be due to the efficient and tightly controlled lighting strategy and the procurement of energy efficient office equipment (for example, laptops rather than desktop PCs), although the appropriateness of these standard benchmarks to modern offices is called into question.

There were few technical issues that appeared to be affecting the energy performance of the building, with the three main exceptions being the faulty vent actuators in the new building, poorly calibrated internal sensors linked to the BMS, and the settings of the hot water system. The role of information management in the effective running of a building and its systems was also highlighted, as was the importance of considering the future flexibility of a building during its design. The impact of the flexible working policy was difficult to define and separate from other factors affecting energy consumption. Should the Council wish to look into this in further detail in the future, it is recommended that some kind of system to record staff attendance/numbers be put in place.

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

Technology Strategy Board guidance on section requirements:	This section of the report should provide comments on the design intent (conclusions of the design review), information provided and the product delivered (including references to drawings, specifications, commissioning records, log book and building user guide). This section should summarise the building type, form, daylighting strategy, main structure/ materials, surrounding environment and orientation, how the building is accessed i.e. transport links, cycling facilities, etc – where possible these descriptions should be copied over (screen grabs - with captions) from other BPE documents such as the PVQ. This section should also outline the construction and construction management processes adopted, construction phase influences i.e. builder went out of business, form of contract issues i.e. novation of design team, programme issues etc. If a Soft Landings process was adopted this could be referenced here but the phases during which it was adopted would be recorded in detail elsewhere. If a Soft Landings process was adopted this can be referenced here but the phases during which it was adopted would be recorded in detail elsewhere in this report and in the template *TSB BPE Non Dom Soft Landings report.doc*.

The refurbishment and extension of the Bourne Hill offices were carried out as part of a wider scheme to rationalise the council's property portfolio and to provide staff with a smaller number of larger 'hub' offices. Due to the listed status of the existing building, it was important that the design for the extension be sympathetic to its heritage setting, but at the same time there was an intention to create a building that would be modern, innovative and high-performing in terms of energy usage. The refurbishment of the existing building was particularly limited by planning restrictions, however there is clear evidence that the energy consumption of the building in use was carefully considered in its design and that a number of measures were put in place to reduce demand in both parts of the building.

This section of the report provides a description of the building fabric and looks at the way in which the project was delivered.

2.1 A description of the building

The original part of the Bourne Hill offices was designated as Grade II* listed in 1952, and the majority of its fabric dates back to about 1670. The history of the site goes much further back however, to around the 1200s, although little of this earlier structure now remains above ground. This part of the property has solid red brick walls built onto a stone plinth and a tiled roof behind a decorative parapet wall. The sash windows are single-glazed, but with wooden frames that were refurbished in 2010. Due to its listed status, and following guidance from English Heritage, the design approach to the refurbishment of the original building was one of minimal intervention. It is, however, likely that some of the work carried out to repair the existing fabric (e.g. the repair and re-pointing of brick and stonework) will have had a positive impact on its energy performance. Overall, only non-intrusive interventions were permitted, such as the replacement of the existing roof insulation with a higher-performing alternative. Similarly, changes to the building services were restricted to the updating of the existing systems with modern components (the servicing strategy is described in more detail in the next section).


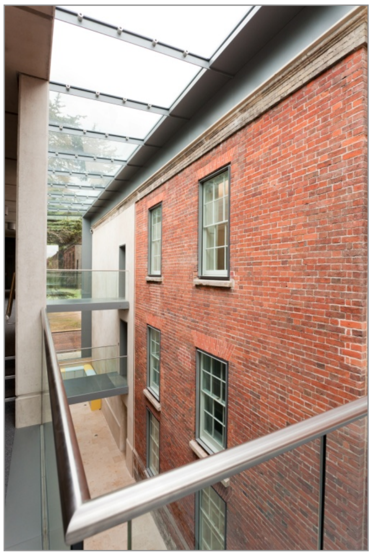

Figure 3: (Left) Inside one of the office spaces within the original building
Figure 4: (Right) View across glazed link, which connects the two parts of the building

In the design for the extension, considerable attention was given to maximising the use of passive features to temper the internal environment in order to eliminate the need for high levels of space heating and/or air conditioning (except within the server room). The extension has a concrete frame, designed for high thermal mass, and is clad in aluminium-framed glass curtain walling (see Figure 6). The extension also has a green roof over some areas (see Figure 5).


Figure 5: (Left) The green roof and external seating area
Figure 6: (Right) Elevation of new build extension

To control the amount of sunlight entering the building, solar control glazing was specified, along with fins fixed to the mullions underneath each glazed panel on the east façade, and freestanding fins positioned clear of the west façade to form a colonnade. Internal user-controlled blinds are also provided to help cut down on glare. It is stated in the BREEAM report that a number of feasibility studies were carried out at an early stage in the design process in order to assess building form, rooflight and window size, and external fin geometry with the intention of creating a comfortable environment for building occupants. The report also confirms that the thermal modelling results met the requirements of CIBSE Guide A in relation to overheating criteria (i.e. the modelled building was shown to not exceed 28°C for more than 1% of the annual occupied period). Whilst some data on internal temperature was reviewed under this study, the data collection period was not long enough and the quality of the data was not good enough to confirm whether these criteria are met in use. The 6 months of data downloaded from the BMS indicate that temperatures within the extension stay well within the industry standard guidelines for an office environment and that they are relatively consistent and independent of external temperatures, although there were no instances of unusually hot or cold weather during that time. Internal temperatures, CO_2 levels and weather data were looked at in more detail under Task 22 (see Appendices 1 and 4). The two parts of the building are connected to each other via a glazed link. Additional photos of the building can be found under Appendix 2.

Accessibility to the building is good. Although car parking facilities on site are limited, there are nearby, well connected bus stops, the train station is located less than a mile from the site and there are good park and ride connections to this part of the town.

2.2 Summary of design, construction and handover processes

The project was originally initiated by Salisbury District Council, and the design of the building took place under the jurisdiction of this authority. Both its design and construction were procured utilising traditional contracts via competitive tenders. In April 2009, after the project had moved into the construction phase, local government restructuring meant that the responsibility for the project moved to the newly-unified Wiltshire Council, hence design information needed to be passed on from one team to another and there was a short hiatus in the project process. At this point the expectations for the way the building was to be used shifted slightly from the original design parameters; this shift included the introduction of the flexible working policy and an increase in the proposed number of staff based at the site of approximately 20 people. It is not thought that these changes have had a significant impact on the performance of the building, as its services are fairly flexible and the two factors effectively cancel each other out in practice.

This BPE study began two years after the building became occupied in its current form, therefore our knowledge of the design process and intent is based on limited discussion with the original project team and on the available documentation. Locating some of the original specification documents and drawings was not straightforward, and those that were accessible were sometimes incomplete or contradictory; for example, the O&M manuals did not contain a full set of record-issue drawings as would normally be expected, and instead contained some earlier revisions that were not in line with the product as built. Very little in the way of commissioning records are easily accessible. Information about the building was also not stored in one central location, and quite a large proportion was only saved on one personal computer, which was not connected to the internal network. Whilst the building log book is accessible (as required under Part L, criterion 5), the BREEAM assessment documentation indicates that there was also an intention to produce a Building User Guide at design stage. According to the BREEAM criteria, this document should contain information on the functioning of the building systems and controls suitable for use by both facilities managers and building occupants. The original project manager confirmed that this document was indeed produced, however its location is not currently known and the existing building occupants have not had access to it. This issue with sub-optimal management of information is likely to be at least in part due to the unification process, and was probably exacerbated by the fact that the current facilities management team was not put together until 6 months after the building became occupied. In addition to this, normal staff turnover as well as several rounds of staff redundancies has meant that none of the staff originally responsible for managing the building are still in council employment. This has resulted in some difficulties both during this study and in the day-to-day management of the building itself; these are discussed in more depth under section 5.

The handover process as a whole was carried out in line with the industry guidance that was current at the time of construction (e.g. the CIBSE Commissioning Codes and BSRIA guidance), and was therefore considered by all involved to have met the requirements of the client (i.e. Wiltshire Council). The commissioning period was, however, put under some time pressure as other priorities (financial and contractual) took on greater importance, as is often the case. For this reason, some of the systems were not perhaps set up and tested as well as they should have been. Examples of this include the mislabelling of some of the sub-meters within the ION system, and the confusing referencing of sensors and their locations within the BMS software. The Soft Landings framework was not available at the time the project began and hence was not followed in this case. More information about the handover process at Bourne Hill is contained within Appendix 3.

Without access to all of the relevant design documentation it is impossible to say to what extent the building was constructed in line with the design, however its form and services do appear to be generally in accordance with the information that is available.

3 Review of building services and energy systems.

Technology Strategy Board guidance on section requirements:	This section should provide a basic review of the building services and energy related systems. This should include any non-services loads – which would therefore provide a comprehensive review of all energy consuming equipment serving the building or its processes. The key here is to enable the reader to understand the basic approach to conditioning spaces, ventilation strategies, basic explanation of control systems, lighting, metering, special systems etc. Avoid detailed explanations of systems and their precise routines etc., which will be captured elsewhere. The review of these systems is central to understanding why the building consumes energy, how often and when.

The building services strategy at Bourne Hill has been described and evaluated under a number of separate research tasks during this project. The aim of this section of the report is to bring this information together to provide a more complete summary of the energy consuming equipment and systems in place. Detailed explanations of the systems and their precise routines are included within the appended reports (see Appendix 4 in particular), and specific technical issues that may be having an effect on the amount of energy consumed at Bourne Hill are discussed later in this report under section 7.

The two parts of the building are serviced differently in line with their fabric characteristics and, in the case of the older section of the building, with the restrictions in place due to its listed status. Both are however served from one central plant room, and there was a clear intention at design stage to minimise energy consumption from the building as a whole wherever possible.

3.1 Heating

Space heating at Bourne Hill is provided by three high-efficiency gas condensing boilers, which serve variable temperature variable flow heating circuits to the two separate parts of the building. In the older part of the building a conventional wet heating system using radiators equipped with thermostatic radiator valves is in place to distribute heat throughout the cellular office spaces. The more open-plan spaces in the extension are heated via perimeter trench convectors. Water flow (and consequently space temperature) is independently controlled for each trench heater using 2 port motorised valves adjusted in response to data collected via a network of temperature sensors (see Appendix 5 for sensor layout drawing). Each floor is divided into a number of zones with a sensor controlling the trench heaters in that zone, and each zone comprises around 16 desks. The temperature in each space is set remotely using the BMS system, however there is also one thermostat located in the centre of each of the floors to allow for limited local control. There are some radiators located in the core areas of the extension (e.g. in the WCs and stairwell area). A copy of the heating schematic for both parts of the building can be found under Appendix 6.

Hot water is provided to the original building via a traditional hot water circuit, which is served from the gas boilers in the plant room. Point of use electric water heaters provide hot water to the WC and kitchen areas in the extension.

The building services cannot be completely separated from the building form when evaluating the energy performance of this building. Whilst the M&E systems were designed to be both efficient and flexible, there are also a number of features of the building's structure that were intended to reduce the demand for energy, and hence they are also an integral part of the 'energy system' in this case. For example, whilst the extension is primarily heated via the perimeter trench heating system, the building also makes use of heat energy from solar gain due to the high level of glazing to the façade, and the heavyweight structure and night cooling strategy help to further regulate internal temperatures.

There are currently no low or zero carbon technologies for generating energy on-site at Bourne Hill. It is understood from discussions with members of the original project team that the decision to focus capital expenditure on the efficiency of the building and key services instead of on energy-generating technologies very much reflected the statutory requirements, costs and the state of the renewables market as they were at the time the design was developed (i.e. in 2005). Wiltshire Council is however currently looking for opportunities to install renewable technologies across its property portfolio, and a study is being undertaken to look at the viability of installing a range of technologies on a site by site basis (hence a detailed feasibility study was not carried out under this project). The work to date indicates that solar photovoltaic (PV) panels are likely to provide the most attractive return on investment over the technology lifetime, and as a result of this, the Council are carrying out a programme to look at the viability of installing solar PV panels at 12 of their sites, including Bourne Hill.

3.2 Ventilation

The original building is naturally ventilated via openable windows in all areas except those that are fully enclosed due to the construction of the glazed link (i.e. those that previously had external windows that now open only into the link area), where mechanical ventilation with heat recovery has been installed (note that the heat recovery function is bypassed during hot weather). Ventilation in the new extension takes place primarily via a stack ventilation system (the glazed link provides the necessary height difference), which is controlled via automatic (i.e. BMS-controlled based on readings from local CO_2 sensors) and manual ventilation panels around the perimeter of the building. There is also some degree of cross ventilation across each floor. The BMS also controls the automatic panels located at a high level to provide night-time purge cooling during the summer months and to maintain comfortable conditions during working hours. This system is dependent on internal temperatures reaching 20^{o}C. One particular benefit of installing opaque ventilation panels rather than traditional openable windows in the extension is that this means that solar gain and glare through the glazed façade can be controlled by the use of internal blinds without restricting air flow.

The core areas of the extension are mechanically ventilated, and the only air-conditioned space within the building is the main server room, which is located at basement level. This room is cooled using two downflow units with self-contained refrigerant circuits (ethylene glycol). Excess heat is rejected to a cooling water circuit to two dry air coolers mounted on the roof of the extension. Free cooling is taken directly from the cooling water when external conditions permit.

3.3 Lighting

A large number (>45) of different types of internal light fittings are in place throughout the building, however the vast majority of luminaires within the office spaces in the new extension are 35W T5 fluorescent lamps with integral high frequency digital dimming control gear. The lighting strategy for the older part of the building was designed to complement its original features; hence the fitting types are more varied throughout the offices spaces, ranging from wall-mounted 80W CF-LE fluorescent lamps to 55W PL-L fluorescent pendant lamps. Lighting in the extension is tightly controlled through the use of both PIR and photocell controls to zones of 3 desks, with additional manual override controls in the meeting room spaces. Lighting within the original building is predominantly controlled via conventional manual switching.

The majority of the external lighting is made up of bollard luminaires (42W CFLs), column-mounted luminaires (150W CDM-TT lamps) and recessed uplighters (70W CDM-TD lamps). The performance specification for external lighting states that the external lighting should be switched on in the evening via photocell control and off again by timeswitch, with the reverse occurring in the morning. The load profile for electricity demand from external lighting shows two peaks per day (i.e. one in the evening and one in the morning), and the width of these peaks increases during the winter months as the days become shorter.

3.4 Rainwater harvesting

Rainwater is collected from the roof and from areas of hardstanding in a large tank below ground. Calculations carried out at design stage suggest that the system could provide up to 86% of the water required for the flushing of WCs, however this has not been verified under this project. The rainwater harvesting unit and Grundfoss pump are located on the second floor of the extension.

3.5 Energy-consuming equipment

Bourne Hill is primarily an office building, therefore most of the energy it consumes arises from the functioning of its building services (in particular heating and lighting), and from the use of standard office equipment. The equipment in the main server room contributes significantly to the electricity baseload, hence it is defined as a 'separable' for the purposes of the TM22 assessment. This includes an MGE Galaxy 3500 UPS system and two Stulz air conditioning units in addition to the server equipment itself.

As a result of the flexible working scheme, almost all staff use laptops rather than desktop PCs, which can be linked to 'docking stations' when staff are in the building. The council has a policy in place which states that laptop hard drives should revert to standby settings after ten minutes of inaction, although there is some uncertainty as to whether this is always the case in practice. There are eleven large Canon printers located around the building (these are manually switched off overnight by the FM staff), six microwaves and four refrigerators are provided within the three kitchen areas, and there is a vending machine on the ground floor of the extension. There is also a heated air curtain over the main entrance by reception and one passenger lift.

The results of the additional questions added to the BUS survey (see section 4) indicate that some use is made of desktop heaters and fans when considered necessary, however this is relatively rare and the equipment is provided to staff at the discretion of the FM staff (this issue is covered in more depth in the next section).

3.6 Systems for energy monitoring and management

Energy is managed and monitored via three separate systems at Bourne Hill. Firstly, at a local level, the BMS, which was manufactured and installed by ADT, is used to control the equipment in the plant room, including the boilers, and also the heating and ventilation systems in the extension (as discussed above). The BMS system is also linked to a weather station located on the roof of the building, which measures factors such as the external temperature, humidity, wind direction and level of insolation. All data is logged on the BMS at 15-minute intervals and is accessible at the main interface within the FM office at Bourne Hill. The system is set up with a number of different permission levels, each giving the user a different level of control over the system. Data collected from the three heat meters installed under this project should also be accessible through the BMS.

Secondly, a unit designed specifically to monitor, log and analyse data has also been installed on site. The unit, manufactured by Schneider Electric, has no control over the functioning of the systems within the building but can be used to identify and display trends in utility consumption and to alert its users to pre-programmed 'events' that could have an impact on performance. The platform used within the unit is called PowerLogic 'ION' software, which has a flexible and scalable architecture and can be extensively programmed to suit a specific building or project. Whilst this system has very broad capabilities in theory, at this time it is used specifically for the monitoring of the electricity sub-meters in both parts of the building. The ION system is currently set up to be accessed from any computer 'docked' in a council property. As with the main ADT BMS, there are a number of different access 'layers' with varying permission levels.

There is a very comprehensive network of electricity sub-meters in place at Bourne Hill, the design of which is fully compliant with CIBSE TM39 and currently accounts for around 94% of the total amount of energy consumed on site (note that due to queries over the labelling of the sub-meters, it is not certain that the network is compliant in operation). There are a total of 33 electricity sub-meters, with internal lighting separately sub-metered from total power for each floor on both sides of the building, and higher-consuming items also being individually sub-metered (for example the passenger lift, UPS system, cooling plant to server room etc.) A copy of the metering schematic is included in Appendix 7 to this report.

Finally, energy use is monitored at a more strategic level using online Systemslink software. Systemslink is a well know and widely used system suited to high level analysis of mains data on a portfolio basis. The software can also be used for a range of additional energy management-related tasks including CRC reporting, the production of DECs, financial analysis and tenant billing (where relevant).

4 Key findings from occupant survey

Technology Strategy Board guidance on section requirements:	This section should reveal the main findings learnt from the BPE process and in particular with cross-reference to the BUS surveys, semi-structured interviews and walkthrough surveys. This section should draw on the BPE team's forensic investigations to reveal the root causes and effects which are leading to certain results in the BUS survey; why are occupants uncomfortable; why isn't there adequate daylighting etc. Graphs, images and data could be included in this section where it supports the background to developing a view of causes and effects.

The aim of this section of the report is to provide an overview of the way in which the occupants of the Bourne Hill offices view their working environment, and to use the findings of other activities carried out during the BPE process to explain the key issues identified. The primary tool used to capture the level of occupant satisfaction at Bourne Hill has been the Building User Survey (BUS). The survey was carried out on the 29th February 2013 by members of Wiltshire Council's on-site Facilities Management team, and the methodology closely followed the guidance provided by Arup. Details of the BUS methodology and an in-depth review of the results are set out within the task report for Task 12, which is included within the appendices to this report for reference (see Appendix 8). The original analysis provided by Arup is also appended (see Appendix 9).

Out of approximately 300 members of staff, 111 survey responses were received. Despite the fact that only 11 of the responses were completed by occupants located within the original building, their responses were considered sufficiently different to warrant separate analysis from those completed by staff located within the new extension. The raw data were therefore broken down and re-analysed by the BPE team to reflect this. These results are set out in the sections below.

4.1 BUS survey results

The headline results for the building as a whole are set out in the diagram below (Figure 7).

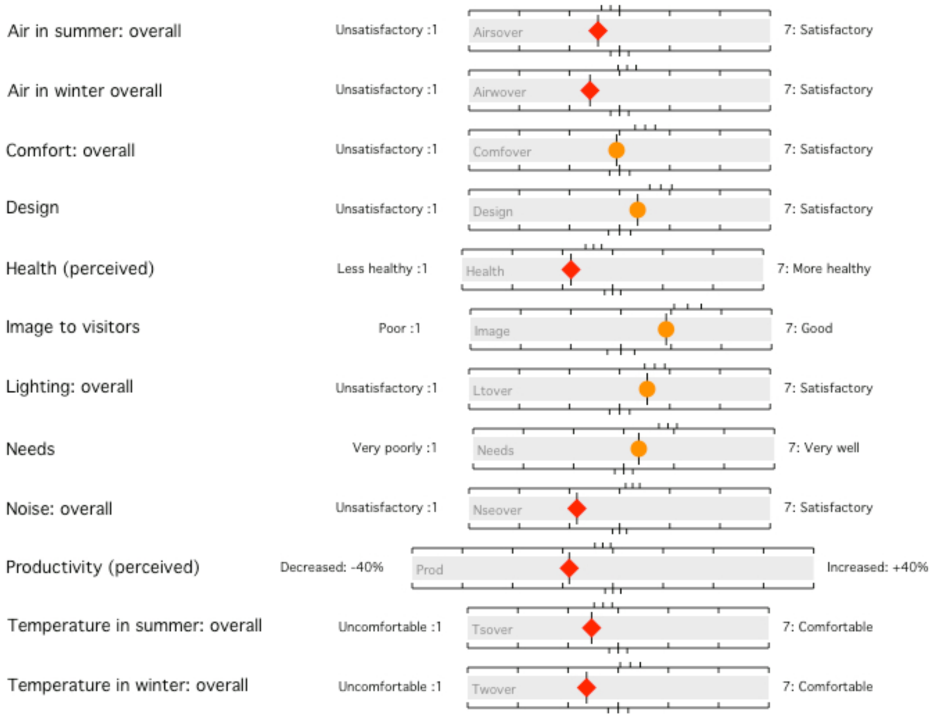

Figure 7: Summary output of BUS survey response analysis, provided by Arup

Overall, these results suggest that Bourne Hill is not performing well in terms of delivering a comfortable working environment. Where the cursor is coloured red the building is outside the critical lower limit (or upper limit depending on how the scale is organised) for the benchmark constructed from all buildings in the ARUP database.

We can conclude that on critical measures of comfort in both summer and winter conditions occupants typically feel somewhat uncomfortable. This potentially has repercussions for morale and productivity with occupants on average feeling less healthy inside the building. Where the cursor is amber the building is between the benchmark upper value and the lower critical value for the scale indicating a middling or "cautionary" performance. The building receives no green ratings, green being better than the benchmarks and/or upper (or lower as appropriate) critical values for the scale.

Personal control

A sense of control is thought to be a critical component in delivering building occupant satisfaction. Where control is denied and comfort levels are not met occupants will generally develop workaround solutions, some of which may potentially create additional energy consumption. The survey demonstrates that across the whole building staff feel that they have little control. However there are key differences between the old and new parts of the building with staff in the newer section having below benchmark figures for the level of control on all services other than ventilation. This is to be expected due to the fact that the trench heating system in the new part is controlled centrally by the BMS and cannot be adjusted locally by staff (note, there is one adjustable thermostat per floor, which is located near the core). In the old part of the building staff are able to control the heating system by adjusting the thermostatic radiator valves fitted to the radiators in each separate space; survey results show these staff generally feel they have more control.

Comfort

Overall comfort is determined by a number of factors including individual preferences, draughtiness, radiant temperatures, air temperatures, air quality and convection currents. Taken as a whole, the building appears to be delivering a middling level of comfort although, once again, when new and old are compared a slightly different picture emerges. Occupants generally feel comfortable in the old part of the building and slightly uncomfortable in the new part. The most comfortable area appears to be adult care but the very small sample size (3 individuals) cautions against over-interpretation of this figure. There is no specific part of the new building that is considered more comfortable than the old building although the reception area is perceived as comfortable (this is surprising, as the thermographic survey indicated that temperatures are noticeably colder in this area due to the proximity to the main entrance). The least comfortable area of the building appears to be planning/public protection with most of the other new building areas also perceived as, on average, “somewhat uncomfortable”. The new building is also considered somewhat uncomfortable in summer whereas the older building is considered, on average, to be “comfortable”.

Understanding why occupants feel uncomfortable temperatures in the new part requires further investigation. There are indications that the fabric in the new part may create cold spots and areas of heat loss. The thermographic survey suggests significant cold bridging through curtain walling frame in the new extension and glazed link. Alternatively, it has been suggested that as most of the building users were previously located in older properties with more traditional heating systems, they are more used to the kind of environment that they create and they understand better how they work. Also, people may be more sensitive to possible discomfort when they are unhappy about other things (for example higher noise levels).

Seasonal Temperatures

The figures suggest that most parts of the building are perceived as being too cold in winter although the old half of the building is considered to be marginally colder on average overall with the exceptions of a) Housing, Revenue and Benefits and b) Revenue and Benefits. Only the hot desks are as good as their name and are considered the warmest part of the building in winter but are neither too warm nor too cold. Revenue and benefits may have received a lower score due to the faulty window actuators which meant that windows were stuck open (top floor of new extension). Despite this, the old part is considered more comfortable overall in winter than the new. This demonstrates the multifaceted nature of comfort whereby a sense of comfort is determined by more than air temperature alone. There is also the possibility that the occupants of the old part are more “forgiving” of their space because of other benefits of working there.

In summer, the results suggest that there is typically some small variability in temperatures through the day across most of the new parts of the building. The old part of the building appears to have the most stable temperature, presumably arising from its fabric characteristics. However, it is perhaps surprising that the new extension does not return similar figures for temperature stability as it too was designed with a high level of exposed thermal mass, and is controlled by the BMS to try to maintain temp of around 21 deg C (depending on the time of year). Measured temperatures (both via the BMS and from the temporary sensors) indicate that temperatures are in fact fairly consistent, however the period of data collection is limited and does not cover any instances of particularly warm or cold weather.

The figures suggest that in winter the air is thought to be stillest in the old part of the building. This is a little surprising given its age but is perhaps explained by the cellular arrangement of the offices in the old part, with the atria sealing the walls of the old part on 2 sides and the CO_2 sensing ventilation system operating in the new part. The draughtiest part of the building in winter appears to be adult care. Again, this may be connected to the faulty window actuators during the winter period (which have now been fixed). The stack ventilation system in the new extension/glazed link may also create a sense of draughtiness during the winter months. In summer, the situation appears to be reversed with the old half of the building considered the draughtiest and the adult care section the least draughty. It is speculated that this is as a result of occupants in the old part having the ability to open up windows as required, in order to to create a cooling effect.

Use of supplementary heating and cooling

When occupants are uncomfortable supplementary heating and cooling devices are occasionally deployed, such as electric under desk fan heaters and desk fans. When widespread these electrical loads can have a very significant impact on building energy consumption. The figures here suggest that only a very small number of staff in the building occasionally use supplementary heating. This may be the outcome of facilities policy rather than an absence of desire to use this equipment. That 3 out of the 10 respondents from the old part of the building either often or sometimes use supplementary heating (a much higher percentage than in the new part) is possibly significant and is in line with the finding reported above that the older part is perceived to be colder than most of the rest of the building as a whole.

Figures suggest that there is a small amount of desk fan use in the summer months in the new part of the building. That desk fans are "never" used by any of the 10 respondents in the old part of the building is also in alignment with previous findings that the old part is thought to be the closest to being neither too hot nor too cold in summer and that it is the most comfortable overall in summer.

Noise levels across building areas

Although noise is not a parameter usually associated with a building's energy performance we explore it further below because it appears that noise levels are a very significant issue at Bourne Hill. These may have indirect implications as staff change their working practices to mitigate impacts of excessive noise in the workplace e.g. by working from home.

The figures suggest that other than adult care, everywhere in the building is perceived to be somewhat or significantly unsatisfactory in terms of noise levels. It should be noted that levels of satisfaction may in part be determined by the activity within the space as well as the noise levels themselves. For example in children services and adult care, where there is a need to occasionally make sensitive phone conversations, noise levels are reportedly particularly unsatisfactory. This may be for the reasons stated. This presents a case for relocation of this department to the older part of the building.

Lighting

The survey results suggest that on the whole lighting levels are considered acceptable in both old and new areas. In order to gauge potential behaviour change in respect to turning off unnecessary lighting, staff were asked how often they perceived lights to be left on unnecessarily in communal space. The figures suggest that most staff do not know if lights are left on unnecessarily. However, of the 39 that did respond either positively or negatively to this question, around 25% feel that lighting is left on always or often unnecessarily. The majority feel that it is only left on sometimes or never. This suggests that in general lighting is well controlled at the Bourne hill site.

We also asked whether staff would personally switch off lights if they found them to be left on unnecessarily. Figures suggest that nearly 70% of staff would either always or often personally switch off lighting if it was being used unnecessarily which suggests a high level of personal responsibility for this. However, there is still some scope for improvement with 16% either only "sometimes" or "never" turning off unnecessarily left on lighting.

4.2 Conclusions

We can conclude that the Bourne Hill offices are not, as yet, delivering a comfortable working environment, particularly in certain areas and particularly in the new part of the building. On virtually every measure the old part of the building is considered a more comfortable environment to work in. Therefore the results demonstrate the value of comparing different areas of the building rather than examining the building as a whole, particularly in a building such as Bourne Hill which has two very different buildings connected together.

The results also demonstrate the multi-faceted nature of comfort. Although the old part of the building is perceived as being amongst the coldest in winter months other aspects of comfort offset this so that, overall, the old part is perceived as being more comfortable than the new part. It is perceived as being more comfortable because it is cooler in summer, less draughty in winter and experiences less temperature variability through the day in both summer and winter.

The servicing strategy in the old building is more 'traditional', meaning people understand it and are able to control their ventilation and thermal needs themselves by opening windows and adjusting thermostatic radiator valves on radiators. The strategy in the new extension i.e. stack ventilation, passive solar gain, BMS systems control, absence of temperature controls such as room thermostats are generally not well understood and may not have been properly explained to staff. Therefore they may not be aware that they might impact negatively on their environment by moving furniture to a new location/stacking boxes high etc. The absence of the ability to control comfort in the new part may also feed through to some frustration and negatively impact comfort.

The variability of comfort across the building presents a strong case for focussed adjustments to the BMS settings and for behavioural change measures to ensure that the staff get the best from their building services. Examples of possible behaviour change methods include a 'get to know your heating system' campaign, an "it's ok to wear a jumper at work" campaign, or some kind of lighting intervention. These are discussed in more depth within the Task 29 (Appendix 18). A separate study looking at providing feedback on energy consumption to building users as a means to encourage energy-saving behaviours is being carried out at Bourne Hill by a team of researchers from the universities of Nottingham and Southampton, although the project is still in its early stages and no interventions have been designed as yet. More information on this project can be found on the project website (http://energyforchange.ac.uk/).

5 Details of aftercare, operation, maintenance & management

Technology Strategy Board guidance on section requirements:	This section should provide a summary of building operation, maintenance and management – particularly in relation to energy efficiency, metering strategy, reliability, building operations, the approach to maintenance i.e. proactive or reactive, and building management issues. This section should also include some discussion of the aftercare plans and issues arising from operation and management processes. Avoid long schedules of maintenance processes and try to keep to areas relevant to energy and comfort i.e. avoid minor issues of cleaning routines unless they are affecting energy/comfort.

The Facilities Management (FM) team in its current form was not set up until six months after the building became occupied, and there was little in the way of formal aftercare in the months following handover aside from the standard defects liability period. At the point of handover, the main contractor led a number of training sessions aimed at providing council staff with information about the building, and on how those that designed it intended the building to be run. All of these training sessions were recorded to facilitate the training of future staff, however these recordings cannot be found and the staff originally in attendance at the sessions are no longer in council employment. This has meant that the FM team have had to work hard to get to know the systems in place with very little guidance being available to them. For example, the front end supervisor screen for the BMS was unplugged and not discovered until approximately two years after occupation, hence the system was not fully functional for some time. Similarly, the AMR unit on the mains gas supply was in place from June 2012 but not properly connected until November 2012, and so all monitoring of gas consumption had previously been based upon quarterly billing data rather than half hourly metered data. As noted in previous sections, the quality of the information contained within the O&M manuals is of fairly inconsistent quality, and it is likely that this has further compounded the issue. The example of Bourne Hill highlights the importance of internal knowledge management post-handover as well as during the handover process. Organisational change (in this case the unification of the council, the formation of the new facilities management department and normal staff turnover) is very common and having a well-embedded process for collecting, storing and passing on important information can help to limit future problems.

The late formation of the FM team also meant that existing issues were not noted and dealt with early on. Some problems in particular were not detected until after the end of the defects period, and therefore it was difficult for staff to seek assistance from the original designers/installers without incurring considerable extra costs.

The day to day running of the Bourne Hill offices is primarily the responsibility of the on-site Facilities Manager and Facilities Officer, who, amongst other duties, ensure that the building and its services are well maintained and work to provide users with a comfortable working environment. The on-site FM team follow a strict 'Planned Preventative Maintenance' (PPM) plan to try to ensure that the building systems are operating effectively and in an effort to prevent unplanned breakdown and downtime. This regular maintenance also helps to make sure that the energy-related services continue to work as efficiently as possible. The PPM schedule was drawn up by members of the FM team in conjunction with a surveyor from Kier Group plc, who are contracted to manage the PPM work on this site by Wiltshire Council. This contract began on the 3rd October 2011 (i.e. a full year after handover). The PPM schedule lists all relevant items of equipment (for example the three boilers, HWS calorifier, pumps etc.), their location and the type of trade required to carry out the maintenance work. The frequency and expected approximate dates of planned maintenance for each item are then shown on a grid, which is divided up on a weekly basis. This information is based on the recommendations of the equipment manufacturers and on the requirements of current relevant legislation. Overall, the management style of the FM team is considered to be proactive, rather than reactive, in as far as circumstances allow.

The on-site FM team are well aware of the need to keep down the cost of utility bills and work to do this within the scope of their remit. In terms of energy used for space heating, the Facilities Manager is regularly required to balance the comfort requirements of the building occupants with the control of gas consumption. As discussed under section 4, the temperature within the office spaces does not always meet with the expectations of some members of staff, particularly within the new extension, despite measured temperatures appearing to be in line with CIBSE recommendations in all areas. This means that the FM team are frequently being asked to alter the temperature settings via the BMS. As a general rule, the Facilities Manager sets the temperatures so as to try and maintain an internal temperature of 19 – 20°C in all office areas, which is in line with the Council's temperature policy (although temperatures are usually recorded as being slightly higher than this in actuality). The FM team find this policy useful as a means to respond to user complaints and to prevent the need to increase temperatures (and therefore energy consumption) on demand. It was suggested during the staff workshop in Quarter 5 that an increased presence of senior staff at Bourne Hill might further assist the FM team to balance the top-down financial pressures with the bottom-up complaints about comfort from the building occupants.

One method that the on-site FM team use to try to reconcile comfort and energy-related issues is the running of a Building User Group. The BUG group meetings are held once every six months and are designed to provide users with a regular route through which they can provide feedback to the FM team on issues related to the building. It is intended that each meeting is attended by at least one representative from every department, however attendance has historically been relatively poor (the Facilities Manager has noted that on one occasion only four members of staff turned up). In addition to complaints about internal temperature, other common topics at the BUG meetings include the functioning of the vent actuators and the low lighting levels in the new building, and complaints about the colour of the recycled rainwater used to flush the WCs.

5.1 Energy management at a strategic level

The on-site FM team are part of a larger council-wide FM department. This department has been restructured more than once since the building became occupied, with the current team structure being as per the diagram below.

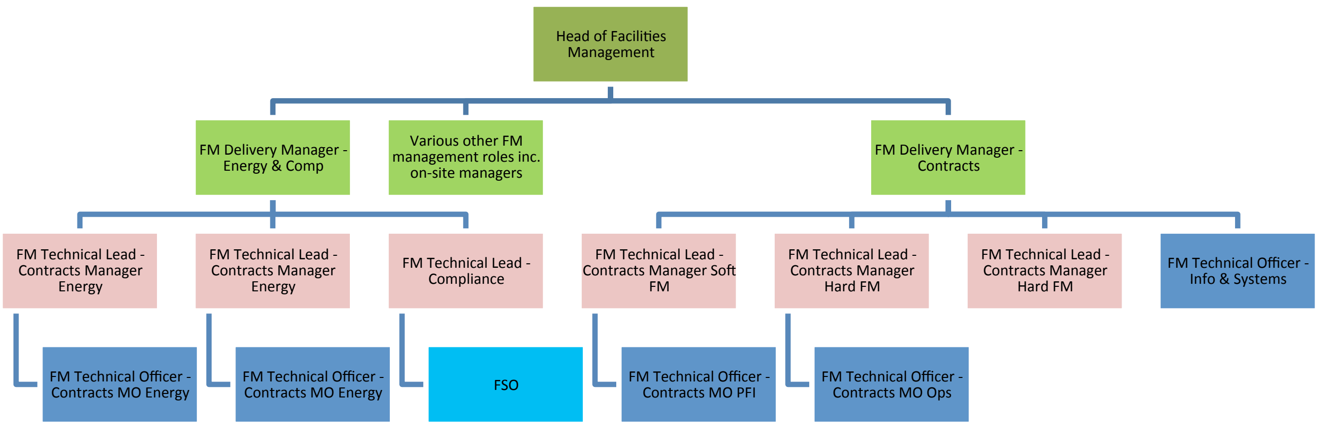

Figure 8: Wiltshire Council FM team organogram

Strategic energy management at Wiltshire Council includes activities such as energy procurement, high-level monitoring and management systems, and regulatory compliance. These are mostly carried out by the personnel listed on the left hand side of the above diagram.

The council was certified to the BS16001 Energy Management Standard for a specified number of sites in 2011. One of these sites was Bourne Hill. Certification to the standard required specific activities to be carried out at the offices. These included the development of an Energy Action Plan (EAP) for the site and the communication of that plan to key staff. The main staff teams tasked with implementing the Bourne Hill EAP were the on-site FM team, the on-site Green Champion, the corporate maintenance staff, and the corporate energy staff.

The EAP for Bourne Hill was developed after an initial Energy Audit carried out by the Energy Team. The audit highlighted areas of energy performance that could be improved and recommended improvement actions. The areas for improvement at Bourne Hill fell into 3 categories.

- Staff behavioural change initiatives
- Allocating responsibility to key staff for energy improvement initiatives
- Training for key staff that have an impact on energy performance (especially operational controls)

There were no technological solutions recommended for improving energy performance at Bourne Hill. This was due to the building being almost brand new and consequently no investment case could easily be made.

The EAP was to be implemented during 2011/12 and its impact reviewed prior to the council applying for re-certification in 2012. In fact, due to a council wide redundancy programme and the consequent staff changes, the impetus behind the standard was diluted, and the capacity to deliver it was weakened by staff shortages. In early 2012 the Council became aware that BS16001 was being replaced with a new international energy standard and agreed to redirect resources into energy management as a priority area for financial scrutiny. Therefore during 2012 a concerted effort was made to upgrade the existing BS16001 standard into the new ISO5001. The new standard included the whole corporate estate within its scope rather than the 10 previously specified sites. The agreed aim was to adopt a broad but shallow approach to energy management rather than the narrow and deep BS16001 remit. The impact of the first standard was never really felt at Bourne Hill, and the new standard has not been in place long enough for its impact to become apparent.

The Council have recently produced a strategic Sustainable Commissioning and Procurement Policy which specifically states that the energy efficiency of a piece of equipment should be considered as a factor in its selection. This document is written at a high level and does not in itself provide detailed guidance on what to look for when purchasing different types of energy efficient equipment and it is not clear to what extent this type of guidance exists elsewhere. Despite this, much of the equipment in place at Bourne Hill is already labelled as energy efficient. It should be noted, however, that electricity consumption at Bourne Hill is not high, and that where a decision to select more energy efficient equipment leads to additional cost, this would most likely need to be weighed up against the potential financial savings on electricity bills. Wiltshire Council's flexible working policy is also likely to be having an impact on the amount of energy consumed at Bourne Hill, however without more detailed information regarding the number of staff on site at any given time, it is difficult to separate the impact of this policy from other factors that might be affecting energy use.

Due to the nature of the Council's property estate, energy monitoring and targeting (M&T) tends to take place at a strategic rather than building specific level (although it is intended that the recent restructuring of the FM team will place more of a responsibility for energy management at the building level). M&T performs a number of functions for Wiltshire Council, as the data recorded is needed for a range of different purposes. The main purpose is to ensure the council complies with statutory requirements such as the CRC scheme, but there are also other functions such as budget monitoring and forecasting; assessment of value of investment projects; data for submission of annual Greenhouse Gas Emissions report; and of course the direct analysis of the energy performance of its buildings.

The council carried out a review of its M&T system in 2009 which led to the old TEAM software being replaced with the current SystemsLink package in 2010. SystemsLink currently receives invoice data on all corporate property supplies; all street lighting supplies; about 90% of school supplies; some housing supplies; and some investment property supplies. The majority of information comes from the monthly corporate contract EDI file. In addition, there are 40 MHH supplies and 500 AMR supplies that record half hourly readings which are then imported daily into SystemsLink. Bourne Hill Offices have a mandatory half hourly electricity meter that has been there since the building was completed and an AMR unit on the gas supply. Half hourly data and costs from both of these supplies are recorded in SystemsLink. As noted in section 3 of this report, Bourne Hill also has a very comprehensive network of electricity sub-meters, which can be monitored via the ION software. At the start of this project the ION system could only be accessed from a PC within the server room at Bourne Hill, however it is now possible to access the system from any computer docked at a Wiltshire Council office. This data does not feed into SystemsLink, and due to the complexity of the system and the sheer volume of data available, the data is not used as part of the Council's routine M&T activities. Should the metered mains data on SystemsLink indicate unusual consumption patterns at Bourne Hill, then the more detailed information on the ION system may then be used to identify the cause.

6 Energy use by source

Technology Strategy Board guidance on section requirements:	This section provides a summary breakdown of where the energy is being consumed, based around the outputs of the TM22 analysis process. This breakdown will include all renewables and the resulting CO_2 emissions. The section should provide a review of any differences between intended performance (e.g. log book and EPC), initial performance in-use, and longer-term performance (e.g. after fine-tuning and DEC – provide rating here). A commentary should be included on the approach to air leakage tests (details recorded elsewhere) and how the findings may be affecting overall results. If interventions or adjustments were made during the BPE process itself (part of TM22 (process), these should be explained here and any savings (or increases) highlighted. The results should be compared with other buildings from within the BPE programme and from the wider benchmark database of CarbonBuzz.

The aim of this section of the report is to provide a summary breakdown to identify where energy is being consumed in the building based on the available data and, where possible, to compare the performance of the building in use to its performance as predicted at design stage and to the most relevant standard benchmark figures.

6.1 Methodology

The first step towards understanding the energy performance of the Bourne Hill offices was to undertake a brief review of the Energy Performance Certificate (EPC) produced by the original design team and the Display Energy Certificates (DECs) that have been generated on an annual basis since occupation. This was carried out during the first research quarter and the results are summarised below. Further detail is also provided within the 'Task 2' report under Appendix 10.

All projects undertaken as part of this TSB BPE programme are required to include the use of a standard set of tools, protocols and techniques in order to assess building performance; for the analysis of energy consumption, BPE teams are expected to use the CIBSE TM22 spreadsheet tool. The TM22 tool allows users to carry out a simple evaluation of building performance based on the total consumption figures of the building as a whole per fuel type, and/or undertake a much more detailed analysis, for example using sub-metered data and modelled demand on an item-by-item basis. There is some degree of flexibility as to how the tool can be used.

Under this project, the TM22 analysis was intended to help answer two of the original key research questions set out within the tender documentation in particular; i.e. "how does the building as a whole perform in use (in terms of energy consumption) compared to it's modelled performance at design stage", and "to what extent does the performance of the new extension differ to that of the original Grade II* listed building".

During the early stages of the project it became apparent that very little information relating to the predicted performance of the building as designed was readily available (see section 2.2 of this report for details of information management and storage issues at Bourne Hill). The only useful and accessible data in this respect was the original EPC documentation, however as previously noted, this relates only to the new extension. This meant that it was not going to be possible to compare the performance of the whole building as designed to its performance in use. Once this had been determined, it was then proposed that one TM22 analysis should be carried out for each of the two parts of the building. The first would compare modelled demand with both design stage predicted consumption figures and actual consumption data from the new extension, and the second would just compare modelled demand to actual consumption for the original building.

To do this, three heat meters were installed within the plant room with the aim of splitting down the energy used for heating by area (heat meters were originally specified for the building during the design phase, however these were never shown on the schematics, perhaps as a result of value engineering, and therefore were never installed). One meter was placed on the space heating circuit to the original building, one on the space heating circuit to the extension, and one on the domestic hot water circuit (note, this supplies only the hot water requirements of the older part of the building; single point of use electric water heaters are used to supply the newer areas). Unfortunately, it has not been possible to get any meaningful data from these heat meters in time to be analysed for this study, as they have either not produced any readings at all or have produced readings that are clearly incorrect due to earthing and calibration errors. It was intended that data from the heat meters would be accessed through the BMS, therefore the problems with the retrieval of data stored on the BMS have made the rectification of this problem difficult. The closed protocol of the BMS system meant that the installers of the heat meters required specialist assistance from the installer of the BMS, which was both logistically complex and expensive (the recent restructuring of the FM team has created three new posts dedicated to the procurement and monitoring of contracts and contractors, which should help to reduce the risk of issues such as this in the future). Because of this issue, it has not been possible to break down gas consumption between the two parts of the building (it was decided that assigning values based on floor area would be inappropriate due to the very different fabric types and heat distribution systems present in the two parts of the building). It is however understood that the meters are now finally working correctly, and the Council's FM team have expressed an interest in reviewing the data at a later date (outside of this project).

In addition to this, a close review of the electricity sub-metering data has led to some uncertainty as to whether or not the sub-meters are correctly labelled and has also revealed a number of gaps in the data, hence there is also doubt as to the accuracy of splitting down the electricity consumption figures. As a result, it was decided that only one detailed TM22 assessment would be carried out for the building as a whole.

6.2 Energy performance as measured through formal certification procedures

As noted previously, prior to this study the level of energy consumption at Bourne Hill was perceived by the Council to be not quite matching up to design stage expectations. The Energy Performance Certificate (EPC) provided at the point of handover in 2010 achieved a score of 50, which equates to a 'B' rating and is slightly higher than the benchmark indicated on the bottom right hand corner of the EPC as being representative of similar buildings of the same type. In the years since the building has become occupied, four Display Energy Certificates (DECs) have been produced, the key results of which are set out in the table below (Table 1).

Certificate Issue Date	Rating Level	Score	Typical Score	Heating Energy Use ($kWh/m^2/year$)		Electricity Energy Use ($kWh/m^2/year$)
				Annual	Typical	Annual
19/11/2010	G	9999	100	n/a	n/a	n/a
23/11/2011	D	76	100	172	136	67
22/10/2012	C	72	100	64	112	74
29/10/2013	D	86	100	116	125	79

6.1: Summary of key information from annual DEC certificates between 2010 and 2013

At a first glance, it appears that the performance of the building in use is considerably lower than its predicted performance, with ratings falling within the G, D and C rating boundaries. There are a number of possible reasons for this, but the first, and most important, is that the two certificates do not cover the same areas of the building. Under the 2007 Energy Performance in Buildings regulations an EPC must be provided whenever a building is constructed, rented out or sold in order to calculate its “asset rating” (i.e. the performance of the building fabric and services). As the original building has not been sold or rented out since the introduction of this legislation in October 2008, the EPC was only required to cover the newly-constructed extension. The DEC on the other hand is required to cover the whole of the building, and therefore also takes into account the performance of the original fabric. This means that the two standards are not really comparable in this case (note, the G rating is a default score assigned where insufficient data is available, and it is therefore in no way representative of the actual performance of the building). This simple miscommunication between those that constructed the building and those that now manage it is the primary cause of the concerns previously raised. The scores shown on each of the three valid DECs are better than the ‘typical building’ benchmark score of 100, which is particularly good when you consider the potential impact that the restrictions placed on the refurbishment of the listed part of the building might present. The consumption of electricity is considerably better than the benchmark figures in all three instances, however gas consumption figures are shown to be more variable. Copies of the EPC and DEC certificates can be found under Appendix 10.

There are a number of possible reasons for the change in DEC rating from year to year; for example it may be due to changes in the performance of some of the services, changes to the way in which the building is managed, or it could be linked to fluctuating occupancy levels and the flexible working policy, particularly unusual weather patterns (i.e. it may be the case that buildings with such a high level of glazing to the façade could be more sensitive to periods of extreme cold or hot weather, and where these occur for long periods the systems may need to work proportionally harder over the course of the year), or to a combination of some or all of these factors. It is also important to note that standard occupancy hours have been assumed as part of the rating calculation, and that council activities at Bourne Hill regularly exceed these due to the slightly extended opening hours during the week and the use of the registry office facilities at weekends. This means that it is possible that the building is actually performing better than the certificates would suggest in practice.

6.3 TM22 analysis and results

Simple Assessment

In this case, the TM22 analysis is only being used to assess the performance of the building in-use, therefore no data has been entered on the design stage worksheets. As a local government office, Bourne Hill falls into the ‘General Office’ category within the TM46 benchmarking guidelines, and a full year of data has been entered for both electricity and gas consumption, covering the period from 01/04/2013 to 31/03/2014. The annual totals used within the tool were taken from the billing data extracted from the Council’s SystemsLink software. In line with the methodology outlined within TM46, Bourne Hill’s server room has been defined as a separable. A separable can be described as a source of energy demand that is either unusual or highly variable, and that can therefore be reasonably excluded from the benchmarking calculation. The total consumption figure for the server room is in line with the total value recorded on the electricity sub-meter for that space (although it should be noted that there is some degree of uncertainty here, as this total consumption figure is shown to be lower than the sum of the individual sub-meters for the items of equipment within the server room). The benchmark figures taken from the 2013 DEC have been used as a basis for comparison for the purposes of the TM22 Simple Assessment tab. The 2013 DEC was selected over the earlier versions as it covered the closest time period to that used within the TM22 tool (the time period within TM22 was originally set to make best use of the heat meter data). The results of the Simple Assessment are set out below in both table and graphical format.

Absolute values	Energy supplied (kWh)		Carbon dioxide emissions (kg CO_2)	
	Fuel/thermal	Electricity	Fuel/thermal	Electricity
Supplied	369,727	332,638	71,727	182,951

Unit values	Energy supplied (kWh/m^2 GIA)		Carbon dioxide emissions (kg CO_2/m^2 GIA)	
	Fuel/thermal	Electricity	Fuel/thermal	Electricity
Supplied	86.8	78.1	16.8	43.0
Benchmark from DEC	125.0	95.0	24.3	52.3

6.2: Simple Building Assessment total consumption figures

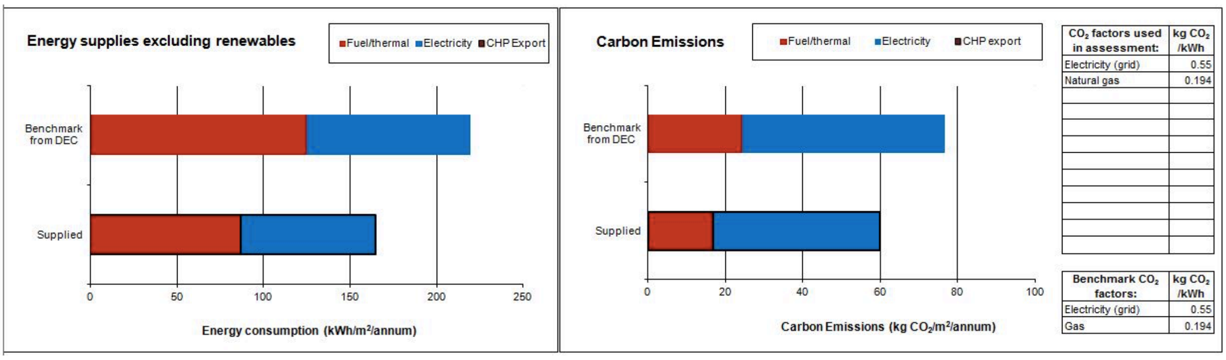

Figure 9: Total energy supplied to site

This basic summary analysis indicates that the building is performing better than the benchmark figures in the case of both fuel types for this period. This is a change from the pattern shown on all three of the DECs produced to date, and is thought to be the result of the more recent alterations to the hot water settings. These settings are discussed in more detail later on in this section, and it is expected that the 2014 revised DEC (due Oct/Nov 2014) will reflect the shift shown here.

The graph on the right hand side demonstrates how the figures for fuel consumption can be converted to represent carbon emissions. The carbon factors behind this conversion are the standard factors provided by DEFRA for the year 2013. In line with the graph on the left, the Bourne Hill offices are again shown to perform better than the standard benchmarks shown on the DEC. Although gas consumption is higher than electricity consumption (in terms of kWhs), the greatest impact on carbon emissions is shown to result from the use of electricity. This is because the carbon intensity of grid electricity is higher than that of mains gas at present. This suggests that the realisation of the Council's plans to install solar PV panels at Bourne Hill would be likely to have a proportionally high impact on the total carbon emissions from the site.

The graphs below demonstrate the impact of removing the separable from the calculation (the separable is shown as the light blue shaded area).

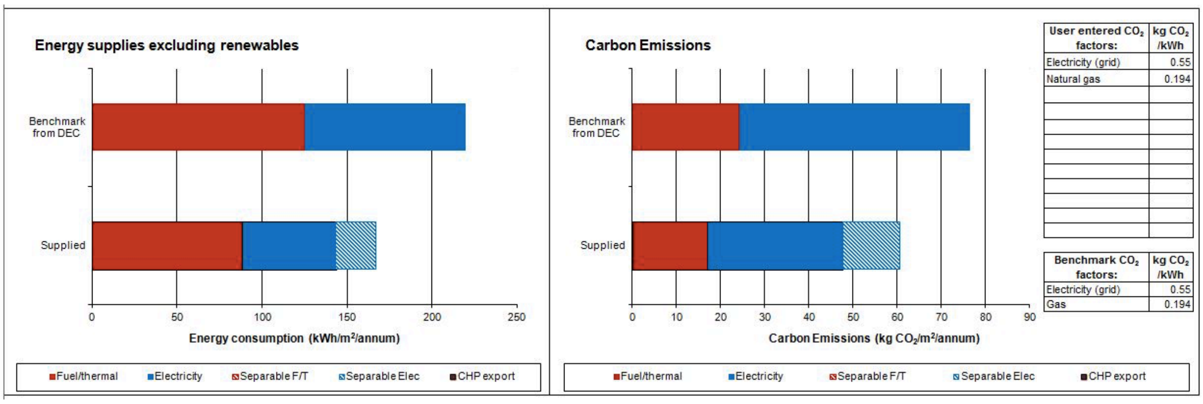

Figure 10: Total energy supplied to site (separable highlighted)

When the separable is excluded, Bourne Hill is shown to perform even better in terms of the amount of electricity consumed at the site.

Whilst this simple analysis shows that Bourne Hill is performing well, it is important to remember that the TM46 benchmark figures for offices are to a large extent based on those set out within Energy Consumption Guide 19 (ECON 19) "Energy Use in Offices". ECON 19 was originally released in 1998, with some minor revisions having been carried out in 2003, therefore no buildings designed and constructed in the last decade or more have been included within the sample used to define the benchmarks. It is possible that newer buildings may use more or less energy than those within the sample, for example as a result of there being more energy-consuming equipment within the buildings, or because of increases in the efficiency of this equipment. It is also possible that these two factors will effectively negate each other.

Detailed Assessment

Once the Simple Assessment section had been completed, four new usage profiles were set up within the In-use tab in addition to those that are standard within the TM22 tool. These were intended to account for the extended office hours from Monday to Friday (which are primarily a result of the flexible working scheme, which allows staff to arrive early and/or leave late), the use of the registry facilities on Saturdays, and the control of the external lighting (morning and evening usage is separated into two separate profiles due to the way the data must be entered into the tab).

A list of electricity–consuming items at Bourne Hill was provided by the on-site FM team, along with their associated power ratings where available. Where nameplate ratings were not available they were estimated based on those of similar equipment. The lighting scheme at Bourne Hill is fairly complex, therefore the aggregate power rating for internal lighting per floor for each side of the building was calculated separately (outside of TM22) and entered into the In-use tab of the tool on this basis (see appendix 24). Due to the questionable accuracy of the electricity sub-meters and the missing data, all individual items were simply assigned to the mains electricity meter (although the location of each item was noted in order to facilitate separate comparison with the sub-meter data, outside of the TM22 tool). Each item was also placed into one of the pre-defined usage categories (for example 'space heating', 'pumps', ICT equipment' and so on), load and usage factors were estimated based on the best available information, and inverse profiles were set up to account for out-of-hours consumption where appropriate.

Whilst it was not possible to use data from the heat meters to accurately separate out energy used for space heating in the old and new parts of the building and energy used for water heating, it was possible to estimate the split between space and water heating based on the amount of gas consumed during the warmest months of the year when it is assumed that little, if any, space heating is required. This data was obtained through the SystemsLink software, and is discussed in more depth later in this section. The space heating shown within the TM22 tool is separate to this and relates to the air curtain over the main entrance. Similarly, the water heating figure relates to the electric point-of-use water heaters in the bathrooms and kitchens within the new extension.

The table below is copied across from the Sub-system analysis tab, and provides a summary overview of the results of the detailed TTM22 analysis. The breakdown is based on the modelled demand, and the end-use categories are those that were previously assigned on an item-by-item basis.

	Heat demand (kWh/m2/year)	Electricity demand (kWh/m2/year)
System	**In-Use (kWh/m2/year)**	**In-use electricity (kWh/m2/year)**
Space Heating	75.8	0.7
Hot water	2.4	1.3
Pumps	0.0	3.6
Controls	0.0	0.6
Lighting (Internal)	0.0	18.6
Lighting (External)	0.0	1.7
Small Power	0.0	1.4
ICT Equipment	0.0	15.5
Vertical Transport	0.0	1.3
Catering - Distributed	0.0	1.3
User 1: Regional Server Room 1	0.0	23.2
Total	**78.1**	**69.3**
Metered building energy use	78.1	78.1
Variance TM22 versus metered total	0.0	-8.8
Variance TM22 versus metered total	0%	-11%

6.3: TM22 Sub-system analysis summary output

This analysis shows a difference of 8.8 kWh/m^2/year between modelled electricity demand and the actual consumption figures as recorded via SystemsLink, which equates to approximately 11%. The shortfall in the modelled figures may be the result of a number of separate issues, for example:

- The list of energy-consuming equipment may be incomplete. This may be in part due to a lack of on-site resources available for this activity. The FM team have a central inventory of fixed equipment (i.e. pumps, controls etc.), and have provided a brief summary of other items such as laptop docking stations and printers for the purposes of this study. The high level of organisational change currently taking place at the Council (in particular the relocation of police staff into the building) means that FM resources are stretched, and that going through such an inventory in fine detail is not a key priority at this time. This may be particularly true in relation to personal equipment use within the building (e.g. the charging of mobile phones at desks). It is recommended that the council put together a more complete equipment inventory should more resources become available at a later date (perhaps as part of the ongoing work under the new energy management system).

- The load and usage factors are mostly estimated based on the best available information. It is possible that some of these do not match exactly with the performance of the equipment in use. For example, the flexible working policy may mean that a proportion of desk spaces are not occupied for the full period assumed within the tool. Without access to more detailed attendance data it is difficult to refine this particular factor further.

The TM22 tool provides the option for users to break down energy consumption into a variety of end use category types and levels of detail. For an office building such as Bourne Hill, and for the purposes of this project, the level of granularity provided by the 'ISO 12 ECON 19' worksheet is deemed to be the most appropriate. This worksheet splits consumption into 12 end use categories (which are in line with the draft international standard ISO/DIS 12655 "Energy performance of buildings – Presentation of real energy use of buildings"), and compares these to the standard benchmarks for each category as set out within ECON 19. As previously stated, some care should be taken when considering how relevant the benchmarks within this document are to modern buildings. The following graphs are taken from this worksheet, and provide a more detailed idea as to where energy is consumed at Bourne Hill.

Fuel/thermal energy demand

Figure 11 compares the amount of energy required for space heating and hot water in the Bourne Hill Offices in use with both the DEC benchmark and with the 'good practice' and 'typical' benchmark figures from ECON 19. This information is also provided in tabular format. Figure 12 shows how these figures convert to the release of carbon emissions.

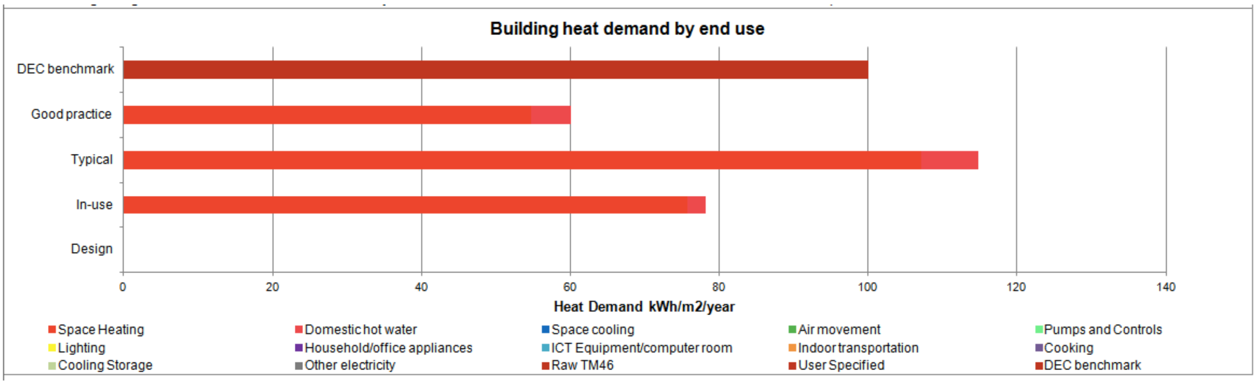

Figure 11: Building heat energy demand by end use

System	Heat demand (kWh/m2/year) In-Use (kWh/m^2/year)	Typical benchmark (kWh/m2/year)	Good practice benchmark (kWh/m2/year)
Space Heating	75.8	107.2	54.7
Domestic hot water	2.4	7.6	5.3
Space cooling	0.0		
Air movement	0.0		
Pumps and Controls	0.0		
Lighting	0.0		
Household/office appliances	0.0		
ICT Equipment/computer room	0.0		
Indoor transportation	0.0		
Cooking	0.0	0.0	0.0
Cooling Storage	0.0		
Other electricity	0.0		
Total	**78.1**	**114.8**	**60.0**
Metered building energy use	78.1		
Variance TM22 versus metered total	0.0		
Variance TM22 versus metered total	0%		

6.4: Building heat demand broken down by end use in tabular form

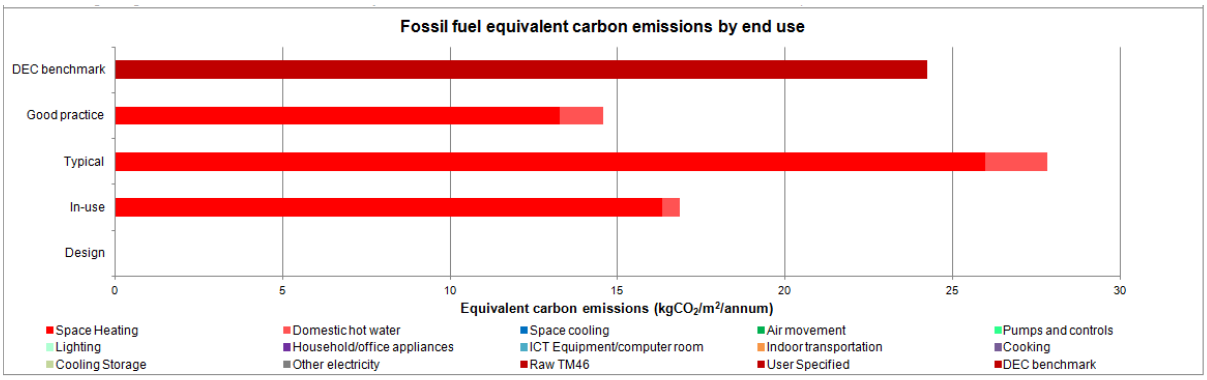

Figure 12: Breakdown of carbon emissions by end use (heat only)

Once again, Bourne Hill is shown to perform better than the equivalent DEC benchmark. The building also demonstrates an improvement over the 'typical' emissions level for a building of its type, however the 'good practice' benchmark has not yet been met. The benchmark figures used here relate to 'Type 2' office buildings (i.e. those that are open plan and naturally ventilated, as set out in ECON 19).

These graphs also show the split between space and water heating, with hot water denoted by a lighter red colour. As previously stated, the split was determined based on the amount of gas consumed in the warmest month when little, if any, space heating would be required. The amount of energy used for heating water at Bourne Hill is shown to be lower than both of the ECON 19 benchmarks, however this is somewhat misleading as this only covers the hot water circuit in the original building. Electric point-of-use water heaters are in place within the extension and are therefore included within the analysis of electrical energy demand below.

There is little scope for analysing gas consumption in much greater detail within the TM22 tool in this case, however some further analysis has been carried out outside of the model using the Council's SystemsLink software. This is discussed later on in the section.

Electrical energy demand

Figure 13 is again taken from the ISO 12 ECON 19 worksheet, and provides a benchmark comparison for electrical energy demand. This data is also provided in tabular format below.

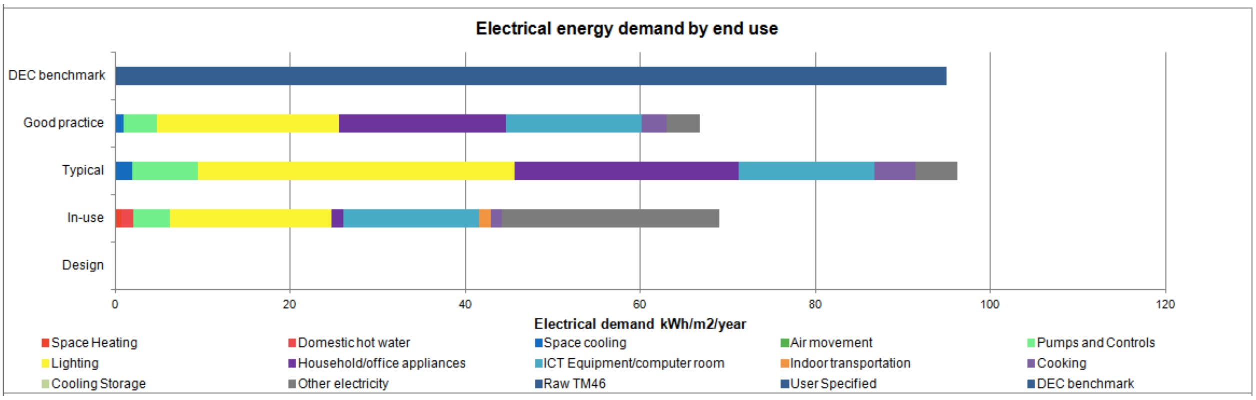

Figure 13: Electrical energy demand by end use

Electricity demand (kWh/m2/year)

System		In-use electricity (kWh/m²/year)	Typical benchmark (kWh/m2/year)	Good practice benchmark (kWh/m2/year)
Space Heating		0.7		
Domestic hot water		1.3		
Space cooling		0.0	1.9	1.0
Air movement		0.0	0.0	0.0
Pumps and Controls		4.3	7.6	3.8
Lighting		18.6	36.1	20.9
Household/office appliances		1.4	25.7	19.0
ICT Equipment/computer room		15.5	15.5	15.5
Indoor transportation		1.3		
Cooking		1.3	4.8	2.9
Cooling Storage		0.0		
Other electricity		24.9	4.8	3.8
Total		**69.3**	**96.2**	**66.8**
Metered building energy use		78.1		
Variance TM22 versus metered total		-8.8		
Variance TM22 versus metered total		-11%		

6.5: **Electrical demand by end use in tabular form**

Bourne Hill again demonstrates an improvement over the DEC benchmark and the ECON 19 'typical' benchmark. Furthermore, in this case it is also shown to be much closer to the 'good practice' benchmark.

Based on the modelled demand within TM22, it appears that Bourne Hill is performing particularly well in terms of 'household/office appliances' and 'lighting'. The first of these categories is a re-categorisation of the 'small power' category used within the In-use tab, and contains items such as the hand driers in the WCs and the CCTV system. The comparatively low level of consumption calculated for this category may be due to improvements in the efficiency of such equipment since the original benchmarks were calculated, or it may simply be the result of the way the category definitions were interpreted. For example, items such as the kettles or printers could technically be placed within this category, but in this case they have been included within the 'cooking' and 'ICT equipment' categories respectively. Whilst the listed status of the building did restrict the lighting design within the original building to some extent, the strategy has been to install high efficiency lighting and tight lighting controls (i.e. PIR and daylight dimming) wherever possible within these constraints. High efficiency lighting has also become more widespread since the benchmarks were originally produced, therefore it is not surprising that Bourne Hill performs well in this respect.

Energy consumption for ICT equipment is consistent between the two benchmarks and the actual consumption level, however end uses such as indoor transport (i.e. the lift) and space heating (i.e. the heated air curtain) are included for Bourne Hill but do not appear at all within the ECON 19 benchmarks. It is likely that an office such as Bourne Hill will have a greater amount of ICT equipment compared to offices in the mid-1990s, but this may be being countered by improvements in the performance of this equipment, particularly as laptop computers are the norm at Bourne Hill rather than desktop computers. This is acknowledged within the tool itself, which assigns an allowance within both the 'typical' and 'good practice' ECON 19 benchmarks which is equal to the level of consumption set for this category within the In-use tab.

The 'Other electricity' category is considerably greater for Bourne Hill compared to either benchmark figure. The majority of this figure is thought to account for the energy used within the regional server room. A comparison with the breakdown shown on the 'Sub-system analysis' worksheet confirms that this is the case. It should be noted that there is some space cooling in place within the regional server room, however this is included above as part of the energy consumption included within the server room.

The following graph presents the carbon emissions arising from electricity consumption at Bourne Hill by end use. This reflects the pattern seen in Figure 13.

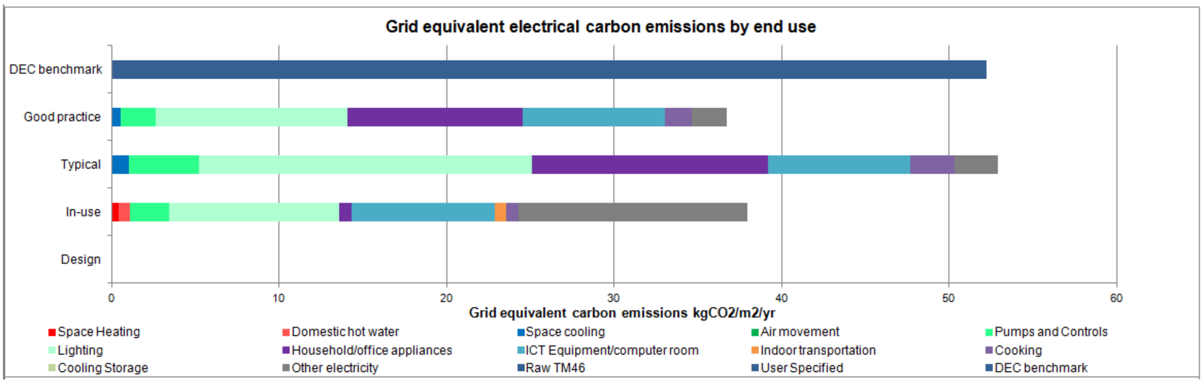

Figure 14: Breakdown of carbon emissions by end use (electricity)

The pattern of electricity consumption has also been reviewed outside of TM22 in an attempt to compare the performance of the two different parts of the building. The results of this are presented later on in this section.

6.4 A closer look at gas consumption

The Council's SystemsLink software is a useful tool that can provide staff with a high-level overview of the pattern of utility consumption across a portfolio of buildings, and it can be used to create standard pre-set graphs that are effective at displaying patterns of consumption and of communicating key trends. These provide an additional layer of detail over and above that provided through the TM22 analysis above.

The chart below (Figure 15) breaks down the total gas consumption figure on a month by month basis for the year 2013.These figures are based on the half-hourly data collected via the AMR unit and stored on the Council's SystemsLink software (hence the TM22 HH module was considered to be surplus to requirements in this case).

Figure 15: Monthly gas consumption during 2013

This pattern of usage is in line with expectations, with demand peaking during the colder months when more energy is required for space heating, and falling as the weather becomes warmer. If it can be assumed that little, if any, gas should be consumed for the purpose of space heating during the hottest months, then the lowest consumption level may be an approximate indicator of hot water use within the older part of the building (as previously noted). In July 2013, 10,194 kWh gas were used, which would equate to a demand of around 4.3kWh/m^2 during that month (note that whilst July shows the lowest level of gas consumption, August was actually the warmest month in 2013. One possible cause of the slight increase in consumption in August may be that more people may have been making use of the on-site showering facilities during this period). It is unlikely that the amount of gas consumed for heating water at Bourne Hill would fluctuate to a great extent throughout the year. The relationship between the amount of energy consumed and the weather is demonstrated in Figure 16 below.

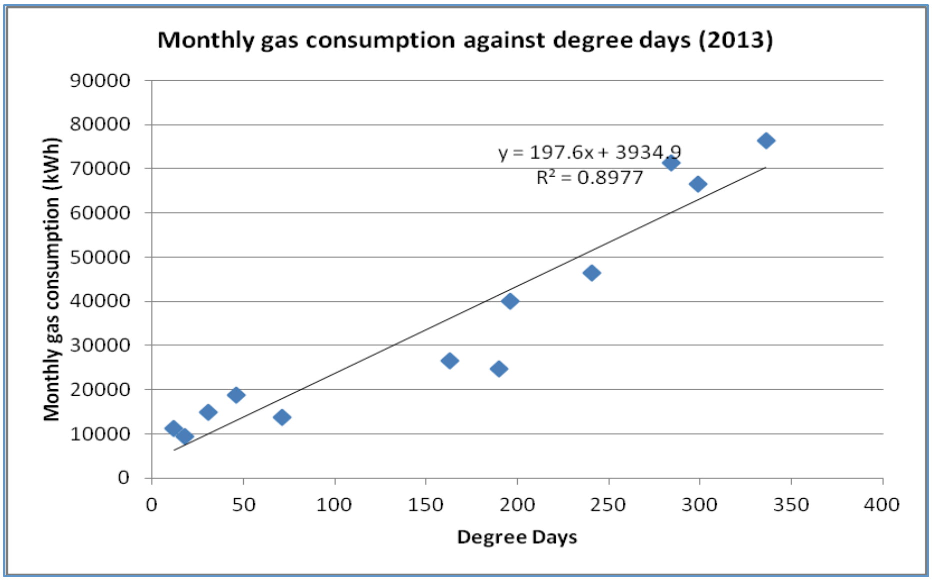

Figure 16: Monthly gas consumption against degree day data in 2013

The data show a clear correlation between the number of degree days and the monthly gas consumption figures. The strength of this relationship has been tested using linear regression analysis, which in this case gives an R^2 value of 0.8977. This indicates that there is quite a steady relationship between the external temperature and the amount of fuel required to maintain the internal temperature at the desired level. It also suggests that the building is being managed in a consistent way, occupancy levels are reasonably constant and that there are no major faults in the heating equipment (or if there are, then they are at least consistent throughout the monitoring period). The point at which the trend line intercepts the vertical axis has been calculated to be at around 3,935kWh/month (equivalent to an average of approximately 11 kWh/m^2/yr). This baseload level is considered to be an approximation of the non-weather dependent portion of monthly gas consumption, and is likely to cover factors such as the heating base load and hot water generation (there is no direct use of gas for cooking in the building).

The chart below (Figure 17) shows the gas consumption 'footprint' for the building as a whole for the month of March 2013, which was a particularly cold month. This chart is an output from the Council's SystemsLink software, and provides an overview of the pattern of gas consumption on a half hourly basis during this period.

Figure 17: SystemsLink gas 'footprint' for March 2013

The constant baseload is clearly evident, showing gas being consumed almost all of the time, even when the building is not occupied. This pattern is the same throughout the year, even during the summer months when the heating should not be switched on. In order to try and reduce this level of usage, members of the Council's FM team investigated the possible factors contributing to the out-of-hours consumption. They found that the hot water settings were switched to provide water heating 24 hours a day, seven days a week. The team then altered the settings to better suit occupied hours, and the impact of this change can be clearly seen on the footprint below (Figure 18, March 2014).

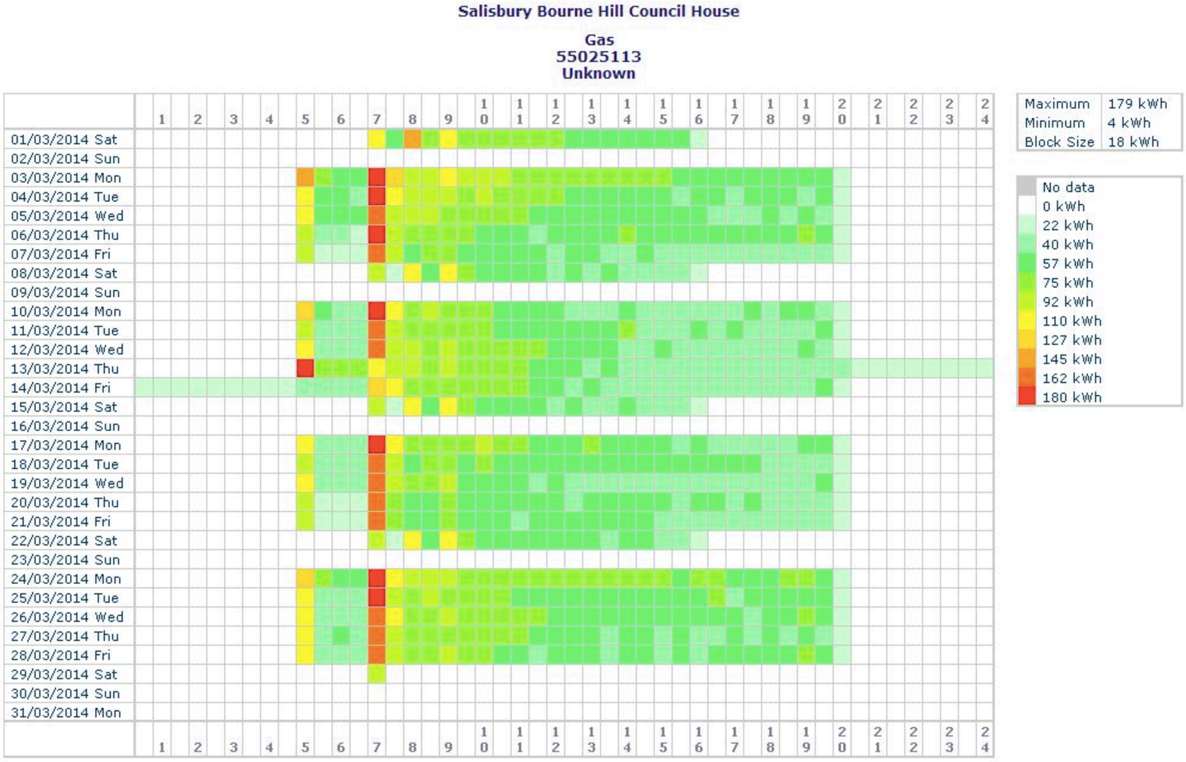

Figure 18: SystemsLink gas 'footprint' for March 2014

This chart provides a much clearer pattern of gas consumption which better suits the way that the building is used. Whilst the change in settings does mean that more energy is needed to heat the water to temperature at the start of each working day, the total consumption of gas has still fallen. The table below demonstrates the effect of the change on the amount of gas consumed in the week after the settings were changed (Thursday 06/02/2014 to Saturday 08/02/2014), compared to the amount consumed in the previous week (Thursday 30/01/2014 to Saturday 01/02/2014).

Day of the week	Week before change in settings	Week after change in settings	% change
Thursday	2164	1462	-32
Friday	1800	1420	-22
Saturday	1371	901	-34

Figure 19: A comparison of gas consumption before and after changes to the hot water settings

Monthly gas consumption figures from January 2014 to the end of April 2014 (i.e. after the change to the hot water settings) were then plotted against degree day data, and produced quite a dramatic shift in the location of the intercept (see chart below).

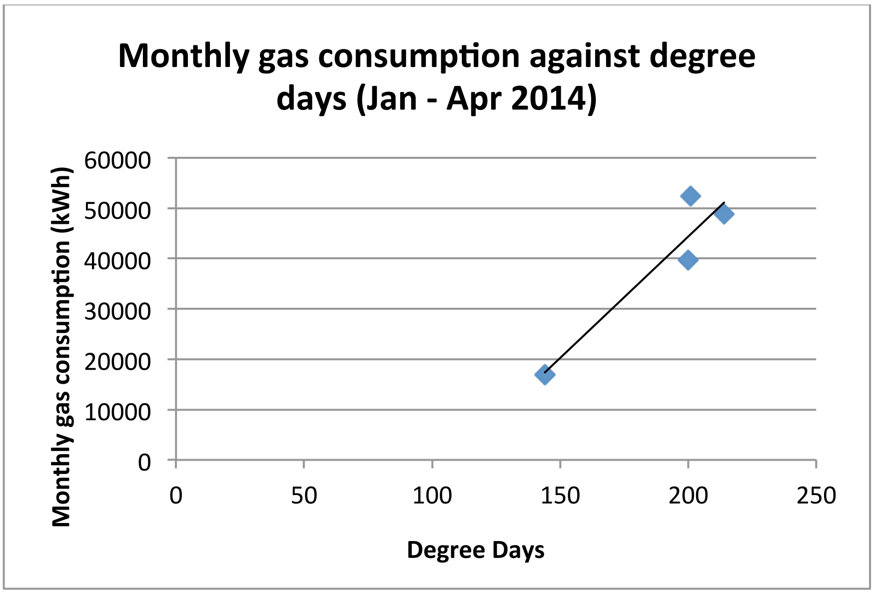

Figure 20: Monthly gas consumption against degree day data between January and April 2014

The new trend line intercepts the vertical axis at -52071kWh. The minus figure could indicate that the base temperature used for standard degree day calculations is no longer appropriate to the building (published degree days in the UK are normally calculated to a base temperature of 15.5ºC). This may be a result of the high level of glazing to the façade of the extension and the building's high thermal mass, meaning that the building does not require additional heating until a certain number of degree days has been reached. It is difficult to fully interpret this change without being able to further split gas consumption between the original part of the building and the extension. It would also be advisable to repeat the analysis in the future with more than just the data from these 4 months in order to even out the impact of any anomalies.

There is no other clear trend in total gas consumption from year to year since the building became occupied in 2010. This is likely to be partly due to inconsistencies in the monitoring methodology, particularly during the first two years.

6.5 A closer look at electricity consumption

Appendix 25 contains annual total figures as collected via the electricity sub-meter network. As noted earlier, missing data and a lack of confidence in the labelling of the sub-meters meant that these were not used within the TM22 analysis itself, however the results of the modelling within the TM22 analysis tool have allowed some of the gaps in the data to be filled (although these are still estimates, rather than actual figures).

Table 6.6 provides a comparison of the performance of the two separate parts of the building, based on the data collected through the sub-metering network.

	Total electricity consumption (kWh/yr)	Consumption per m^2 (kWh/m^2/yr)	ECON 19 benchmarks (kWh/m^2/yr)	
			Type 1 Good practice	Type 1 Typical
Lighting in original building	50,328	33.60	14	23
Lighting in extension	73,905	32.06	22	38
Power in original building	20,054	20.51	19	31
Power in extension	55,491	31.20	76	47
Central equipment (excl. separable)	14,230	3.74	30	60
Central equipment (inc. separable)	112,960	29.70	30	60

6.6: A benchmark comparison of electricity demand in the original building and the extension

The two sections of the Bourne Hill offices fit into different benchmark categories within ECON 19, hence the differing benchmark figures shown in the table above. The older part of the building falls into the *naturally ventilated cellular* (Type 1) category, whilst the *naturally ventilated open plan* (Type 2) category is better suited to the new extension. As it is only possible to select one category type within the TM22 tool, the Type 2 category has been selected, based on the fact that the floor area of the extension is greater than that of the original building.

Unlike the results of the TM22 analysis (which was based on modelled data), the figures above suggest that Bourne Hill is not performing well in terms of lighting. The electricity consumption per square metre values for lighting in both parts of the building are considerably higher than those calculated under TM22, and are well in excess of the 'good practice' benchmarks. The 'typical' benchmark is also exceeded within the original building. There are a number of possible reasons for this, for example the load and usage factors within the TM22 may not reflect actual usage of lighting, with lights perhaps being left on out-of-hours more often than it has been assumed. As there are no detailed records of occupancy it may be the case that we have underestimated the amount of time the building is used at weekends. On the other hand, this discrepancy may simply be due to the sub-meters not actually covering the parts of the building and the end uses that we think they are. Overall, lighting consumption is shown to be slightly higher in the original building than the extension, which may be a result of the restrictions to the design imposed by the heritage value of this part of the building.

The building appears to perform much better in terms of total power (this excludes lighting, but includes all central equipment except the regional server room). Less electricity is used for this purpose per square metre within the original part of the building compared to the extension. This may be because the cellular nature of the space limits the number of workstations that can be comfortably accommodated in this area. Both areas perform better here than their respective 'typical' benchmarks, and the extension also performs significantly better than its 'good practice' benchmark. It is thought that this may be partly due to the appropriateness of the benchmarks, which (as previously discussed) are based on a sample of buildings in the mid-1990s, as the efficiency of plug-in office appliances is likely to have improved considerably since that time. The power figures above include an allowance for central equipment such as fans and pumps, but the separable (regional server room) has been excluded. The inclusion of the separable appears to make quite a significant difference to the central power figure, with its inclusion increasing the consumption per square metre from 3.74 kWh/m^2/yr to 29.70 kWh/m^2/yr (see table 6.6 above). It should also be noted that whilst some of the gaps in the electricity sub-metering data were filled by comparing the results to the TM22 analysis, there is still some data missing regarding power consumption on the ground floor of the original building, hence the values above may not be truly representative.

As there are two separate sets of benchmarks being used here, it is still difficult to say for certain that one part of the building is performing better than the other overall.

During the third research quarter individual demand profile reports were generated using the ION system in order to probe more deeply into the patterns of energy consumption within the building. These were reviewed under task 27 (see Appendix 12), but the key results of the previous analysis are briefly summarised below. Due to the amount of time required to obtain this data from the system, this exercise has not been repeated again during the remainder of the project.

The graph below (Figure 21) provides an example of a typical load profile ION output for a weekday (in this case a Thursday) for the whole building.

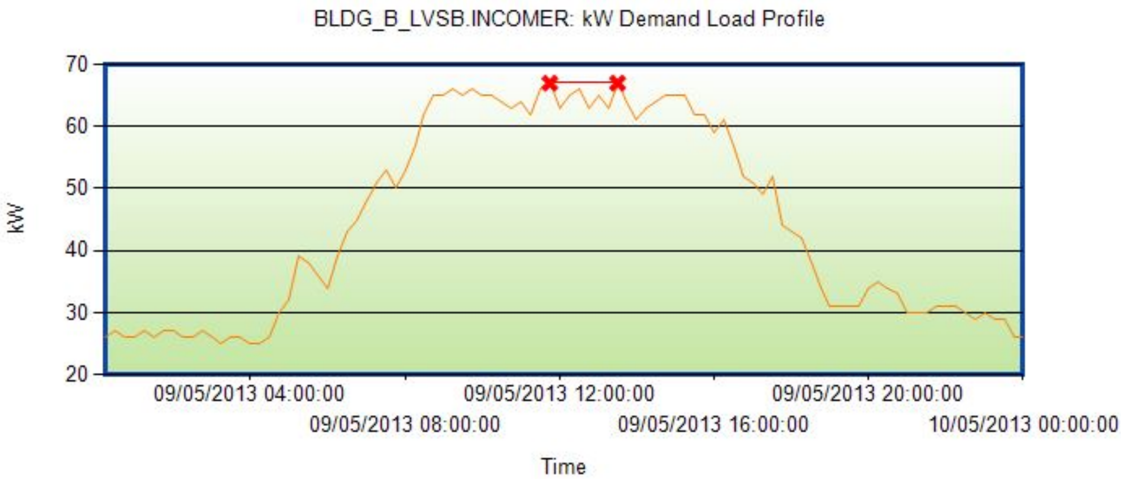

Figure 21: ION output showing load profile for whole building

The graph indicates a baseload of approximately 27 kW, which begins to increase from about 04.00am, peaks during the lunchtime period, and then falls gradually until midnight. A closer look at the individual end use load profiles indicates that the server room cooling plant makes up a large proportion of the base demand (cycles with peaks of between 8 and 10 kW), and that the timing of the external lighting coincides with the increase in consumption outside of core hours (i.e. 04.00am to 08.00am and 19.30pm to 24.00pm). In addition to this, IT room power and back up power (which includes both the server room and the UPS system) are both high (above 6kW) throughout the day.

At the weekend the base load looks to be slightly lower (around 25 kW) and, on the Saturday, the overall pattern of total consumption generally mirrors that of a weekday, but on a smaller scale. It is not clear why this is, however it may be a result of more people leaving desktop/IT equipment switched on (or on standby) overnight during the working week. This may be an area that the council wish to address in order to further reduce consumption (for example through a behavioural campaign). The Sunday example shows a very different pattern, with two peaks in the total demand, one between 04.00 and 08.00 and one between 19.30 and 24.00. Again, these peaks appear to broadly reflect the timing of external lighting, and also consumption by IT equipment and back-up power.

These profiles again suggest that there may be some confusion still in the labelling or functioning of some of the sub-meters within the ION system. For example, the demand (in kW) recorded for the power and lighting on the ground floor of the old building is shown to be zero throughout most of the (week)day, with one sharp peak at 08.00, whilst the demand measured for lighting alone for the same area has a separate peak at approximately four-hour intervals throughout the day, all of which are higher than the single total peak of the previous graph. This reinforces the idea that the system still needs some fine tuning before it can be used as an effective energy management tool.

6.6 A comparison to other case studies

A comparison of the performance of Bourne Hill to other case studies both within the BPE database and elsewhere was carried out under tasks 30 and 49 (see appendices 13 and 14).

At the time of writing there are 96 naturally ventilated 'general office' buildings within the Carbon Buzz database in total, although only 14 of these include in-use data and are published on the website. The chart below (Figure 10) provides an overview of the energy performance of the 15 identifiable case studies (in terms of kWh/m^2/yr), with Bourne Hill highlighted by the blue arrow. The chart indicates that Bourne Hill performs relatively well in comparison to other buildings of its type, despite part of the building being a traditionally-constructed listed structure. Whilst it is not explicitly stated on the website, the green dotted line appears to represent the CIBSE TM46 benchmark for a 'general office' building (95kWh/m^2/yr for electricity plus 120kWh/m^2/yr for gas), which less than half of the buildings exceed (i.e. perform worse than). The variation in performance highlights the difficulties in setting and applying benchmarks such as these.

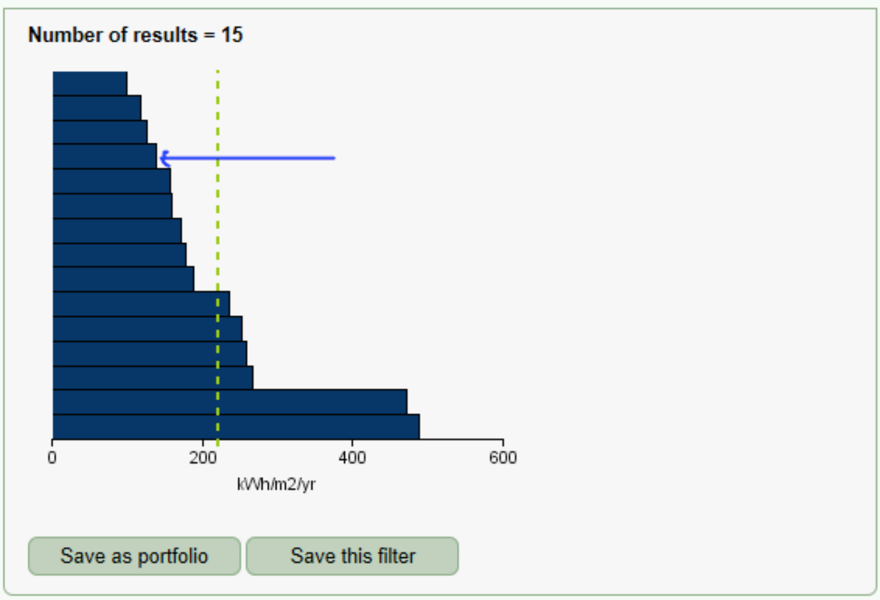

Figure 22: Extract from Carbon Buzz website showing comparison of 15 identifiable case studies based on actual kWh/m^2/yr

Due to the unusual nature of the building it was difficult to make many direct comparisons, however the task report for Task 49 in particular does contain reference to another local authority building and listed property. The Council's Systemslink software allows users to make a direct comparison between the performances of different buildings within the same portfolio. Wiltshire Council has one other naturally ventilated hub offices, and the table below provides a comparison of the performance of Bourne Hill to that buildings.

Site	Electricity			Fossil fuel		
	Floor area (m^2)	Actual metered total (kWh)	Actual (kWh/m^2)	Actual metered total (kWh)	Degree days	Weather corrected (kWh)
Chippenham Monkton Park Offices	5,920	857,611	145	555,834	1,583	864,475
Salisbury Bourne Hill Council House	3,855	332,666	86	332,478	1,583	517,095

Figure 23: A comparison of the performance of Bourne Hill to another Wiltshire Council hub offices

The Bourne Hill offices are shown to perform the better in terms of electricity consumption.

7 Technical Issues

Technology Strategy Board guidance on section requirements:	This section should review the underlying issues relating to the performance of the building and its systems. What are the technical issues that are leading to efficiency results achieved to date? Are the automated or manual controls effective, and do the users get the best from them? Are there design related technical issues which either need correcting/modifying or have been improved during the BPE process? Did the commissioning process actually setup the systems correctly and, if not, what is this leading to?

Overall, it is considered that the building fabric and services at Bourne Hill are performing broadly in line with expectations. There have, however, been a number of technical issues within that have had (and may still be having) a negative impact on performance overall. These are discussed below.

7.1 The performance of the building fabric

Without the heat meter data it has not been possible to separate the energy performance of the extension from that of the original part of the building. Based on standard u-value figures for the fabric of traditionally constructed buildings (see report for Task 23 in Appendix 15) it was assumed that the historic fabric of the older building would lead to higher than average rates of heat loss, and that the fabric of the much newer extension would be considerably more efficient. Whilst there was not scope under this project to measure actual u-values of elements in situ, the performance of the building fabric in terms of its ability to retain heat was tested via a thermographic survey. The survey was carried out by Catherine Simpson of Building Simulation Limited on the 20th February 2013 and copies of her reports, along with a summary review of the key points, were submitted to TSB during the second research quarter (these are also included in the appendices to this report).

The thermographic images taken by the surveyor suggest that the fabric of the original building is performing broadly as predicted. It is likely that the refurbishment did result in some improvement in the energy performance of the windows through draughtproofing, but the single glazed windows are still considered to be the main source of heat loss from the building as a whole (see Figure 24). Overall, the walls of the original building were shown to perform relatively well (it is likely that the work carried out to repair and re-point the existing brick and stonework will have improved the energy efficiency of the walls to some extent), although a number of weaker points were noted (see Figure 25). These weaker points are thought to be the result of factors such as the use of slightly different materials (for example where a window has been blocked up and rendered over at some point in history), moisture ingress or possible de-lamination of render. Other weaknesses highlighted by the survey include poorly insulated pipe runs underfloor (see Figure 26), and air ingress around skirtings, floorboards (particularly over the cellar) and external doors.

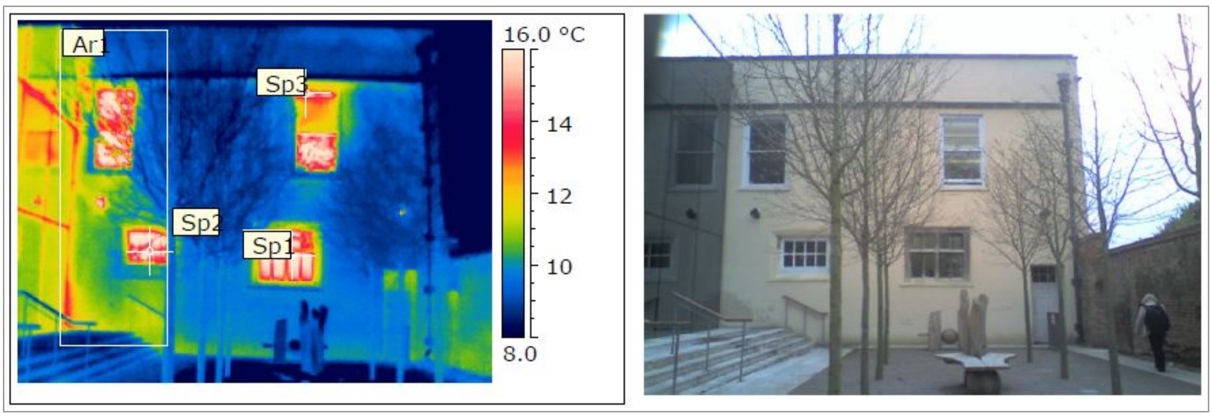

Figure 24: Thermal image of north elevation of the original building with new glazed link to the left

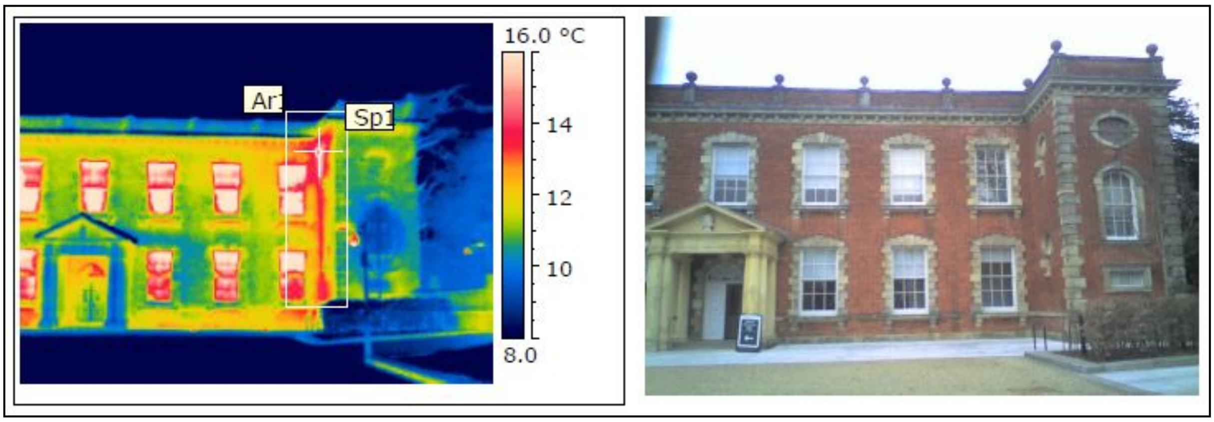

Figure 25: Thermal image of registry office entrance with weaker point highlighted in the corner

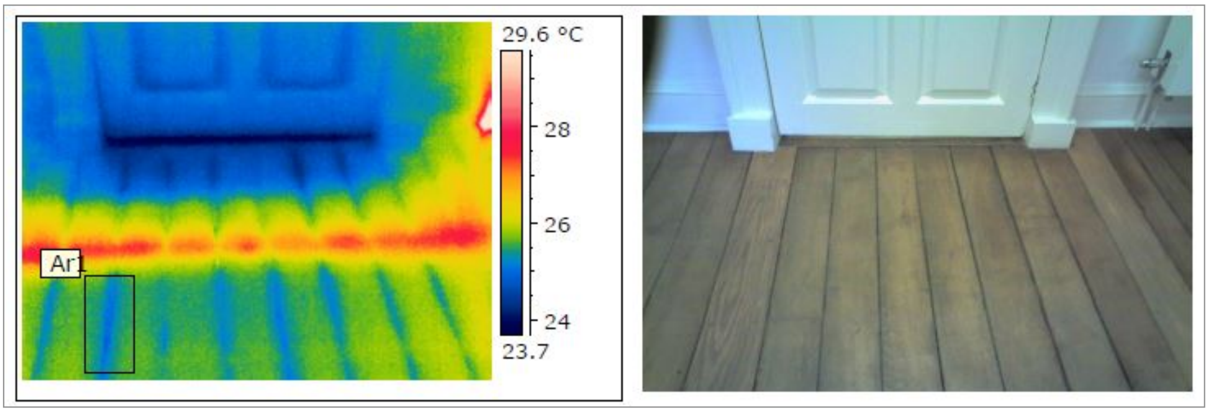

Figure 26: Thermal image showing underfloor pipework

The survey indicated that the performance of the fabric of the modern extension was variable, with higher than expected exfiltration being seen at the glazing joints of the façade (see Figure 27) and an unusual level of temperature variation amongst façade components (see Figure 28), which suggested conductive heat loss through the ventilation panel framing (the images suggest a difference of up to 6ºC between the frame and infill panels in some areas). This variation may also be a contributing factor to the discomfort experienced by staff in this part of the building. It is however important to remember that the design for the extension took place earlier than would be expected for a building constructed in 2010 due to a hiatus in the design and construction process during the council unification, and hence the building was constructed in line with the standards of that time and according to an earlier version of Building Regulations than would otherwise be assumed. The glazed link and main entrance door perform particularly poorly (despite the air curtain over the door), and it was suggested by the surveyor that installing a revolving door may help to reduce heat loss from this area. The thermal performance of the roof was not assessed as part of the survey due to issues with access and cost restrictions.

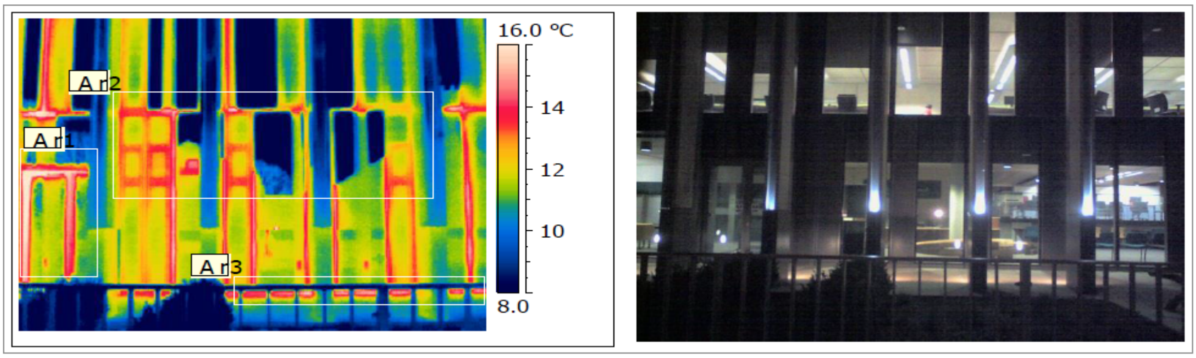

Figure 27: Thermal image showing exfiltration at glazing joints

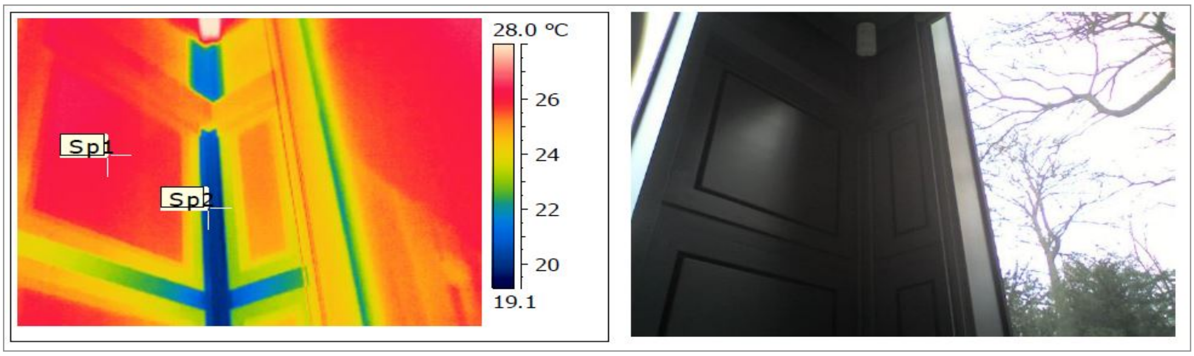

Figure 28: Thermal image showing variation in thermal performance of ventilation panel

Another factor that may have led to an increased level of heat loss from the original part of the building was recently noted by the on-site FM team. It was discovered that the insulation in the roofspace that had been installed as part of the refurbishment had been moved to one side by contractors working in the space, and had not been replaced once the work had been completed. It is not clear for how long this had been the case, but it has now been remedied.

7.2 The performance of the building services

On the whole, the services at Bourne Hill appear to perform relatively well, and there have been few physical faults to date. One exception to this has been the functioning of the vent actuators within the new extension. For some time a number of the vent actuators were permanently 'hunting' (i.e. opening and closing), due to either faulty signals from the BMS and/or faulty instructions from the OS2 boxes located beneath each floor plate. The consequences of this have included reduced motor life, noise, and poor CO_2 and temperature control. It is also likely that the issue has led to a temporary increase in heat loss from this part of the building, however these actuators have now been replaced and the problem appears to be largely resolved. The case study review carried out under Task 30 indicated that this weakness is not unusual with this type of ventilation system, and that it may be an area worthy of further research elsewhere.

The calibration and location of the sensors connected to the BMS are also possible weaknesses in the system and may be having an adverse impact on internal conditions within the office space in the new extension. The FM team have previously identified a number of internal temperature sensors that were incorrectly calibrated, and whilst these known instances have since been rectified, they are likely to have had an impact on the way that the BMS controlled the internal environment prior to solving the issue. This could mean that the automatic vents may have been open more than necessary where temperature readings were higher than the actual temperatures. The comments on the BUS survey confirm that comfort conditions were indeed affected during this time (occupants on both the first and second floor of the extension note particularly draughty conditions). It is possible that some of the other sensors have still not yet been correctly calibrated; for example, one of the sensors on the second floor appears to consistently read 22°C over the whole period from 30/09/2013 to 16/12/2013. In order to try and determine whether the BMS-linked sensors were correctly calibrated, a number of individual temperature sensors were placed around the extension during the site visit dated 09/08/2013. A comparison of the temperatures recorded on these sensors demonstrates a variation of up to 2°C between the fixed and the temporary sensors nearest to them, however the precise location of the sensors is likely to have some impact and it was not possible to locate the temporary sensors directly adjacent to the fixed sensors. A temperature difference of up to 2°C was also found between the temporary sensors located around the perimeter of the spaces and those located more centrally. The location of the fixed sensors was determined prior to the unification of the Council, and in accordance with the furniture layout proposed at that time. Following unification the seating plan was altered, and it may be the case that their locations are now not so well suited.

Some of the office spaces within the extension can feel quite dark, due to the solar control glazing and shading strategy. In order to ensure comfortable working conditions, this is often compensated for with higher levels of artificial lighting at all times of the day, and therefore increased levels of electricity consumption.

Other relatively minor (and less energy-related) technical issues at Bourne Hill include the functioning of the rainwater harvesting system (which was not working at the beginning of the project, and it has taken some time for staff to get used to the colour of the recycled water), the robustness of the low-flush WCs and the slightly ill-fitting blinds that do not completely block out glare. It is possible that there may be some other minor issues with the building, however without access to more of the data stored on the BMS it is difficult to detect these.

The majority of the problems with the services appear to be more due to human error rather than faulty or badly performing equipment. For example, the results of the BUS survey seem to indicate that some of the building occupants do not have a good understanding of the systems, and therefore they may unintentionally be adversely affecting their performance. For example, the thermographic survey highlighted instances where furniture and paperwork had been placed on top of the trench heaters and were having a significant impact on the release of heat. Similarly, the filing cabinets in the extension are considerably taller than originally intended and it may be the case that they are restricting air flow across the floor plates. This could affect both air quality and temperature control in these spaces. Providing users with information about how the building is designed to function and how to get the best out of the heating and cooling systems (for example by providing them with access to a Building User Guide) might help to combat this.

The biggest barrier that we have come up against during this project is data accessibility. It is difficult to thoroughly assess the performance of the building with any degree of accuracy without access to the appropriate data. Whilst this issue does not particularly cause problems with the day to day running of the building, it does make the identification of minor faults and the tweaking of settings in order to achieve the best from the services more difficult. This relates to both the data stored on the BMS and the ION system and is partly due to the complexity of these systems and partly to the way in which they were initially set up. The ION system in particular is considered to be more advanced than is really necessary for council purposes, and as such is not being used at all. Simple problems such as the mislabelling of sub-meters and the confusing referencing of meters and sensors make the systems even more difficult to navigate and are likely to have been a result of a combination of factors including the lack of involvement of an on-site FM team at the time the systems were being installed and set up; poor commissioning; and a lack of suitable training documentation and guidance on how to use the systems. The format of the data that can be exported from both systems is also limiting, and the amount of time required to process it in its current format is considered to be excessive.

These issues are discussed in more length under tasks 22, 23, 24, and 29 (see appendices 1, 15, 17 and 18), and recommendations for measures aimed at remedying the technical issues covered in this section and improving the performance of the building are set out in task reports 43 to 47 (see appendices 19 to 23).

8 Key messages for the client, owner and occupier

Technology Strategy Board guidance on section requirements:	This section should investigate the main findings and draw out the key messages for communication to the client/developer, the building owner, the operator and the occupier. There may also be messages for designers and supply chain members to improve their future approaches to this kind of building. Drawing from the findings of the rest of the report, specifically required are: a summary of points raised in discussion with team members; recommendations for improving performance, with expected results or actual results where these have already been implemented; a summary of lessons learned: things to do, things to avoid, and things requiring further attention; a summary of comments made in discussions and what these could be indicating. Try to use layman's terms where possible so that the messages are understood correctly and so more likely to be acted upon.

This report has highlighted a number of weak points in the building's form and running, however it is important to be clear that overall the building performs better than the benchmark figures for others of its type. As the benchmarks are based on average figures from a range of office building types that were assessed during the 1990s, this is to be expected within the new part of the building, however the limitations to refurbishment options presented by the listed status and the traditional construction type of the older part of the structure may have had a negative impact on the overall performance of the building (although little evidence has been found under this study to definitively support this assumption). The results of this study also indicate that the facilities management team are doing a good job of working with the systems in place and of balancing the sometimes conflicting objectives of comfort and energy consumption.

Detailed recommendations for improving the performance of the building were set out under a number of different tasks during Quarter 6 (see reports for tasks 43 to 47 in the appendices). The aim of this section of this report is not to repeat these recommendations, but to summarise the key lessons to be learnt for the ongoing management of Bourne Hill itself, and also across the rest of the Wiltshire Council property portfolio.

Procurement of equipment

There are two separate learning outcomes that relate to the procurement of equipment for building and energy management. The first, and most important, is that those responsible for overseeing the specification and installation of a particular piece of equipment need to be confident that the selected system will be easy for the FM team on site to use. Overly complex systems are more likely to require specialist support, which may be costly, and could lead to the equipment not being used efficiently, or perhaps (as in the case of the ION system) at all. The use of standard specifications for different types of equipment across the Council estate was proposed during the final stages of the project, however it was noted that the timescales appropriate to the rollout of a particular technology type mean that by the time it had been installed in all relevant buildings, it is likely to have become out of date and be in need of replacement. The concern that specifying a particular make of system might go against the competition rules embedded in council procurement processes was also raised. Open, rather than proprietary, protocol systems are recommended.

The importance of defining the responsibility of contractors to ensure that any equipment that they install is properly set up and functioning correctly was also highlighted during the course of this project. For example, it has not been possible to obtain any valid data from the heat meters installed under this project, and it has been necessary to pay for additional follow-up support from the installer to get the meters to actually work. Potential overlaps or gaps in responsibility should be identified early on and explicitly covered within contracts for this type of work.

Handover and commissioning process

Whilst the handover of Bourne Hill was generally carried out in line with the best practice guidance available at the time, it is understood that the process was very much complicated by the unification of the Council. For future projects of a similar nature, a fully comprehensive programme of commissioning should be drawn up and sufficient time allocated to enable it to be closely followed. Seasonal commissioning is also encouraged, and the involvement of the building/system designers for at least the first few months of occupation is advised. This will provide an opportunity for systems to be fine-tuned to better suit occupant requirements, to train FM staff to use the building as it was designed to be used, and also for designers to learn about the performance of their designs in use. This is an area in which the Council are already working to improve.

The Council should aim to proactively identify issues early on so that they are more likely to be covered in the defects/support period. This includes making sure that the contents of the O&M manuals are complete, logically set out, and that where technical jargon is used it is clearly explained in layman's terms. Strict requirements for the provision of appropriate information (including complete records of the commissioning process) should be included with the contract documentation for contractors/sub-contractors where possible, and should be followed up soon after handover.

The accessibility and quality of basic information about the building has been a key problem throughout this project. Information such as the O&M manuals and recorded training sessions should be kept in a central location (at least in electronic format on a shared drive), where it is accessible to all relevant members of staff. A simple building user guide for Bourne Hill was produced at design stage to provide building occupants with information on the functioning of the heating and cooling systems and instructions as to how to best use the environmental controls in each area; this document should also be placed in an accessible location and staff should be made aware of its existence.

Roles and responsibilities for energy management

There has previously been some overlap between the roles of the on-site FM team, who have direct control over the systems that consume energy, and those with a more strategic responsibility for energy management at the Council, particularly in terms of monitoring and targeting. The recent restructuring of the wider facilities management team aims to broaden building operational responsibilities and help to bridge the gap between onsite and offsite energy management. This is considered to be a positive move.

It is also important to recognise the role of the building occupants in reducing energy consumption from personal equipment and, where applicable, control of space heating.

Support review of opportunities for LZC technologies

Wiltshire Council is currently looking for opportunities to install renewable energy generation technologies across its property portfolio. A separate study is being undertaken to look at the viability of installing a range of technologies on a site by site basis, and funding has already been allocated for a programme of solar PV installations on sites where they can be demonstrated to be financially viable. The findings of this BPE project support the rollout of renewable technologies as a positive step towards reducing carbon emissions arising from council operations, particularly at sites where installing a range of energy efficiency measures might be challenging. For example, it is common for local authorities to occupy buildings of heritage value and, where technologies can be installed sensitively and without damaging the building fabric, they may present an opportunity to both meet legislative requirements and cut utility bills in the longer term. It is also considered that local authorities are well placed to set an example to the wider community on environmental issues.

The need for comfort and for flexibility in design

Finally, it is important to be aware of the complex and subjective nature of comfort. It is highly unlikely that an environment can be created that will please every member of staff, particularly in an open plan office space. Specifying a more cellular layout and giving people an increased level of control over their immediate environment could potentially improve occupant satisfaction, however it is likely that such a design would make a building less flexible in terms of future usage, and this in itself would make the building less 'sustainable'. Bourne Hill is a good example of the need for flexibility in design; its occupancy level, distribution and the nature of its use having changed significantly on more than one occasion since plans for its refurbishment and extension began.

This study has presented a number of recommendations for improving occupant satisfaction that do not require any physical alterations to the building and that may also be appropriate to other sites. These include running campaigns to change the behaviour of building users to better suit the systems in place (see tasks 29 and 47), working to improve staff knowledge and understanding of the way that the systems work and how they can be optimised, and also continuing to provide and promote a platform for discussion and feedback (i.e. the Building User Group in this case). It was also suggested during the staff workshop (Quarter 5) that increasing the presence of senior staff at buildings like Bourne Hill may help to mediate between conflicting requests for alterations to office temperature in the new extension, and also between requests for higher temperatures and the ongoing need to keep heating costs down.

9 Wider lessons

TSB Guidance on Section Requirements:	This section should summarise the wider lessons for the industry, clients/developers, building operators/managers and the supply chain. These lessons need to be disseminated through trade bodies, professional Institutions, representation on standards bodies, best practice clubs etc. As well as recommendations on what should be done, this section should also reveal what not to do on similar projects. As far as possible these lessons should be put in layman's terms to ensure effective communication with a broad industry audience.

Bourne Hill is a prime example of why BPE projects such as those being funded through this TSB scheme are so important. In this case it has been difficult to quantify the extent of the 'performance gap', however the difference between user expectations and their experience of the building was apparent, particularly at the beginning of the project.

There are a number of lessons to be learned from this project that are valuable on a wider scale. The most important of these are set out below.

BMS software design

The results of this study indicate that designers of BMS user interfaces need to work harder to create products that are more intuitive to use and that can provide outputs that are useful for both day to day facilities management and energy management purposes. Such designers should perhaps work more closely with the users of their systems to find the most useful and flexible solutions. Whilst it important that BMS systems monitor conditions at short and regular intervals for operational purposes, the volume of data that this produces is too great to facilitate straightforward manual analysis. Where they are intended to be used as a tool to support energy-related decision making, BMS systems require suitable software to enable simple analysis of data. Similarly, clear user guide documentation should be compiled and provided to users alongside the more technical guidance.

Component design for demand controlled ventilation systems

Vent actuators and sensor location/calibration appear to be common weaknesses of demand controlled ventilation systems, and therefore these are areas that industry should focus on improving in order to ensure that these systems perform well in use.

The practicalities of glazed facades

The use of solar control glazing and shading at Bourne Hill was considered to effectively control solar gain and cut glare, however some areas of the extension were thought to be quite dark and required some level of artificial lighting to be switched on at all times. High levels of glazing seem to make the control of internal conditions more difficult, and therefore this should be thoroughly considered when this type of facade is specified. Where glazed facades are selected, more effort needs to be given to ensure building managers have access to easy to follow guidance on how to manage the heating and ventilation systems effectively.

Need for ongoing support from designers

The findings of this study highlight the value of programmes such as Soft Landings, which encourage detailed planning for commissioning and handover processes and ongoing support from the designers of the building. Despite the present drive to 'cut red tape' within the construction industry generally, local government (and clients generally) should look to encourage the use of voluntary schemes such as this to improve the performance of the buildings they commission.

The changing role of the facilities manager

A detailed knowledge of controls systems is not a traditional part of the job description for a Facilities Manager, however as more and more buildings are being designed to rely on complex BMS systems these skills are increasingly in demand. There is perhaps a need for this type of expertise to become a more integral part of FM training schemes (for example degrees or apprenticeships). FM teams also need to be aware of any overlaps between the roles of those that manage a building directly, and those that are responsible for wider energy management.

The need for further research into the performance of traditional buildings

There is a commonly accepted need for more research into how traditional solid walled buildings function in terms of the movement of heat and moisture. Accurately estimating the thermal performance of traditionally-constructed buildings can be particularly difficult as materials and construction methods vary widely and there are significant gaps in our understanding of how traditional buildings function as 'systems' rather than simply as the sum of the thermal performance of each individual building element. This has the potential to impact the design calculations for heating and cooling systems and in some circumstances may lead to the over-sizing of equipment. For example, this includes a need for more research into the accuracy of the standard u-values generally accepted for use in relation to this type of construction.

Appropriate use of technology

Voluntary schemes such as BREEAM are often a good way of ensuring that issues such as the environmental impact of a development are considered in its design. It is important, however, to make sure that particular aspects of the design are not included simply to fulfil a theoretical box-ticking exercise, and should only be specified where they fulfil the needs of the client. Where complex systems are installed that are excess to the requirements (and possibly the in-house capabilities) of the client, there is a chance that they will not be used at all (hence, if these result in a reduced level of energy consumption in the design stage calculations, this effect may not be realised in practice).

Flexible working policies

There are a variety of benefits to setting up a flexible working system as part of an office-based culture. One of these benefits is the potential for reduced energy consumption and hence lower utility bills. Whilst this may be the case, companies wishing to measure the impact of such a policy may wish to set up some kind of process to monitor the number of staff who are at the site at a given time. Where such a system is not in place it is difficult to separate the effect of daily changing staff numbers from other factors that might be affecting energy consumption patterns, such as faulty equipment. Good attendance records would make it easier to compensate for this.

Flexible building design

As noted in the previous section, in order for a building to be truly 'sustainable' it needs to be flexible. Whilst a building may be designed and constructed for a particular purpose, it is likely that over its lifetime its usage may change and the number of occupants may fluctuate. This raises the question as to whether it is more effective in the longer term to design a building to be as energy-efficient as possible in terms of its original design parameters, or whether it is better to focus on flexibility of design instead.