Brighton Aldridge Academy

NOTE: This report combines two studies into one report
Brighton Aldridge Community Academy and Thamesview School

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	450030 B
Project lead and author	Feilden Clegg Bradley Studios
Report date	2014
InnovateUK Evaluator	Peter Tse, BSRIA

Building sector	Location	Form of contract	Opened
Schools (Secondary)	Brighton	Design and build	2011
Floor area (TFA)	**Storeys**	**EPC / DEC**	**BREEAM rating**
8,505 m^2	2	N/A	Excellent

Purpose of evaluation

The study at Brighton Aldridge Community Academy (BACA) examined the handover and initial occupation of the building. Energy and occupant surveys were conducted. Both schools took a similar route to servicing the buildings, using mixed-mode ventilation with biomass heating. In both schools the BMS has been largely overlooked due to issues with the systems. **Note that the energy assessment in the report was based on an NIA of 8,883 m². The energy consumption data have therefore been modified below to account for the revised floor area. The figures below override the data reported in Section 6.2.**

Design energy assessment	In-use energy assessment	Electrical sub-meter breakdown
No	Yes. Below modified on TFA	Yes

BACA estimated electricity use: 102.2 kWh/m² per annum; thermal (gas): 149.3 kWh/m² per annum. Both schools have complex building services systems that struggled to service the buildings' operation efficiently. Both schools were found to be using more energy than expected - between 77% and 102% more energy than the design intent. Both schools have high electricity use, with over 60% relating to small power and lighting. The high energy use at BACA was primarily due to the early morning preheating of the underfloor heating system, which also heats up the rest of the school as a consequence of the difficulty in controlling the zoning of the building. Neither school used their biomass boilers, relying instead on mains gas for heating.

Occupant survey	Survey sample	Response rate
BUS, online version	24 of unspecified population	N/A

Only 24 members of staff at BACA completed the questionnaire fully, too few to enable full analysis. Occupants found both schools to be aesthetically pleasing and were satisfied with the intuitive layout within spaces, though teachers reported a lack of storage. Poor internal comfort conditions, particularly in winter, were reported by occupants in both schools. The layout of the science classrooms was not optimal, with many comments highlighting science services being located around the edge of the classroom. This caused the students to work with their back towards the class and the teacher, compromising supervision.

Thamesview School

NOTE: This report combines two studies into one document
Thamesview School and Brighton Aldridge Community Academy

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Innovate UK project number	450030 A
Project lead and author	Feilden Clegg Bradley Studios
Report date	2014
InnovateUK Evaluator	Unknown (Contact www.bpe-specialists.org.uk)

Building sector	**Location**	**Form of contract**	**Opened**
Schools (Secondary)	Gravesend	Design and build	2010
Floor area	**Storeys**	**EPC / DEC**	**BREEAM rating**
Not reported	2	N/A	Excellent

Purpose of evaluation

The study at Thamesview School covered the operation and maintenance of the building. Energy and occupants surveys were conducted. Both schools took a similar route to servicing the buildings, using mixed-mode ventilation with biomass heating. In both schools the BMS has been largely overlooked due to issues with the systems; whether the number of errors apparent in the system or the lack of control flexibility the BMS was intended to provide.

Design energy assessment	**In-use energy assessment**	**Electrical sub-meter breakdown**
No	Yes (2014)	Yes

Estimated electricity use: 67.3 kWh/m² per annum; thermal (gas): 75.7 kWh/m² per annum. Both schools have complex building services systems that struggled to service the buildings' operation efficiently. At Thamesview the largest end use of energy is lighting, followed by services and then small power. Both schools were found to be using more energy than expected - between 77% and 102% more energy than the design intent. Both schools have high electricity use, with over 60% relating to small power and lighting. Neither school used their biomass boilers, relying instead on mains gas for heating.

Occupant survey	**Survey sample**	**Response rate**
BUS, paper version, modified	47 of 82	57%

Note that various surveys were conducted at Thamesview, including a BUS survey of staff.

Occupants found both schools to be aesthetically pleasing and were satisfied with the intuitive layout within spaces, though teachers reported a lack of storage. Poor internal comfort conditions, particularly in winter, were reported by occupants in both schools. At Thamesview, many of the staff and students also felt that some furniture was of poor quality and uncomfortable.

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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.

FOREWORD

This report has been prepared by Joe Jack Williams on behalf of Feilden Clegg Bradley Studios, with additional input from Keyur Vadodaria and Arup Building Performance and Systems team.

We thank the Technology Strategy Board for their funding which has enabled this project to be carried out and their valuable guidance into this project.

We also wish to especially thank the schools and the Kier contractor and FM teams for their engagement with the process and their support with providing information and helping with questionnaires.

This report has been commissioned and developed over a period to time, and includes observations on some technical issues and defects which at the time of publication may be resolved or being dealt with.

The observations are made in the spirit of learning and advancement to encourage project teams to improve practice towards better outcomes on future projects.

Our recommendations are made in sections 1, 8 and 9 of the report.

On the findings at Brighton Aldridge Community Academy, Kier do not endorse the contents and do not expect to have to formally respond to the report. They observe that "*the project was designed to all legal and applicable standards and the budget constraints at that time, which influenced the types of installations and the level of building services controls. The installations were installed by competent specialists, witness tested and fully commissioned on handover. It has to be recognised that there were elements of defects and 'snagging' but these are consistent with any project of this nature and often come to light when the building is in use. We would state that all these issues have been dealt with and we maintain contact with the academy should there be any 'latent defects' which come to light.*

"That said the biomass boiler has yet to be successfully run over a period of time. The cause for this not being operable is due to the fuel deliveries not providing a wood chip which is consistently within the grading set. The out of specification pieces of wood chip have constantly 'jammed up' within the auger from the day tank to the boiler. Currently this auger is being replaced with one which will hopefully cope better with these larger, out of specification, pieces of fuel."

Contents Overview

The report is set out by topic against which feedback from each school is provided.

Recommendations are grouped using feedback from both schools in sections 1, 8 and 9.

Contents in detail

1 INTRODUCTION AND OVERVIEW

This report covers the summary findings of the Technology Strategy Board (TSB) funded Building Performance Programme (BPE) at Thamesview School, Kent, and Brighton Aldridge Community Academy (BACA), Sussex. Both schools were designed by Feilden Clegg Bradley Studios and constructed by Kier.

The study at Thamesview School was a phase two study, covering the operation and maintenance of the building. This school was procured under Wave 1 of the Kent BSF Programme. It was built by Kier and is maintained by Kier Facility Services under a PFI contract.

The study at BACA was a phase one study, examining the handover and initial occupation of the building. This school was procured under the academy framework under a design and build contract. It is maintained by the Academy Trust.

The schools studied exhibit similar traits, particularly with regards to services, reflecting the design guidance at the time.

Both schools are largely successful as learning spaces, with the buildings themselves providing inspirational spaces that enable learning.

Occupants found both schools to be aesthetically pleasing and were satisfied with the intuitive layout within spaces, though teachers reported a lack of storage.

At Thamesview, many of the staff and students also felt that some furniture was of poor quality and uncomfortable, with future schools needing to carefully choose the furniture based on longevity and comfort.

The open plan areas were rated as too noisy and distracting, with many comments highlighting the difficulty experienced in teaching in those spaces.

Despite the difficulties of the internal environment, the overall responses to the buildings were good, highlighting the success of the buildings overall.

The building fabric is of a high standard, with good air-tightness and only few minor cold bridges.

Poor internal comfort conditions, particularly in winter, were reported by occupants in both schools.

Both schools have very complex building services systems that are struggling to efficiently service the building's current operation.

Both schools were found to be using far more energy than expected - consuming between 77% and 102% more energy than the design intent (see section 6 in this report, including predicted unregulated energy use.

BACA:	240.8 kWh/m^2/annum
Thamesview 2012-13:	143.0 kWh/m^2/annum
Thamesview 2011-12:	117.8 kWh/m^2/annum
CIBSE TM46 benchmark:	190.0 kWh/m^2/annum

The high energy use at BACA was primarily due to the early morning use of heating in order to preheat the underfloor heating system, but heats up the rest of the heating system as a consequence of the difficulty in controlling the zoning of the building.

Both schools have high electricity use, with over 60% relating to small power and lighting.

Neither school was found to have used the biomass boiler extensively, predominantly caused by fuel delivery problems, either into the storage hopper or the auger feeding the boiler itself.

At both buildings, it is clear that insufficient attention has been paid to building services testing, commissioning, validation, training and handover. This is particularly evident in the performance and lack of usability of the larger and more complex systems (BMS, lighting control, and metering). Given the prominence of the BMS to the services strategies, the problems experienced with the BMS had a significant effect on the buildings. Both systems had poor logging of data, particularly energy data, with little way of exploring the end uses of energy. Neither system was extensively used, with a lack of trust in the systems and a lack of trained personnel seemingly preventing extensive use (more applicable to Thamesview than BACA). At BACA, this was compounded by the FM that attended the handover training leaving the academy shortly after occupation.

Key recommendations emerging from this study for potential implementation at the schools are listed below; with more detail provided in section 8.

- Improve the BMS (note this was being undertaken at Thamesview at the end of this study, partially as a result of these findings)
    - To enable monitoring energy usage in each zone and complete the commissioning of the existing meters where appropriate
    - Improve the zoning of systems and ensure plant operation times match the end-use of the zones.
    - Build trust in the system by fixing any software bugs
    - Grouping and prioritising alarms to avoid nuisances, exploring the possibility of notifying staff via email/text for critical alarms
- Incorporate intelligent ICT switching, such as wake-on-lan software to reduce energy use
- Ensure that the lighting sensors are working optimally, with a reduction in timers in transient spaces and additional switches in rooms
- Rectification of biomass problems to reduce the schools' carbon footprints (note that both schools are in the process of improving the biomass systems)
- Reduce the operating gap between the FM team and the staff at Thamesview School, created by the building ownership and the multi-school PFI process.

The wider lessons from this study for application in future projects (more detail is provided in section 9):

- Reduce the complexity of the services
  - This will simplify maintenance, commissioning, handover and improve future flexibility (see section 9.1)
- Think about the end-users and how they will control the space
  - Find a balance between central control and local flexibility (see section 9.1), such as the simple TRVs fitted at BACA.
- Pay close attention to the on services during installation
  - This is a large portion of the project cost (typically 25% of the overall cost) and can be incredibly difficult to understand without the appropriate background (see section 9.4)
  - On the client side there should be a person dedicated to ensuring the installation meets their requirements and understands how the building is to be operated
- Encourage extended handovers
  - Reducing the rush at handover and the difficulty of defect rectification can substantially reduce the after-care necessary at the school (see section 9.4)
- How will the teaching style fit in with the school
  - Ensure that the if rooms are very specialist that the further implications are considered (see section 9.3 and section 9.5)
- Maintain a whole life view throughout the project
  - Particularly with regards to building management and future flexibility (see section 9.4 and 9.5)
- Interactive white boards are causing problems with lighting and daylighting
  - The location of these boards needs to incorporated early into the design as it impacts the servicing and glazing strategy (section 9.5)
- Encourage flexibility in the end design
  - Allow spaces for extensions and creation of classrooms (see section 9.5)
- Soft Landings may be used as a framework to address issues with managing commissioning and would additionally provide support to the building occupants as they learn the complex new systems.

2 DETAILS OF THE BUILDING, ITS DESIGN, AND ITS DELIVERY

This post-occupancy evaluation study covers two different school, designed and constructed by the same architect and main contractor; Thamesview School and Brighton Aldridge Community Academy (BACA). Both buildings replaced existing schools and were built next to the original school building to ensure continuity of the school within the community. Thamesview School is located in Gravesend, Kent, and BACA is located in Falmer, on the outskirts of Brighton in Sussex and replaces Falmer High School. As this study included a phase one study at BACA, this section will focus on the delivery of BACA, rather than of Thamesview School.

2.1 Thamesview School

Thamesview School replaced an existing school and was built next to the original school building to ensure easy decant of the school and continuity within the community. Thamesview School is located in Gravesend, Kent,

Thamesview School was completed in July 2010 and was designed by Feilden Clegg Bradley Studios and constructed by Kier London, as part of the Kent BSF programme. The building has been built next to the site of the existing building, with the site re-landscaped in order to incorporate the new building (shown in Figure 2.1). Two additional refurbished buildings, the Maths block and the Vocational building, located in north-east corner of the site and are part of the school, but are outside the scope of this study, as they are existing buildings not designed by FCB Studios or built by Kier.

Figure 2.1 - Thamesview School site layout plan

2.1.1 General Building

The building is predominantly two-stories tall, with only the art room and art store on a third storey. It is arranged around the central atrium, with four teaching wings (named after NASA space shuttles; Discovery, Endeavour, Challenger and Enterprise), and a fifth wing simply known as school 5. The named teaching wings contain a mix of open plan and conventional teaching spaces, and school 5 contains a mix of teaching, administration, sports and ancillary spaces, as shown in Figure 2.2.

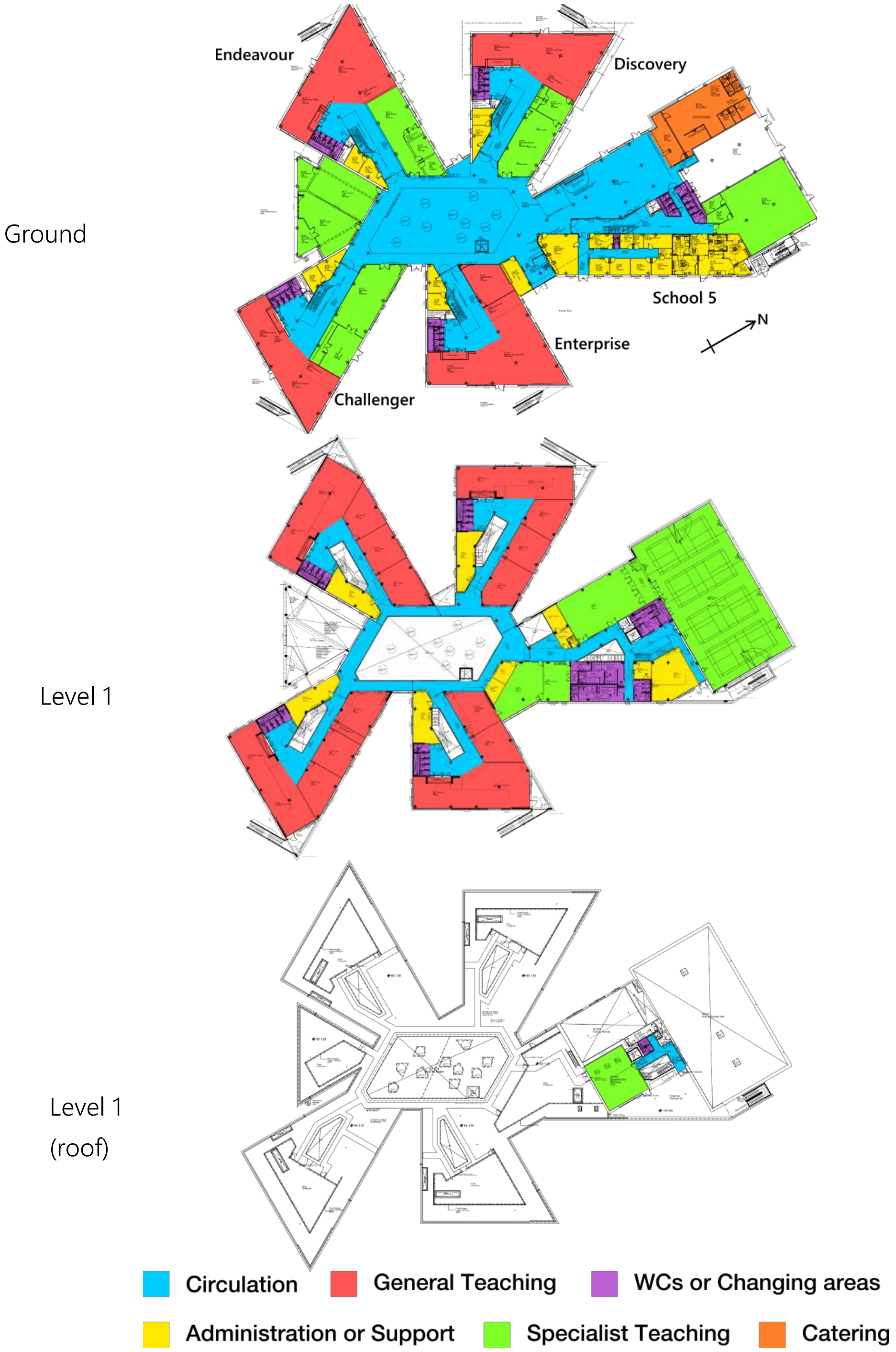


Figure 2.2 - Thamesview School plan, showing area activity type, (top: ground floor, middle: first floor, and bottom: second floor)

2.1.2 Building Construction

The building fabric of Thamesview School was designed to be better than the minimum requirements of the Building Regulations UK Part-L 2006. Maximising natural daylight was a major design driver and hence, there is a large amount of glazing provided in this building. Careful attention was paid to reducing solar gains by selecting appropriate glazing types. The building was designed to have an air tightness of 4.7 $m^3/hr/m^2$ @ 50Pa. Types of construction used at the Thamesview School are given in Table 1 below.

Table 1 - Tables showing fabric construction types at Thamesview School

Element	Construction	U-value
Ground floor	175mm concrete slab, 60mm insulation and 75mm screed	0.2 W/m^2 K
Roof	flat inverted roof type constructed of 300mm concrete slab, waterproofing and 185mm insulation	0.15 W/m^2 K
Facades	Outer brick leaf, 60mm cavity, 100mm insulation and within 150mm Metsec, 15mm plasterboard on the inside	0.2 W/m^2 K
Glazing	Velfac Solar control double glazing for doors and windows and Velfac clerestory glazing	1.5 W/m^2 K

2.1.3 FM Services

Thamesview School is maintained under a PFI contract by Kier Facility Services (Kier FS), as part of a package with two other local schools commissioned under the Kent BSF scheme (Northfleet Technology College and St Johns School). The three schools have one dedicated helpdesk located in Northfleet Technology College, with staff generally shared between the three sites. This is different to the usual Kier FS sites, which are served by a large regional helpdesk, with specialist teams in each region. One member of staff is permanently based on the site, whereas the other members of the FM team rotate between buildings.

2.1.4 Handover

Although Thamesview School is a PFI project, it was still handed-over in similar manner to other projects, with Kier FS operating almost independently from the construction wing of Kier. At the time of writing this report, Kier FS took over full responsibility for the building, but there was an extended defects period, which has delayed focusing on energy efficiency due to the complexity of the resolving outstanding issues. .

The time taken to rectify some of the defects has had a direct impact on the school environment, with the cold drama space a prime example. While each building issue takes time to understand and find its root cause, this has been a particularly complex issue, with a number of solutions attempted. While it is important that the solutions implemented are appropriate and address the underlying issues, it is just as important to speedily rectify problems that directly affect the school. Without the direct control of the building, the school can feel particularly powerless when dealing with issues that relate to the building. It should be noted that both Kier construction and Kier FM services on site do endeavour to reduce issues when they occur, but a full solution can be slow.

Due to this reliance on the construction team, both the O&M and logbook remain unused, with the O&M rapidly becoming obsolete as the building evolves. It is important that as changes are made to the building, the FM team ensure that the O&M is kept up to date, and refer to that as their first authority on the building.

2.2 Brighton Aldridge Community Academy

BACA replaced an existing school and was built next to the original school building to ensure easy decant of the school and continuity within the community. This section will focus on the design and delivery of BACA.

BACA is located in Falmer, Sussex and was recently occupied at the end of August 2011. It was designed by Feilden Clegg Bradley Studios and was constructed by Kier Southern. The academy replaces the existing Falmer High School and has received funding by the government's academy programme with additional sponsorship by both Brighton and Hove City Council and The Rod Aldridge Foundation.

2.2.1 General Building

The academy occupies a large site, with the two-storey school located in elevated position above the sports pitches in the southern part of the site. The teaching areas are located on the southern side of the building, with the office and admin areas on the north-west side, overlooking the sports pitches. Figure 2.3 and Figure 2.4 illustrate the concept behind the building layout and its relation to the overall site. The teaching has been moved to the back of the building to overcome the high ambient noise as a result of the nearby dual carriageway and rail line adjacent to the sports pitches.

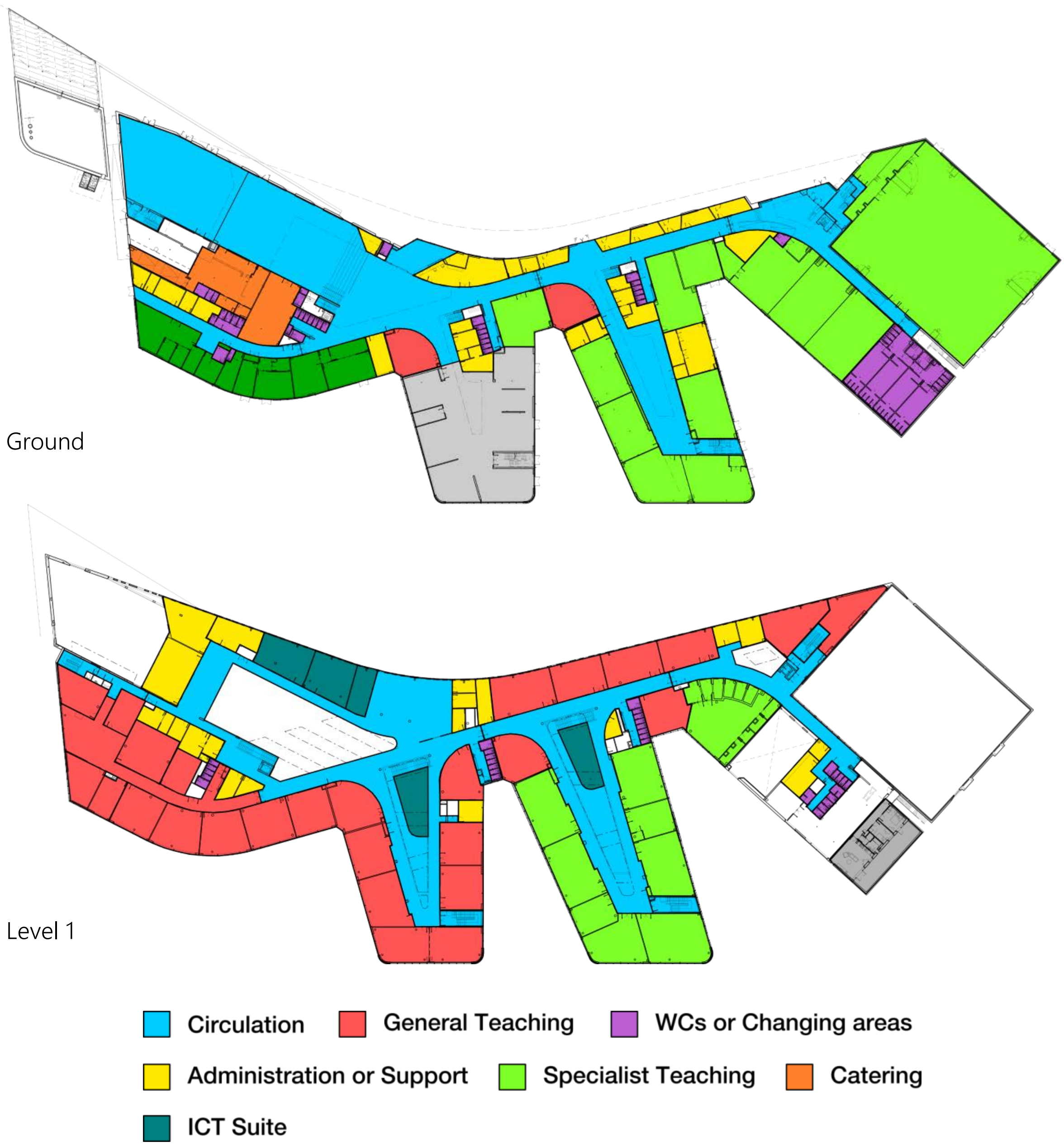


Figure 2.3 - BACA Building Layout Concept (top: ground floor, bottom: first floor)

Additionally, BACA now temporarily hosts a bilingual primary free-school on the ground floor of one of the teaching wings, until the free school can find a suitable location to be permanently based (shown in grey on the ground floor in Figure 2.3).

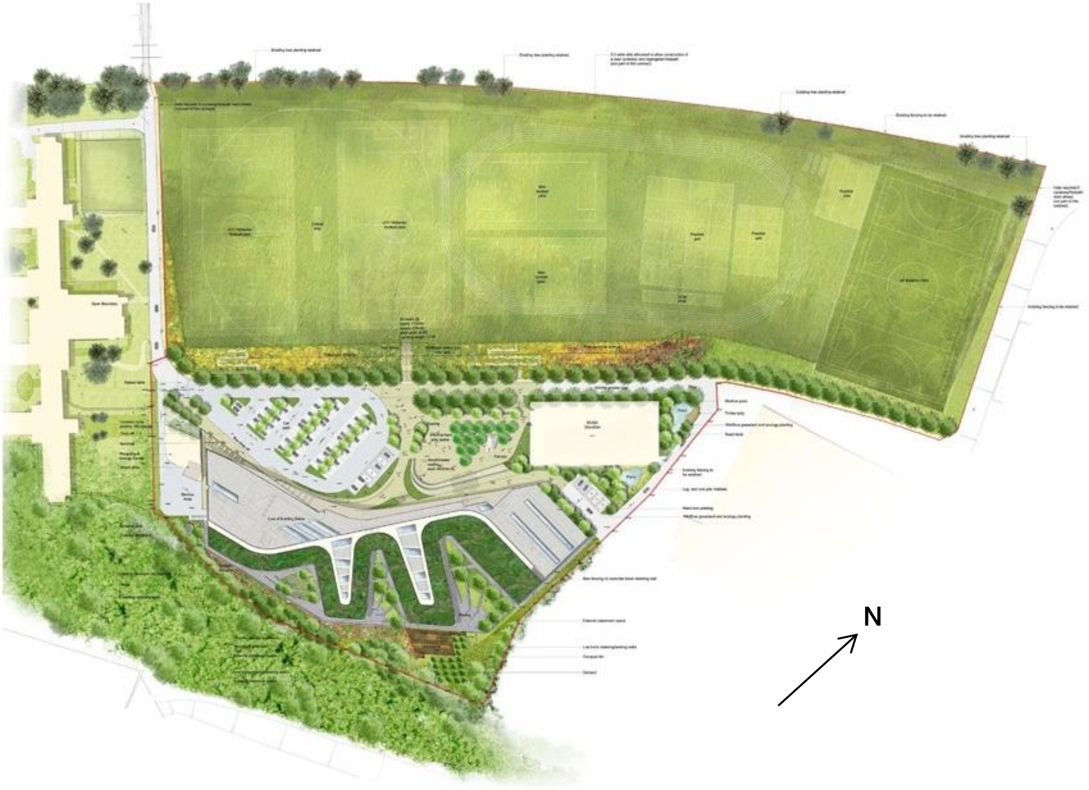


Figure 2.4 - Image showing BACA site layout

2.2.2 Building Construction

Brighton Aldridge Community Academy was built to Part L:2006, with the building fabric designed to improve on the minimum requirements set on by the building regulations. The main construction types can be seen in Table 2 below. The building infiltration rate was tested following construction and was found to be an exceptionally low 2.93 $m^3/h/m^2$, considerably lower than the required 10.0 $m^3/h/m^2$.

Table 2 – Main construction types used at BACA

Element	Construction	U-value
Ground floor	In situ concrete slab with floating floor screed on insulation	0.2 W/m^2 K
Roof	In situ reinforced concrete slab, vapour control layer, insulation, Bauder Extensive green roof waterproofing system - sedum, ballasted& paved	0.2 W/m^2 K
Facades	Brickwork outerleaf, insulation, cavity, blockwork inner leaf	0.27 W/m^2 K
Glazing	Double-glazed, with solar control to south façade, aluminium-timber composite frames.	1.6 W/m^2 K

2.2.3 FM Services

BACA is maintained directly by the academy with a dedicated on-site Facilities Manager since January 2012. Prior to this date, including the previous building, facilities management was undertaken another facilities manager on behalf of BHCC (and later the academy). All specialist and planned maintenance is under taken by TSS Facilities Ltd acting as sub-contractors on behalf of BHCC and the academy.

2.2.4 BACA Design Process

The original design intention produced by Brighton and Hove City Council (BHCC) consisted of four options:

- option one - a single phase build on the existing site
- option two - a single phase build on the playing field
- option three - a two phase build on the site of the north building
- option four - a two phase build part on the existing site and part on the playing fields

Of the above options, option one and option three were the favourites, with increased visibility and better chance of natural ventilation due to the increased distance between the school and the train line. However, it was noted that both schemes would cause considerable disruption to the teaching, with option one requiring the existing school to be demolished and the students housed in temporary buildings until building completion. Option two caused disruption through the phased move from the old building to the new, but did provide better overall teaching facilities during the construction phase at the expense of a longer construction time.

The solution put forward by FCB Studios and Kier had the new building wrap around the rear of the existing school building, without greatly affecting the working of the school. This design allowed the school to continue in the existing building while also having a reduced construction time.

As this was a departure from the original brief, managing the delivery of the design intent became more complex as the design intent had to quickly adjust to the new building form and construction schedule. However, interviews with the project manager on behalf of BHCC and the design manager on behalf of Kier suggest, that the design was delivered predominantly as the initial tender design. Both Kier and BHCC made changes throughout the construction phase to ensure build-ability and cost effectiveness, with examples given (such as rationalising the guttering in the block paving). In the case of BHCC's management, they sought to produce a contingency that didn't exist at the start, enabling additions such as the sports hall viewing gallery at no additional contract cost.

The major area of the design that has suffered according to discussions with all available parties is that the M&E services within the building do not match the quality of the rest of the building. It was noted through discussions with the design team that the original Kier M&E supervisor left the site during the final phases of construction (roughly in April 2011). Although a replacement was found, it was an additional responsibility to that person's current involvement with the project. It was not known whether this had an impact on the final quality of the M&E installation, but it was felt that the lack of M&E ownership was detrimental by the project team.

2.2.5 Building Process

From the building O&M manual, sites visits and discussions with the design team and school, the following issues were noted:

- The building fabric was constructed to a high standard, with little ongoing issues outside of the defects. There have been a couple of on-going issues for the maintenance staff
    - White paint used for the walls has proved difficult to clean, requiring repainting rather than simpler cleaning. This is particularly noticeable where chairs are at high risk of rubbing along the wall, for example in the hall.
    - Doors along the main street have had repeated problems with the door locks breaking as the students push against them.
- The BMS description of operation for MCC4 (the Energy Centre) was reviewed and the following noted:
    - The description appears to have comments still outstanding – some sections are highlighted in yellow as if there are still notes to be incorporated.
    - The description refers to two plate heat exchangers installed between the biomass boiler and the common LTHW return header. Two thermal stores have been installed in place of the heat exchangers but these are not referenced in the BMS description of operation.
    - There are no motorised thermal store isolation valves shown on the as-built schematics (Document reference: 70386-M-Z-XX-SM-1004) or described in the BMS narratives. Therefore there is no way to automatically isolate the thermal stores, should the biomass system become unavailable for any reason. The only option would be to manually isolate the cylinders, however this process is not described in the O&M documentation reviewed.
- It is noted that the as-built drawing for the primary heating system shows the heat meter for the DHW circuit installed on the feed to the AHU and UFH CT circuit, and vice versa (this may just be a drawing error).
- The mechanical services description found in the O&M manual notes that the VT circuit has been designed to operate at 80°C/60°C flow and return temperatures at peak load. However, the BMS documentation notes that the common boiler return for this system is designed at 72°C. This may have a number of affects:
    - The boiler itself is not designed to run with only a 10°C running through the system as the internal resistance would be too high.

- Irrespective of the design conditions, the flow temperature was not matching the calculated flow temperature, remaining at 72^{o}C. There is a clear underlying issue with the control strategy, whether through a malfunctioning actuator, or through the controls systems themselves.

It should be noted that the majority of issues found with the building are based on the building services installation rather than the building fabric, which have been to a high standard. As previously noted, one of the root causes of the services' issues noted appears to be related to the lack of a site M&E coordinator working on behalf of Kier during the final stages of the installation. It was generally felt by the team involved that had the M&E sub-contractor been monitored closer by a dedicated Kier representative, then the final outcome may have been improved. Working with the project manager on behalf of Brighton and Hove City Council was an architect that assisted with identifying defects. The increased focus on the fabric and the subsequent high-quality achieved indicates the value of external reviews of the building during construction. It is inappropriate to attribute the sole improvement to the extra focus on the fabric, as it generally easier to identify issues with the building fabric relative to the technical aspects of the services (such as identifying the correct actuator for a three-port valve). Although a number of issues have been identified, Kier have been in constant contact with the school, and have endeavoured to rectify all issues as they arise.

2.2.6 Review of sign-off and commissioning procedures

The M&E subcontractor mechanical commissioning programme has been reviewed with the following comments;

- The commissioning period shown covers a total of seven weeks with a number of overlaps between activities.
- There was no indication as to when the utilities will be provided to enable commissioning e.g. power on, gas, water etc.
- There was no time allocated to commission the auger feed system to the biomass boiler.
- The programme shows pressure testing and flushing of the heating system indicating that this was planned.
- The BMS controls section of the programme shows the need to commission the MCCs but there is no indication of how long this activity will take.
- There is no time indicated to complete proportional balancing of the heating system CT and VT circuits and underfloor heating circuits.

The Createmaster O&M document handling system has been reviewed for commissioning and as-built content to give an indication of the success of the commissioning procedures. The following observations were made during this review;

- There are 20 mechanical and 36 electrical documents uploaded into the test certificate section including commissioning certificates for the boilers, the solar thermal system and Armstrong booster pumps.
- The commissioning certificates do not contain the actual day the commissioning was undertaken, only the day the commissioning certificate was completed. This does not allow scrutiny of the certificates beyond ensuring the correct readings were recorded (flowrates for example).
- There is no record of any pressure testing or flushing related to the heating system.
- There is a test sheet indicating that a UKAS accredited laboratory analysed a water sample taken from the heating system on 22nd July 2011. The results sheet does not show the level of pseudomonas present in the sample but shows some of the criteria required (pH, total dissolved solids etc.).

The mechanical ventilation balancing commissioning test sheets are not uploaded to the Createmaster system, however the following comments are made against test sheets received from the Kier site team as they were completed.

- There are some records indicating chlorination and water sampling of domestic hot and cold water services.
- AHU R04 Extract is shown as reaching only 84% of design with the inverter at 33Hz. The note on the test sheets indicates that the FLC of the motor would be exceeded if the inverter frequency was increased. This is indicative of motor /fan unit that is undersized for the static pressure in the system, potentially through changes to the ductwork layout or incomplete commissioning, but the root cause was not identified during this study.
- AHU R04 Supply is similarly shown as reaching only 76% of design with the inverter at 38Hz again with notes to the effect that the FLC would be exceed if the inverter frequency was increased. This is similar to the extract noted above.
- AHU RO5 Supply fan (serving the Kitchen and Hall) is shown as reaching only 71% of design with no indication why.
    - It should be noted that the supplies R04 and R05, and extract R04 are designed to work in unison. This section was later found have dampers that were closed. It is not known whether this was the underlying cause for the difficulty with commissioning the fan duties, but clearly the static pressure within the system was higher than the fan/motor combination could manage.
- P1 and P2 (the gas boiler primary pumps) are both shown at 88% of design with the inverters at 50Hz.

- BMS commissioning certificates provide very little detail, with no dates, witnesses, or the name of the person undertaking it. MCC1 and MCC2 have not been checked on the software side, only on the panel.
- None of the electricity sub-meters have been commissioned with the BMS, with no checking of connection to the MCC panels.
- The BMS commissioning records highlighted a number of outstanding issues, with no further documentation to state whether they have been rectified.

It should be noted that due to the lack of dates on the commissioning certificates, it is difficult to determine how effective the initial commissioning plan was. However, it has been noted that the commissioning certificates provided by other sub-contractors point to dates typically a week later than planned. It is not known whether there is a particular root cause for this delay, but the commissioning was completed on time prior to handover of the building. From reviewing the BREEAM certificate and points schedule, it was noted that two points were awarded for commissioning at the design stage, but were yet to be awarded at the post-construction review stage.

Within the O&M manual, 19 training certificates have been provided which match the predicted dates in the training plan. There are a number of training certificates currently missing that have been undertaken by the BACA FM team and TSS, predominantly relating to the mechanical services.

2.2.7 Review of plans for occupation

The plans for the occupation of the new building were identified through discussions with key members of staff involved with the move. The following sections discuss the planning and execution of the occupation of the new building.

2.2.7.1 Planning

The original design brief used in the tendering documentation identified four construction plans for the development of the new building, with two taking particular precedence: a two-phase build on the site of the existing building, and singe-phase build on the existing building, using temporary accommodation during the construction phase. The solution put forward by FCB Studios and Kier (and subsequently accepted) placed the new building around the existing building, enabling the old building to be used during construction.

This change in design will have affected the original plans for occupation, as the other schemes all involved a staggered move, either into the new building or into temporary accommodation. It is not known how detailed the plans for occupation were at this stage; however they would have required revising as they would not have reflected the updated design.

The initial handover date was scheduled to be the first day of term (3rd September 2011), with the building to be ready for occupation. On this date, the building was to be fully commissioned, all training and documentation completed, all defects cleared and the building to be clean. At Kier's request, the building handover date was moved forward by two weeks and the standards for the handover requirements were relaxed slightly. The additional two weeks allowing for any outstanding issues to be rectified prior to the school opening to students, hence the reduced handover requirements.

As part of Kier's contract with Brighton and Hove City Council (BHCC), Kier were to supply assistance with moving the school form the old building to the new. This appears to have been an ambiguous part of the contract as both sides interpreted it differently; Kier understanding that this related solely to transporting the school equipment from one building to another, and BHCC believing this to mean the packing and the transportation of the school materials from the old building to the new. This discrepancy was noted by the new principal shortly after her joining the school. Ultimately, the additional costs of packing the school were covered by the school/BHCC using the same contractor as Kier for the transport.

In order to assist with planning for the occupation, a consultant was brought in by BHCC and The Aldridge Foundation who worked closely with the facilities manager. Their joint task was to determine what existing equipment/materials from the old building should be brought over and which should be replaced. From discussions with the project team, this appears to have been a particularly difficult set of choices, producing considerable discussions. This difficulty appears to have compounded by the increased complexity of both the FM and the consultant planning the move.

The school move was planned for the two weeks following the handover prior to the start of the new academic year. This would be undertaken by a combination of the moving company and the teaching staff, supervised by the FM and the finance director. All new materials/equipment were to be delivered to the old building if arriving prior to handover and the new building if after handover.

2.2.7.2 Execution

The building was handed over on schedule, with all the requirements met. During the following two weeks, the school was moved over from the original building to the new building. However, during this time the FM was also closing out defects in the building and overseeing the final elements of training and commissioning. Due to these additional tasks, there was little time for the FM to manage the transport of the school.

It was planned that the staff within the school would assist in the move by packing their work into boxes prior to the move, either at the start or the end of the summer holiday. This appears to have been undertaken only sporadically, with a number of teachers arriving back at the school just before the start of term. With confusion over what exactly was still required by the individual teachers, the move took longer than the planned two weeks. During the first week of term, the school moved the last parts across to the new school, with the students moving over in phases.

2.3 Conclusions

Looking at BACA, the quality of the building services do not meet the standard of the building fabric. The most likely cause of this discrepancy was the lack of attention during the final stages of the building programme to the services, which in many ways is the most important part when dealing with such complex systems. The commissioning of each system, in particular the controls, is necessary to ensure not only that the systems will work as intended, but also that the systems are working optimally. Future projects could avoid this issue by ensuring the M&E services remain closely monitored, preferably through an independent body aligned with the client and the end user.

At Thamesview School, there have been benefits of the close relationship between the contractors and the facilities management, ensuring that there is a good dialogue for when problems occur. However, the reliance on the contractors to resolve underlying problems has prolonged the time taken to repair defects, occasionally to the detriment to the school environment. With the building over three years old, it is imperative to find a solution to the defects, particularly as the building ages and fault becomes increasingly difficult to apportion.

2.3.1 Conclusions of the handover at BACA

From discussions with the project team, it is clear that while the occupation had been discussed at a high level, such as issues with phasing the construction, the detail had not been considered. Following the awarding of the contract, this should have been carefully thought out to ensure that the handover date enabled the move of the school. It appears to have been fortunate that Kier pushed for an early handover during which time the school could have been moved, although it is not clear if part of the original handover was the move of the school equipment to the new school.

The addition of an external consultant working on behalf of BACA appears to have created conflict within the client team, particularly with the FM. It is difficult to quantify the impact that the external consultant had, with no ability to understand how the move would have progressed without. However, it is understood that their focus was reducing costs associated with the move, which appears to have been successful (from discussions with the school staff). Potentially, planning for the move may have been smoother if the consultant took sole responsibility for the move, enabling the FM to concentrate on other aspects of the new building.

The reliance on the staff to assist in packing appears to have been an area that led to the overall delay in the move. It was noted that since the school became an academy, a number of the staff had left (including senior teaching staff) and there was felt to be generally low morale. Clearly this is a very specific issue, but the overall effect was tangible and should be considered when planning a move, including the packing prior to the school breaks.

3 REVIEW OF BUILDING SERVICES AND ENERGY SYSTEMS

3.1 Thamesview School

Thamesview School is a mixed-mode system, with a centralised LTHW system, fed from a lead biomass boiler, with gas backup. The following sections outline the details of the systems and the schematics can be found in Appendix A1.

3.1.1 Heating

The primary heating system installed at Thamesview School consists of the following;

- A 360 kW Broag-Remeha Gilles biomass wood chip boiler linked to a 2500 litre thermal store to act as the lead heat source.
- Two 365 kW gas condensing boilers to cover peak loads and provide standby should the biomass boiler be unavailable.
- LTHW variable volume constant temperature secondary circuits feeding Air Handling Units, a DHW calorifier, underfloor heating and radiant panels.
- LTHW variable volume and variable temperature secondary circuits feeding radiators and local zone re-heater batteries.

3.1.2 Ventilation

Thamesview School utilises a mixed-mode ventilation scheme, with two predominant system types:

- Mechanical supply and extract from roof mounted air-handling units, with openable windows in the classroom/teaching areas and additional Monodraught Windcatcher units in the sports hall.
- Natural ventilation with high level louvers in the atria and the sports hall.

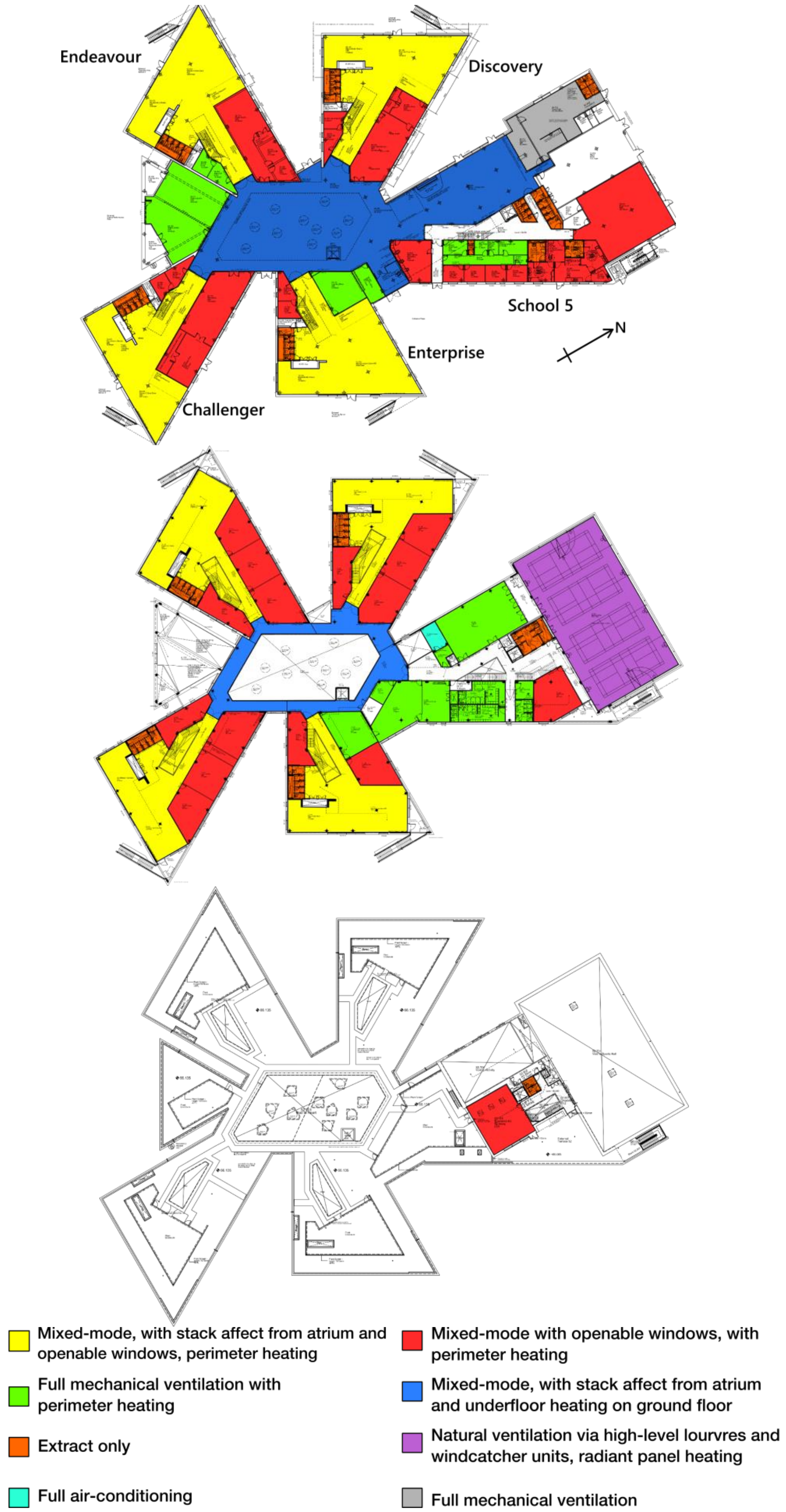


Figure 3.1 – Thamesview School layout plans illustrating the heating and ventilation methods for each zone (top: ground floor, middle: first floor, and bottom: second floor).

3.1.3 Controls

Thamesview School is predominantly controlled through the central Trend BMS, with the head end located in the FM's office. This system is responsible for controlling/monitoring the following items:

- Controlling CT and VT heating circuits, including:
    - Boilers and biomass
    - Pumps
    - Zoning/mixing valves
- Modulating Monodraught windcatcher units
- Operating and modulating air handling units
- Logging utility sub-meters
- Logging temperature sensors

The BMS at Thamesview School is generally operating well, with much of the basic functionality expected of the system incorporated and operational. Many of the items of equipment connected to the services can be controlled directly by the BMS, such as the pumps or AHUs, with the status of each item connected visible. Where sensors are located within the building, either in the systems or in the spaces, these are addressable and open a log of 15-minute records for the previous week. The plant is interogatable from the BMS, with the AHUs for each zone accessible from the layout plans, ensuring that the correct AHU is selected (see Figure 3.2). Through these layout plans, the space temperatures for each area can be quickly determined, although each thermostat does not directly control the AHU. Instead, the AHU is controlled through an average of the temperatures recorded, which causes issues when one space within the zones is significantly different from the others.

Reviewing the metering from within the BMS, it is apparent that the energy/water meters log according to a different algorithm to the thermostats, with the 15-minute usages over-writing the previous days usage. This creates a log of daily usage, with no profiles within the day possible. This would appear to be a simple fix (given it works correctly for the thermostats), but continued throughout the period of the BPE study. The metering did not meet the same standard as the thermostats in terms of accuracy either, with validation of the heat, gas and water sub-meters difficult, due to non-intuitive location of some of the meters (see Figure 3.3) or the initial problems with the BMS monitoring (see Figure 3.4) which Kier have since resolved. As such, only the electrical sub-meters were able to be robustly monitored.

In order to retrieve historical meter readings, it was found to be prohibitively difficult, with a number of alarming and misleading sub-menus preventing all but the most determined user. A majority of the FM staff at Thamesview School are not familiar with the installed BMS and rely on the few members of staff that do or the specialist contractor. The lack of confidence of the staff when using the system relates to the inaccuracies they have spotted and the potential to cause considerable changes to the systems. It has been advised that the inaccuracies of the system be rectified (currently being undertaken) and different levels of access be provided, preventing accidental changes to fundamental properties (flow set points for example). By enabling the differing levels of access, users would be confident to interrogate the BMS without the danger of changing key properties (low-level access personnel), but the necessary functionality would remain for those with the knowledge (high-level access personnel).

Figure 3.2 – Screenshot of Thamesview BMS showing the layout plans and colour-coded AHU zones

Time clocks for each zone are specifiable for days of the week, and can be pre-set for future periods of different use (regularly used for the school holidays). However, these were difficult to access, with significant prior knowledge required to access these settings. As with the access to the meter logs, access should be improved to the timeclocks, improving the flexibility of the systems, particularly out-of-hours use. This should be enable though the use of differing levels of access, enabling only those with prior knowledge to access the underlying settings, but the monitoring aspects and simple time clocks could be readily examined by those with less training.

Due to the underlying energy metering issues, it has been hard to identify the effectiveness of the system, however through the use of local thermostats, it was possible to determine the operation of the BMS optimiser. The optimiser interprets the timeclocks, set as occupancy hours for the building, and determines the correct plant operation times to meet the need, based on past experience and the current building situation (internal and external temperatures for example). However, following a power outage, which locked out the incoming gas meter, it became apparent that the AHUs were working through the weekend, despite not being requested by the timeclock. It appears that the optimiser has been operating the building services needlessly, increasing the overall energy consumption. Due to the lack of available metering at the time, this has been particularly difficult to spot, hindered by the lack of understanding regarding how the optimiser actually works.

Figure 3.3 – Image showing the location of the heat meter controller on the underside of the soffit in the plant room.

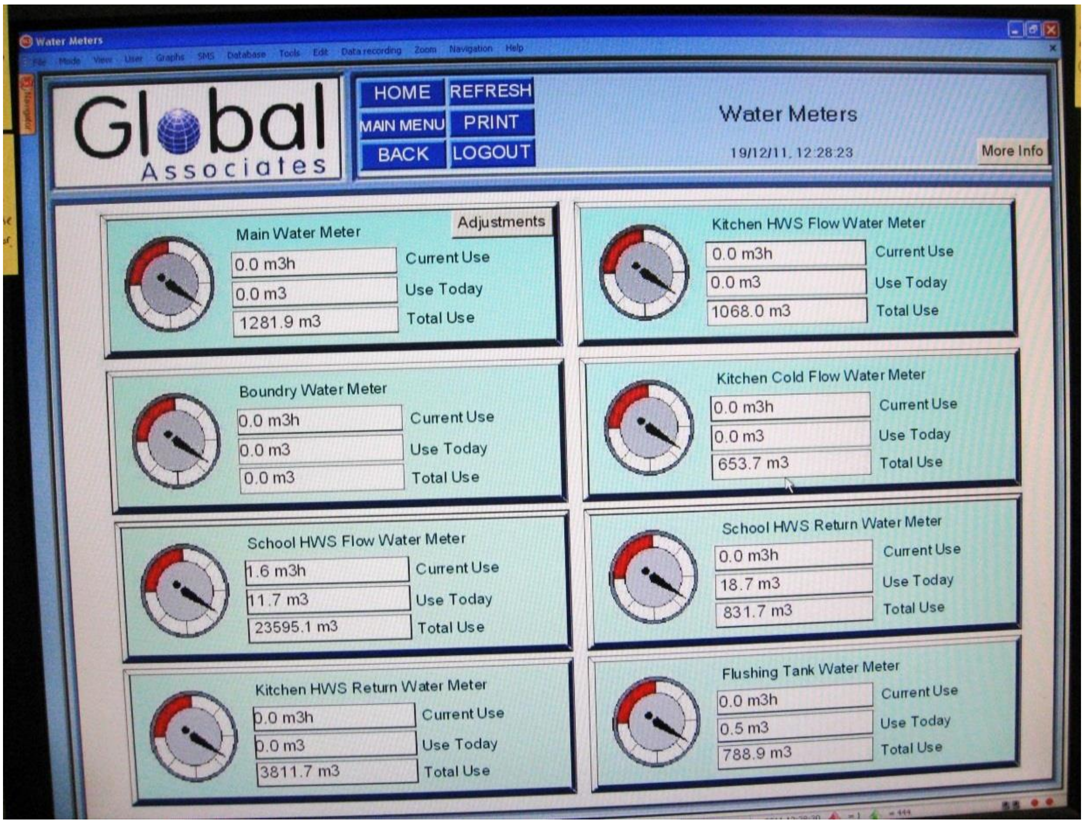


Figure 3.4 – Screenshot of Thamesview BMS showing the water meter readings

As a consequence of the BPE programme and through the increasing need to efficiently run the building, a new BMS is being installed at Thamesview with increased remote monitoring capability. This will also include remote logging fault alarms, allowing the remote help desk (located at the nearby Northfleet Academy) to easily monitor Thamesview School. This also has the advantage of storing the data in the cloud, negating any issues with hard-drive failure or running out of memory.

3.1.4 Daylighting and Lighting

Thamesview School has considerable glazing and atria in each teaching wing to increase the amount of natural light available to the school. This is complemented by zoned artificial lighting throughout the building. (Note the full daylighting report is available in appendix C1)

3.1.4.1 Daylighting

The daylighting survey of Thamesview School examined the available daylight in the open plan teaching areas of the Discovery teaching wing (see Figure 3.5, Figure 3.6 and Table 3). Three spaces were tested, with the results showing the importance of the room layout and ceiling height. Rooms 1 and 3 both good daylight factors (over 5%), assisted by the double aspect glazing, which largely negates the impact of the interactive white boards partially blocking windows. Within Room 2, the daylight factor is much lower than the recommended 5% from Building Bulletin 90 to enable the space to be solely lit by daylight, but still higher than the minimum of 2% at 2.6%. Despite the large amount of glazing, the light penetration is poor, significantly hampered by the low ceiling, large depth of the space, and neighbouring School 5 block overshadowing the Discovery block.

Table 3 – Table showing the results of the daylighting survey at Thamesview School

	Room 1	Room 2	Room 3
Sill Height	1100 mm	1100 mm	1100 mm
Window Height (AFL)	2980 mm	2980 mm	2980 mm
Ceiling Height	2700 mm	2700 mm	2700 mm
Glazing Orientation	South-West and North-West	North-East	South-West and North-West
Measurement Height	850 mm	800 mm	850 mm
Indicative External light level	27500 lux	21000 lux	22000 lux
Average Daylight Factor	5.9%	2.6%	5.8%
Uniformity Factor	14.3%	11.6%	18.8%

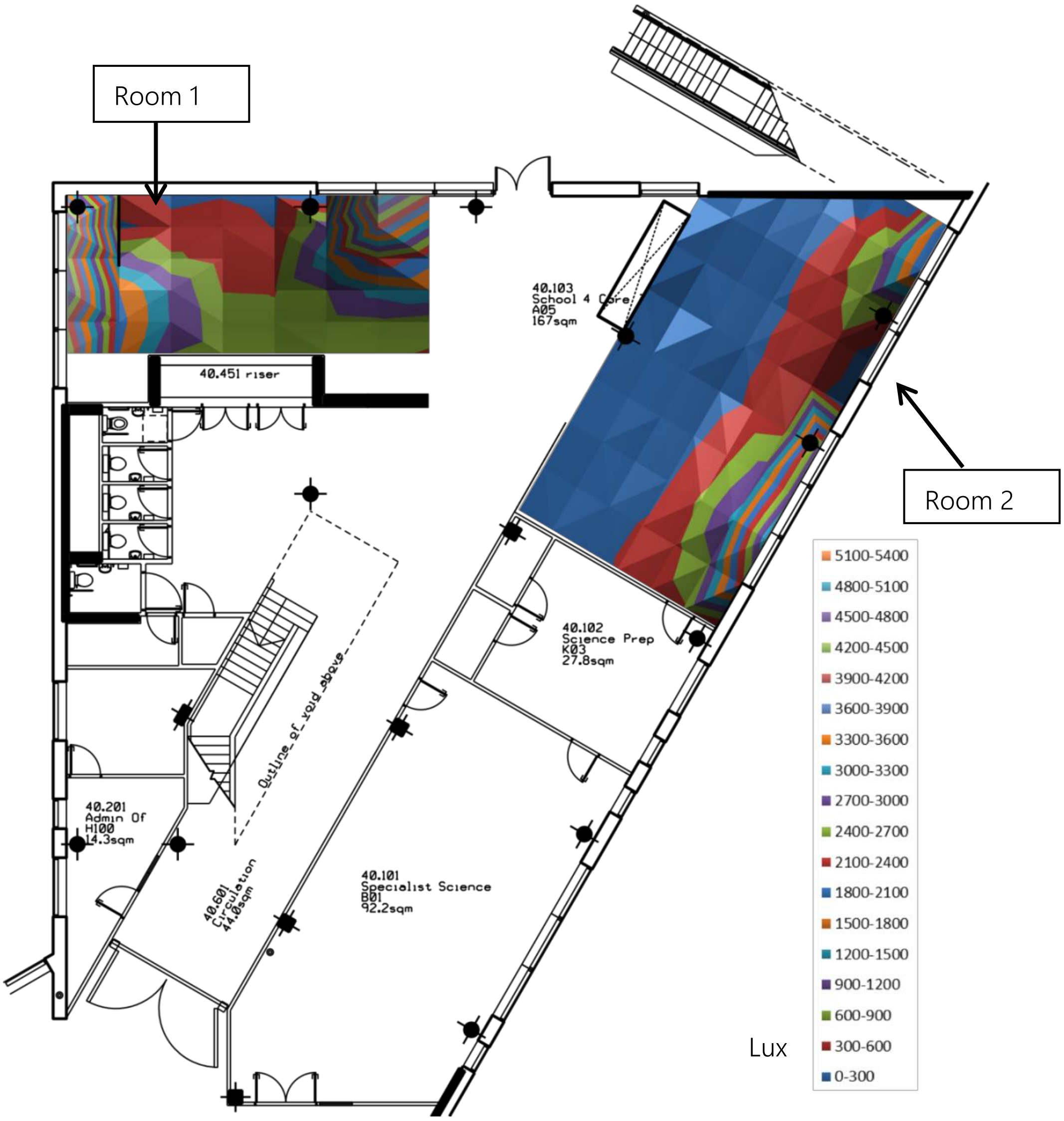


Figure 3.5 – Daylight analysis of the ground floor at Thamesview School, with rooms 1 & 2

Uniformity in all three spaces tested was above 11%, with the Rooms 1 and 3 showing good uniformity due to the double aspect glazing. In Room 2 the low uniformity and poor daylight factor combines to prevent the glazing from effectively lighting the space, with blinds used to prevent glare close to the windows and lighting necessary elsewhere. None of the rooms benefitted from the additional daylight available from the central atrium, with Room 2 in particular separated via large furniture to create a more typical teaching space.

In all spaces, prior to the survey all the blinds had to be raised, indicating that even in Rooms 1 and 3 the amount of daylight was producing issues within the teaching spaces, particularly with the interactive whiteboards. The full daylighting report is available in Appendix C1.

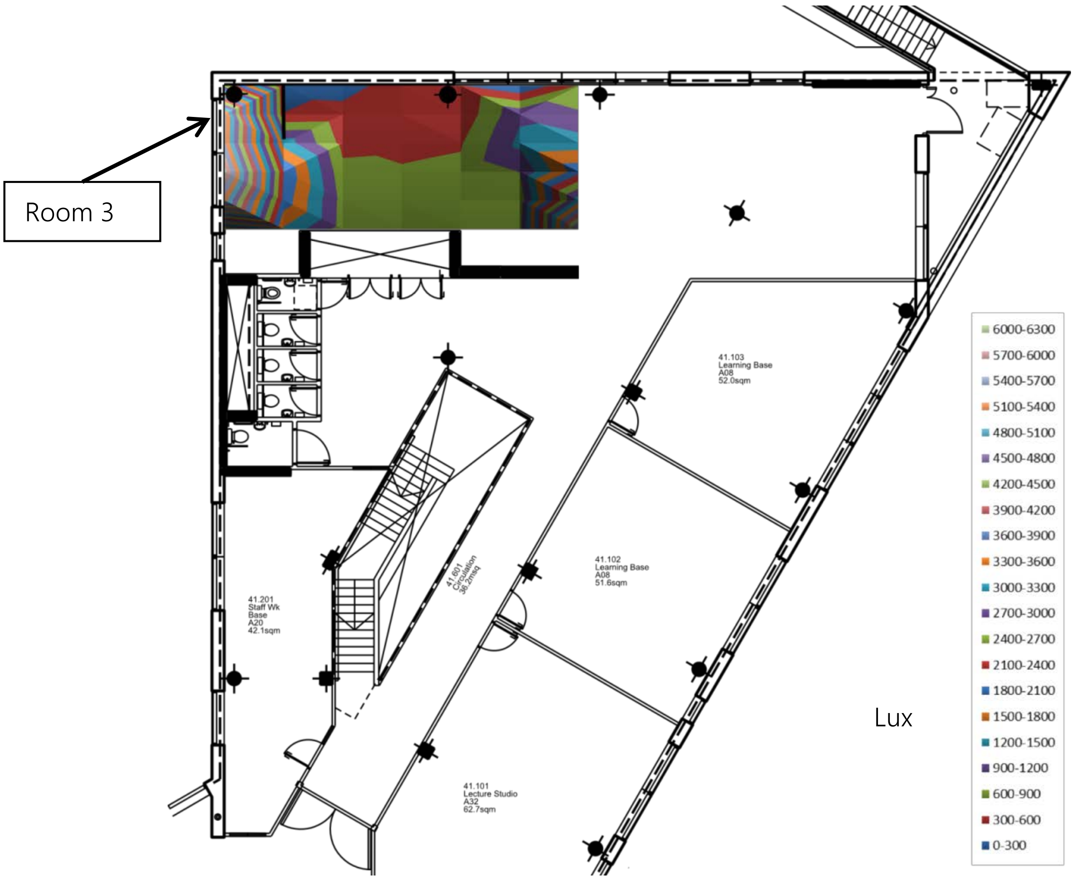


Figure 3.6 - Daylight analysis of the first floor at Thamesview School, with room 3

3.1.5 Artificial Lighting

The artificial lighting in Thamesview School is well zoned and controlled using a mixture of PIRs, daylight sensors, and manual overrides. Where manual overrides are installed (in the teaching spaces and offices), they are fitted in series with the PIRs and the daylight sensors, ensuring that they only operate when necessary. Elsewhere, the lighting relies solely on the automatic controls.

Manual overrides are provided only in teaching spaces and occupied offices, allowing the occupants to reduce the nuisances associated with occupancy detection. It is also necessary to provide manual controls to ensure that the interactive white boards in the teaching spaces remain visible during lessons, with nearly all teaching spaces closing their blinds during lessons. Many of the classes are used with the blinds predominantly closed, preventing daylight glare from interfering with the interactive white boards, necessitating the use of artificial lighting. In nearly all the spaces with manual overrides, the lights are zoned according to distance from the external windows, but without a zone close to the interactive white board. In the open plan spaces, there are a number of non-fixed boards preventing the zoning of lighting to match the location of the board. Optimally, only the blinds close to the interactive white boards would be closed, with the lighting close to the board operated separately for when the board is not in use. However, without the necessary zones this has not been possible, although in practice many more blinds are closed than would appear necessary. Anecdotal evidence suggests that this is simply because it is easier for the teacher to control the lighting than the window blinds. This end use of the space and its influence on the lighting control needs to be factored into future briefs.

In the areas with no manual switching, such as the communal area, the lighting is only activated when the daylight sensor and the PIR deem it necessary. This works well for the corridor areas, but many of the lights were on when it was not necessary, particularly those over the atria, which provide little beneficial light to the surrounding corridors (see Figure 3.7). The sensors controlling these lights need to be set up correctly, ensuring that they only operate when absolutely necessary.

Figure 3.7 – Image showing the atria lighting working during daylight hours.

Lighting in the sports hall has caused problems in the past, with excessive usage at weekends noted during this study. The root cause is the lighting controls are within a locked box outside the hall, preventing easy control. While it is important that tampering with the lights is prevented during sports hall use, it is also necessary to reduce the chance of the lights been left on out of hours. As such, it has been recommended that a routine inspection during cleaning should be implemented, particularly given there are windows in the door.

3.2 Brighton Aldridge Community Academy

BACA, like Thamesview School, is serviced by a mixed-mode ventilation system with LTHW heating circuits provided by a lead biomass boiler, with gas backup. The following sections describe the systems used in greater details.

3.2.1 Heating System

The primary heating systems installed at BACA are as follows;

- ASiber C400 465 kW biomass wood chip boiler linked to 2no. thermal stores, acting as lead boiler.
- Two Ultramax R606 gas condensing boilers each rated at 475 kW.
- LTHW variable volume constant temperature secondary circuits feeding Air Handling Units, underfloor heating, overdoor heaters and domestic hot water cylinders.
    - Underfloor heating to large circulation spaces and halls
- LTHW variable volume and variable temperature secondary circuit feeding perimeter radiators.

3.2.2 Ventilation

BACA utilises a mixed-mode ventilation scheme, with the types of system employed varying between each area of the building. These systems fall into four main categories:

- Full mechanical supply and extract to rooms along the front façade of the building, main hall and internal offices, served from roof mounted AHUs.
- Monodraught Windcatcher units and actuated windows in the first floor classrooms at the rear of the building, operating on CO_2 and temperature levels.
- Automated windows to the ground floor classrooms at the rear of the building, operating on CO_2 and temperature levels.
- Manually openable windows in all other areas.

Figure 3.8 – Layout plans showing the servicing zones for BACA (top: ground floor, and bottom: first floor)

3.2.3 Controls

BACA is predominantly controlled through a central Honeywell Tridium BMS, with the head end located in the FM's office. This system is responsible for:

- Controlling CT and VT heating circuits, including:
    - Boilers
    - Pumps

  - Zoning/mixing valves
- Modulating Monodraught windcatcher units
- Operating air handling units
- Operating extract fans
- Logging utility sub-meters
- Monitoring and controlling space temperatures

In addition, the underfloor heating is controlled by local units at each manifold, connected to separate thermostats located in the relevant rooms. Lighting is also controlled locally, with PIR and daylighting sensors located in circulation areas, and manual switching in the classrooms/offices.

The control system itself has been a source of difficulty for the efficient running of the installed services, with the high-quality interface and graphics not being matched by the poor control strategies it allows. Initially the building was treated as one homogenous zone, with all the services operating at the same time. In addition, systems that responded to the internal environment were struggling to operate effectively, for example the wind-catcher units were not accounting for the external temperature, only the internal CO_2 levels, creating cold columns of air during winter. Compounding the on-going usage of the system, is the difficulty of understanding the end-uses of energy due to the lack of metering logged by the system. While much of the necessary meters are installed, few have been connected back to the BMS where they can be readily analysed.

Throughout the study Kier has worked with the school to improve the BMS; with the separation of timeclocks, improved control strategies and increased metering. This has created a system that been a significant improvement of the initial system, but is not as intuitive due to the fragmented improvements and the difficulty following the state of the system. While there are still many outstanding issues, particularly the number of meters not being correctly read, the system needs updated manuals to ensure that the system is still intelligible by new users. There has been significant complications caused by the lack of continuity in the FM at BACA, this would be considerably worse should the current FM move on before the documentation for the updated BMS is completed.

3.2.4 Daylighting and Lighting

BACA has been designed with large amounts of external glazing and central atria to harness the natural light and reduce the usage of artificial light. (Note the full daylighting report is available in appendix C1)

3.2.4.1 Daylighting

The daylighting in one teaching wing at BACA was measured to determine the effective daylight factor and uniformity created by the room layouts. Table 4, Figure 3.9, and Figure 3.10 show the results of the survey at BACA.

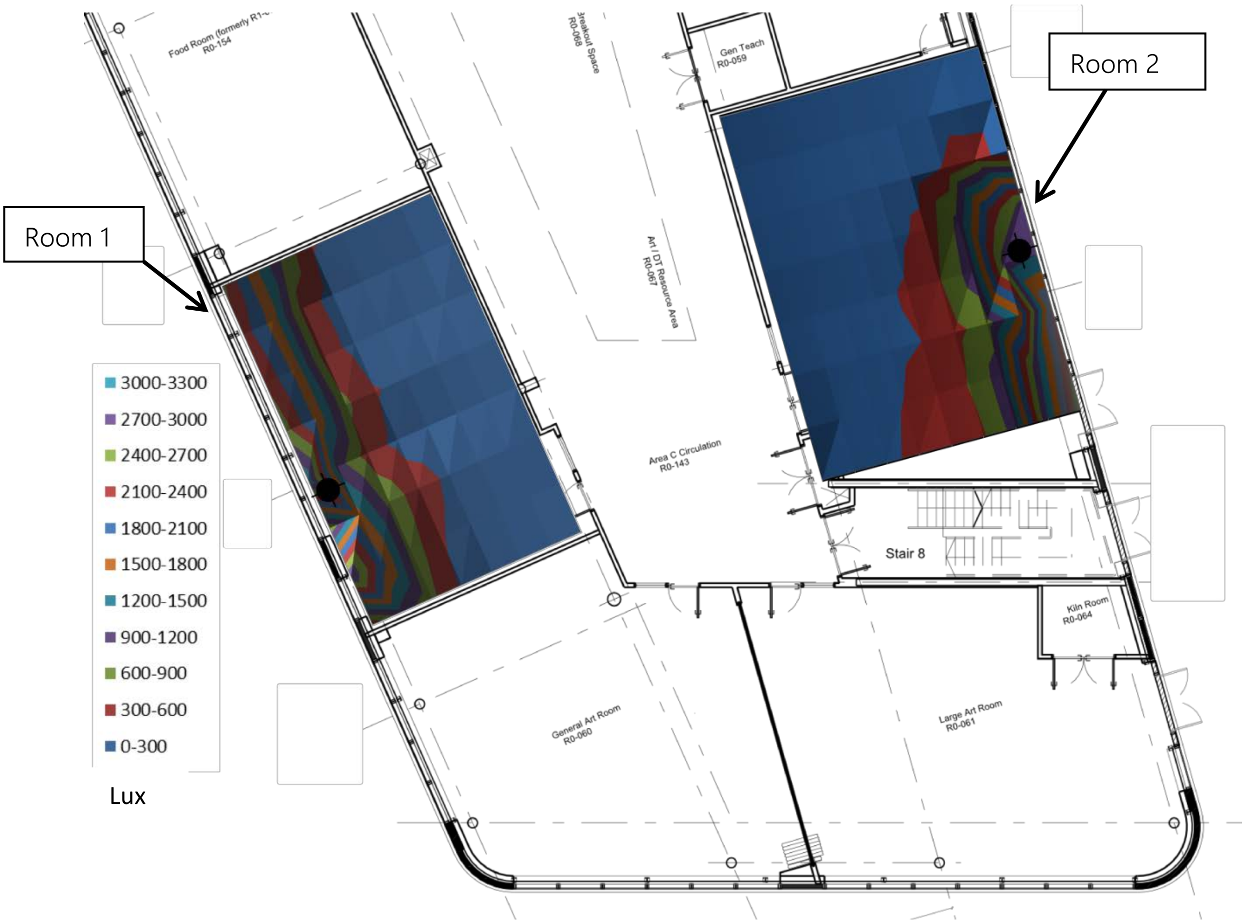


Figure 3.9 - Ground floor daylighting levels at BACA

Overall, the daylighting study has revealed mixed results for BACA, with the daylight plots shown in Figure 3.9 and Figure 3.10, and the room details summarised in Table 4. The ground floor rooms examined had average daylight factors lower than the guideline of 5% in Building Bulletin 90 needed for a fully daylit space, but still above the minimum 2%, whereas the first floor rooms had daylight factors over 5%. The ground floor rooms at BACA both had low daylight factors due to the lack of light penetration across the space. This has been caused by a combination of influences; neighbouring parts of the building blocking light, and the lower ceilings. In these spaces it will be necessary to use artificial lighting to supplement the daylight to ensure the correct working light level. The first floor rooms monitored have sufficient levels of light, all over the 5% recommended enabling fully daylit rooms, with room 3 in BACA having a particularly high daylight factor.

Table 4 - Details of the rooms measured during the daylight survey at BACA

	Room 1	Room 2	Room 3	Room 4
Sill Height	1100 mm	1100 mm/ 10 mm	1100 mm	1100 mm
Window Height (AFL)	3070 mm	3070 mm	3070 mm	3070 mm
Ceiling Height	2770 mm	3370 mm	3370 mm	3370 mm

	Room 1	Room 2	Room 3	Room 4
Glazing Orientation	South-West	North-East	South-West	North-East
Measurement Height	850 mm	850 mm	850 mm	850 mm
Indicative External light level	23000 lux	24000 lux	20000 lux	18000 lux
Average Daylight Factor	2.8%	3.1%	7.1%	5.1%
Uniformity Factor	10.4%	7.0%	11.7%	20.9%

One issue that has afflicted all the rooms investigated is low uniformity of the daylight within all the spaces monitored. As before, this is symptomatic of the poor light penetration within the space; the higher lux levels near the window tail off sharply before reaching the middle of the room. Room 4 in BACA had the uniformity at 20.9% enabled by the lack of the over-shadowing by nearby objects (particularly trees and the rest of the building). Additional light from the day-lit circulation area would have benefited the rooms at BACA as this central area could provide daylight into the darkest part of the rooms.

It should be noted that all the spaces had the blinds closed or partially closed prior to this survey. From discussion with the teachers it became apparent that the main reason this blinds were closed is to ensure the students could see the interactive white boards. It was noted that in BACA the white boards on the first floor would have to overcome significant daylight to be readable. Through careful use of the blinds, closing only the ones near the board, this affect can be minimised, but future projects should carefully integrate the location of these boards into the scheme design. During visits to the school, it was noted that many of the teachers regularly use artificial lighting in preference to the daylighting, largely due to the blinds being down to prevent glare on the white boards. The full daylighting report is available in appendix C1.

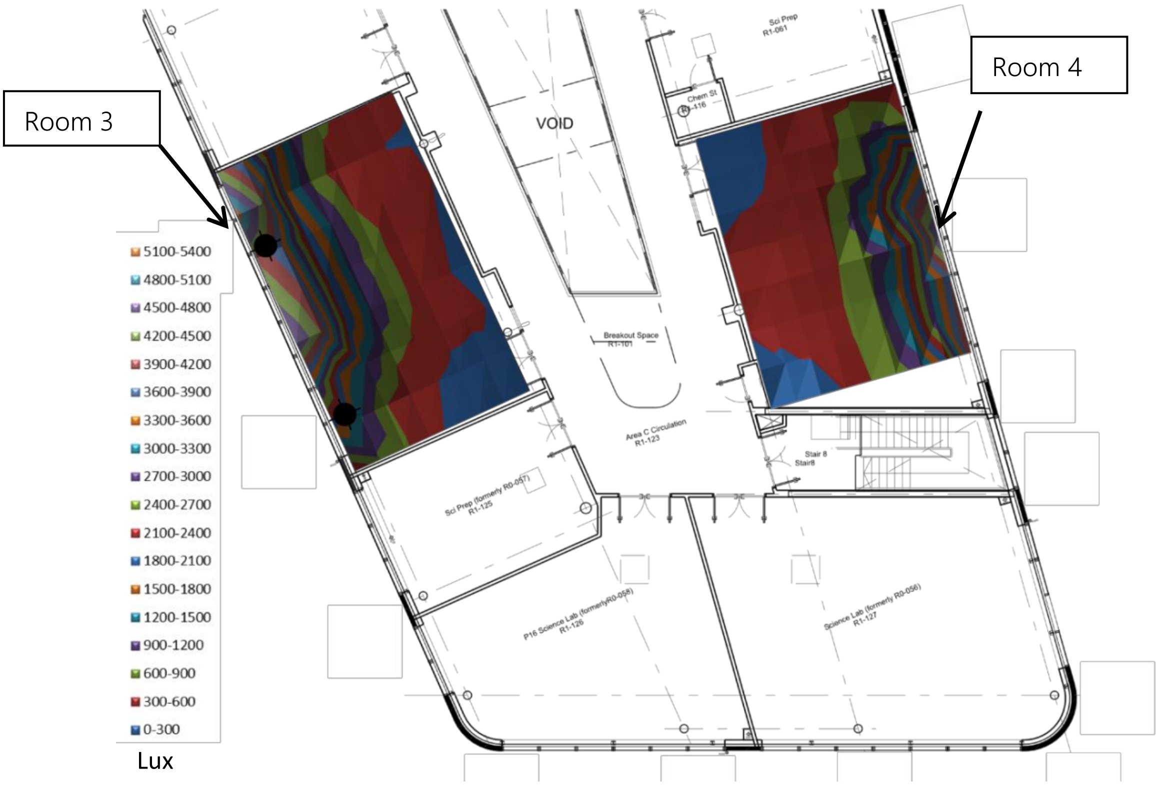


Figure 3.10 - First floor daylighting levels at BACA

3.2.4.2 Artificial Lighting

Lighting in BACA is controlled through two predominant methods;

- Manual switching with presence and daylight detection in the classrooms and meeting rooms
- Presence detection in the communal areas (corridors, halls, etc.)

Within the classrooms, the line of lights next to the window is dimmed by the daylight sensor mounted in the ceiling as the daylight level increases, but the rest of the room remains as set by the manual switches. The lighting in the rooms is organised in gangs that run parallel to the shortest wall, generally perpendicular to the external wall, giving the teaching staff control over the lighting adjacent to the interactive white board. In practice, the blinds are predominantly closed, negating the benefits of the daylight dimming next to the window. Through discussions with the staff, the blinds are mainly closed to reduce glare and increase the visibility of the interactive white board, despite the control strategies employed. In order to reduce energy usage, it is recommended that the teaching staff be advised on the control strategies available to them when teaching, particularly the ability to turn off the lights nearest the white board and the daylight dimming.

Within the circulation areas the lights are controlled solely on presence detection, ignoring any daylight that may be present in the space. While the timers and the presence detection have been optimised, with shorter timers and a higher threshold for detection, without the daylight detection it is still inefficient, particularly given the quantity of rooflights in the atria. As one area of the school has been used for a free school, the atria have been covered over, however the atria lights are still active (see Figure 3.11). It has been suggested that these be disconnected, or manually controlled, to prevent unnecessary usage.

Figure 3.11 – Image showing the atria lighting, controlled by the sensors on the ground floor, illuminating the cover over the atria to the free school below.

3.3 Conclusions and key findings

Both buildings have taken a similar route to servicing the building, using mixed-mode ventilation with biomass heating. This is common with many other new school building built under the guidance of the Department for Education's Building Bulletin series. At the time of the project, the strict internal requirements for fresh air, daylight, noise levels, and internal temperatures had pushed most new schools towards this servicing strategy. This level of complexity has necessitated the use of BMS, with the multitude of control strategies and monitoring points preventing reliable manual operation. However, with both schools the BMS has been largely overlooked due to issues with the systems; whether the number of errors apparent in the system or the lack of control flexibility it provides. While the complexity was difficult to avoid given the internal environments specified, future projects should look to reduce the complexity of the systems installed to reduce the reliance on one overarching item, namely the BMS. Due to the necessity of the BMS, it has been extensively revisited in order to rectify any errors.

The use of biomass boilers in both cases has been fraught with problems, with neither school using them for significant periods of time. At BACA, the main issue surrounding the use is the specified fuel causing jamming the auger. It was initially thought that the jamming of the auger occurred due to poor fuel quality, but later it was attributed to the incorrect auger/screw feed size. Compounding matters, it is difficult to deliver fuel into the hopper as there is not enough space for the wood-chip company to deliver a full load of wood chip due to the layout of the access route. Kier are currently engaged with the school to improve the biomass system. At Thamesview School, the biomass boiler has not been used due to problems initially arising from the sprinklers accidental damage of a sprinkler head causing the soaking the wood chips, followed by a prolonged period of drying and access problems. As with BACA, there have been issues surrounding the fuel delivery mechanism, but caused by the noise associated with the 'blower-type' mechanism originally used by the supplier. This has since been rectified by Kier, with a more robust, auger method used.

Daylight analysis in both schools showed that although a majority of the rooms met the recommended 5% average daylight factor (four out of the seven), with the rest meeting the guideline 2% average daylight factor, uniformity of light distribution was a significant issue. Those rooms that were less over shadowed at BACA on the first floor and those with light from central atria at Thamesview School had better daylight factors, and in the case of BACA, better uniformity. Also of note is the ground floor Art room at BACA (room 2), which had much better light penetration than neighbouring room 1, due to the higher ceiling height allowing greater penetration. Leveraging higher ceilings and the atria to provide daylight to the darkest parts of rooms would be a significant benefit in future designs. Despite the amount of available daylight in all of the space examined, the blinds were pulled down prior to the survey. Anecdotally, this appears to be to improve the visibility of the interactive white boards and reduce glare. No amount of improved daylighting will assist when the blinds are lowered, hence it is important to carefully layout the space to reduce glare issues.

Examining the energy usage of both schools (see section 6, with Thamesview using up to 42% of annual electricity usage on lighting), it is clear that lighting is a considerable end-use of the building electricity use (although it should be noted that at BACA it has not been possible to separate the lighting and small power). This is despite the considerable control strategies in place to minimise the lighting, presence detection and daylight sensors for example, indicating that the there is a disparity between how the building is currently used and the overall lighting strategy. As noted above, the controls in the classroom do not appear to be reflecting the needs of the teaching environment, hence the closing of blinds and use of lighting, whereas the corridors seem to be highly controlled, but lacking the careful management necessary to operate them efficiently. These issues largely stem from the brief, the design guidance available at the time, and changes to the end use of spaces. Future designs should look to incorporate this flexibility into the design, with schools regularly changing in accordance with varying curricula and booming student numbers.

4 KEY FINDINGS FROM OCCUPANT SURVEY

4.1 Thamesview School

As this study covered two years of occupation at Thamesview School, two annual surveys were conducted. This firstly enabled testing of a new questionnaire, but also allowed the progress of the school to be compared over time.

4.2 Thamesview first survey

The staff at Thamesview School were asked to complete an occupant satisfaction survey based on the BUS survey developed by the Usable Buildings Trust, but incorporating more building aesthetics and school relevant questions. The questionnaire was distributed in paper format on the 14th May 2012 during a teacher training session, and achieved a response rate of 77%, enabling a full analysis of the results collected. The full analysis is in Appendix A2.

Overall, the questionnaire gives a mixed response regarding the building, with general praise for the aesthetics, but concerns over the internal environment, such as air quality and temperatures. The building itself was praised for being pleasant both inside and outside (see Figure 4.1 and Figure 4.2 below), as well as for providing a sociable and friendly environment. Respondents were generally positive about the layout of the building, but were neutral about the classrooms, finding them too public. This was unsurprising, given the number of open plan classrooms provided in the school. The open plan areas appear to have affected the perceived noise intrusion in building, with many respondents noting that most noise occurs as a result of the other spaces in the school. As with many other POE studies into schools, storage was universally rated as too little, with comments indicating that the staff felt they had no storage. Furniture was found to be not robust enough for the teaching environment, but like the fixed teaching equipment, was generally fit for purpose.

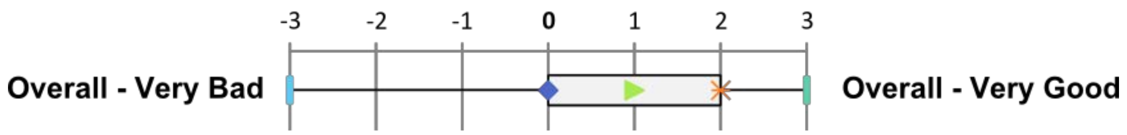


Figure 4.1 - Overall satisfaction with internal aesthetics

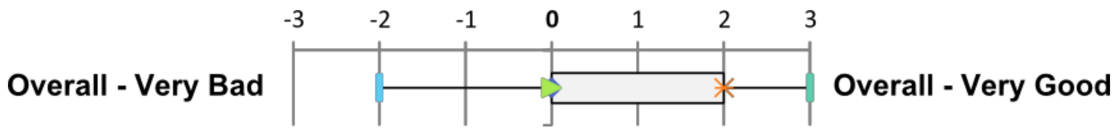


Figure 4.2 - Overall satisfaction with the external aesthetics

Both the winter and the summer internal temperatures were reported to be generally uncomfortable, but with a large amount of variance in the responses, indicating that certain areas of the building are performing better than others in operation. For both periods, the respondents rated the air quality as neutral, with a negative skew, indicating that there are areas where the ventilation appears to be inadequate. This may be related to the uncomfortable temperatures experienced in some of the spaces, as the services for the building include supplying tempered air to some of the rooms. Many of the comments for both winter and summer note that conditions are worse in rooms where there are no windows. This may be related to lack of perceived control when the temperature is not optimum and openable windows counteract this effect. It also suggests that the mechanical ventilation is not performing as needed, with additional air needed. However, overall the respondents were negative about the internal conditions, as shown in Figure 4.3 and Figure 4.4 below.

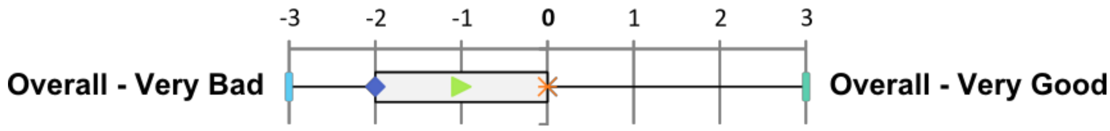


Figure 4.3 - Overall satisfaction with internal winter conditions

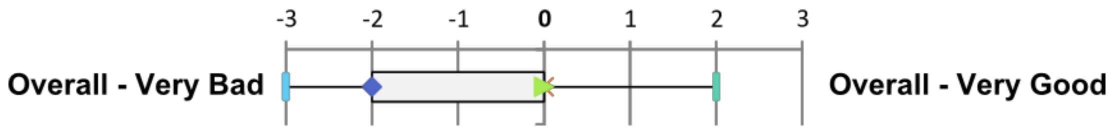


Figure 4.4 – Overall satisfaction with internal summer conditions

Despite the generally negative response to the internal conditions, the overall building satisfaction was rated as neutral, with almost equal distribution across about the neutral point, see Figure 4.5 below. In order to understand which aspects of the building were most important to the occupants, a correlation analysis was undertaken. This produced a list of the most important factors to the respondents overall building satisfaction, with the most important shown in Figure 4.6.

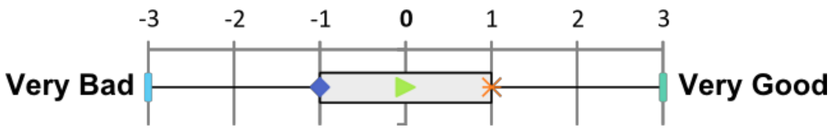


Figure 4.5 - Overall building satisfaction

From the correlation analysis, it can be seen that the most important factors in determining overall satisfaction with the building are the robustness of the furniture, air quality, thermal comfort and the external aesthetics. The furniture and the internal environment are both controlled/maintained by Kier FS, rather than an in-house facilities management team. It may be that the staff have higher expectations of the external facilities management team as the building is a PFI project, or simply an indication that there is not enough dialogue between the staff and the FM leading to less tolerance.

Two major aspects of the building design were referred to throughout the questionnaire by the respondents; the windows (or lack of) and the open plan teaching spaces. In spaces that have no windows, the services are designed to provide enough fresh air and ensure that optimum temperatures are maintained within the space. Many of these spaces were found to be uncomfortable, either due to poor air quality or temperature, however it is not known whether this is purely psychological or the services are not providing the optimum conditions. Further investigation into these spaces will be required to clarify the causes for these responses, which is currently being undertaken by the Kier and the M&E contractor. In addition, the ability to open windows was viewed as useful when available; again there is a well reported link between ability to control the environment and building satisfaction. Whether opening the windows significantly affects the room environment is not known, but occupants appreciate the choice.

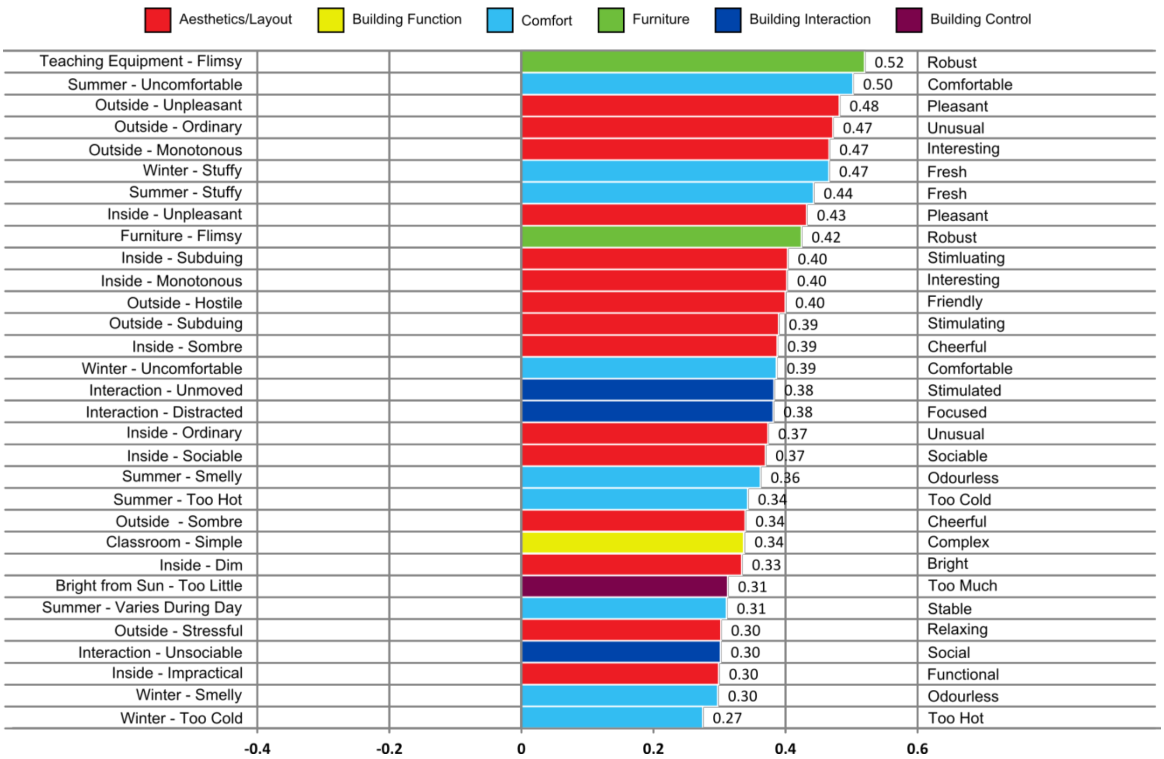


Figure 4.6 - Analysis of the contribution for each question towards overall satisfaction

The open plan classrooms have raised a number of issues, predominantly related to the ease of sound transfer between the spaces. Many of the comments found that the students in these spaces became easily distracted and others reported that noise affected their lessons in these spaces. From discussions with the school, it is known whether careful scheduling of the lessons has been undertaken to ensure the correct balance of teachers and classes. However, it is apparent that the underlying issues of this type of arrangement can only be mitigated to a limited extent. Of particular note is a comment from a teacher that uses a hearing aid that finds the background noise particularly difficult to cope with.

Future efforts should be placed into improving the internal environment, particularly the temperatures of the spaces. Other investigations have shown that the responsiveness of the facilities management team has a direct relation on the perceived thermal comfort of the building occupants. Through improving the link between the school and Kier FS there may be additional benefits of tolerance and satisfaction with the building as a whole.

4.2.1 Thamesview School Second Survey

Two separate occupant satisfaction surveys were undertaken by Thamesview School; a typical BUS survey for the staff and a shorter, bespoke for the students. Both were carried out in mid-June as paper-based questionnaires. The full report is in appendix A3.

4.2.1.1 Thamesview School Staff

The staff were given the BUS survey in the morning of 17th June 2013 and collected back at the end of the day at reception with no prior notification. The staff were aware of the BPE study from the previous questionnaire and the questionnaires were introduced in a staff meeting. A total of 47 responses were collected, from a total of 82 distributed (with a total staff count of 108). The BUS survey is backed by a database of other buildings that have completed the survey, enabling not just comparison to the scale average, but also relative performance to other similar buildings.

The BUS questionnaire found that the performance of the Thamesview School was average, with the comfort in the 53 percentile, satisfaction in the 43 percentile and overall attitude in the 52 percentile, relative to the other buildings in the BUS database (see Figure 4.7, Figure 4.8, and Figure 4.9). These measures are a composite of the other results, illustrating the underlying feeling towards the building rather than the respondents' claimed satisfaction. While this is not a poor result, it is not as good as would be expected with a new building.

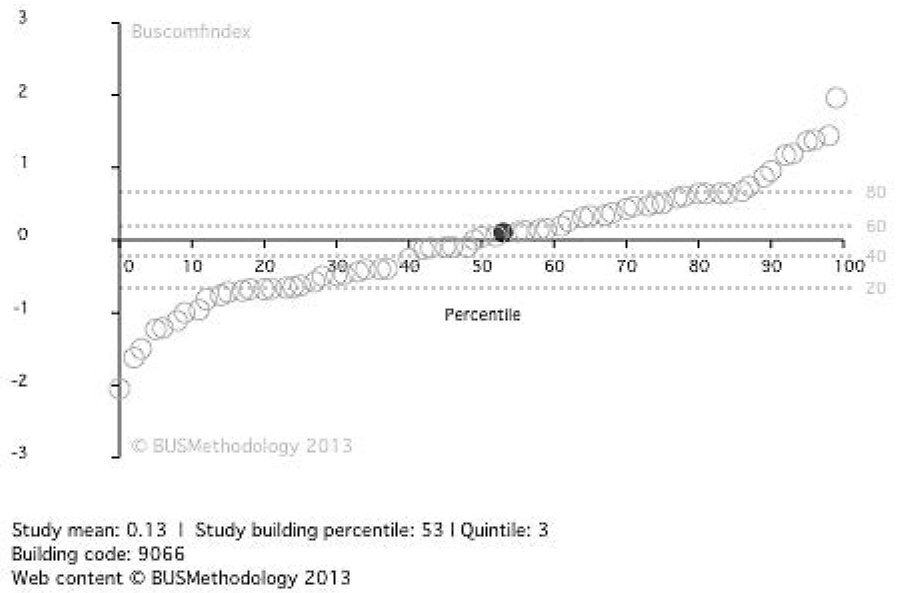


Figure 4.7 – Results of the BUS survey at Thamesview School with regards to overall comfort (source: BUS Methodology 2013)

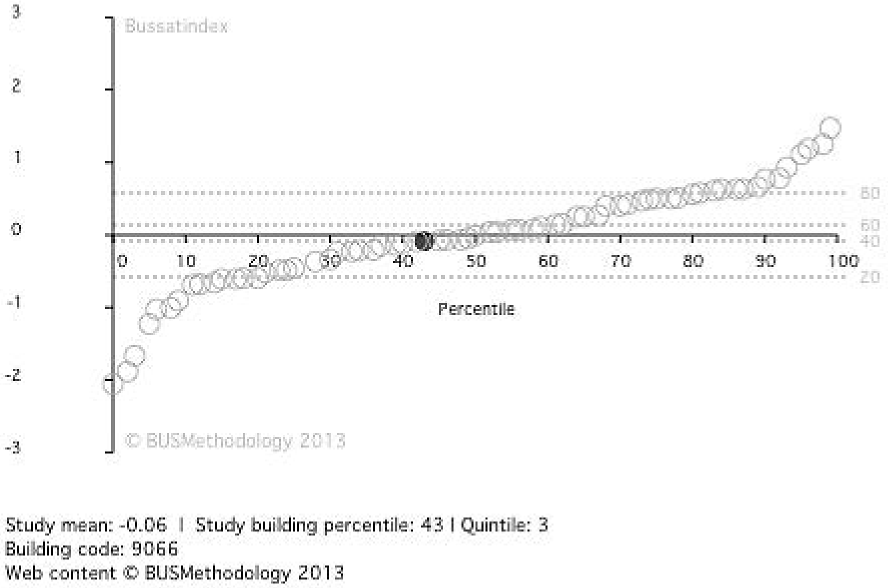


Figure 4.8 – Results of the BUS survey at Thamesview School with regards to overall satisfaction (source: BUS Methodology 2013)

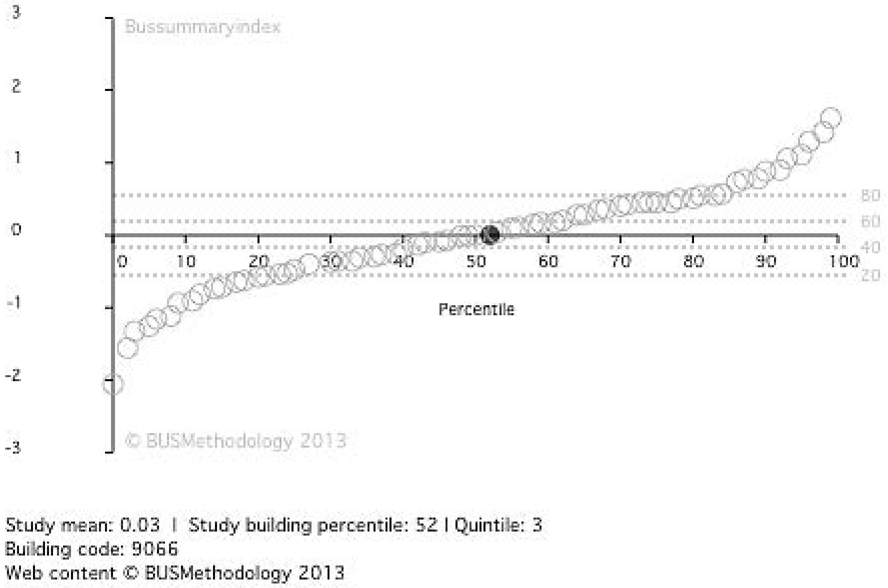


Figure 4.9 – Results of the BUS survey at Thamesview School with regards to overall building feeling (source: BUS Methodology 2013)

The staff at Thamesview did not feel that the building significantly affected their productivity, but they noted that they think the building has a very good impression to visitors and that there was not enough space, either teaching or at their desks (see Figure 4.10 below). All other aspects of the building design and comfort showed no significant results.

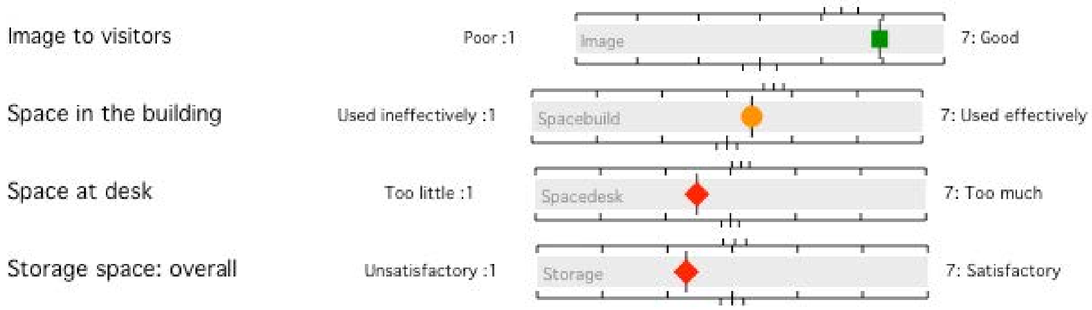


Figure 4.10 – Results from BUS survey at Thamesview showing perceptions of space and image

The air quality in both winter and summer was reported to be too stuffy, with too much humidity in summer. Overall the air quality in winter was rated more satisfactory than the database benchmark, while the summer air quality was found to be poor, in common with the other schools in the BUS database (see Figure 4.11). The thermal comfort was generally reported to be okay in both winter and summer, with the temperatures in winter deemed to be more comfortable than both the database and scale benchmark (see Figure 4.12).

Figure 4.11 – Results from the BUS survey at Thamesview School showing perceptions of air quality

Figure 4.12 – Results from the BUS survey at Thamesview showing the overall perceptions of the thermal comfort

The open plan areas of the school caused concern with the lighting and the noise levels experienced, with too much artificial lighting and too much noise from other people. However, it was felt that there was an acceptable amount of light from the outside as well sufficient amounts of daylight, with both noise and lighting close to the BUS benchmark (see Figure 4.13).

Figure 4.13 – Results from the BUS survey at Thamesview School showing the overall perceptions of the lighting and the noise levels

The facilities management of the building had mixed reviews, with the building rated as very clean, over and above the BUS database benchmark, however those that had requested a change found that the response could be more satisfactory (although it should be noted that only 12 of the 47 respondents had made requests for changes).

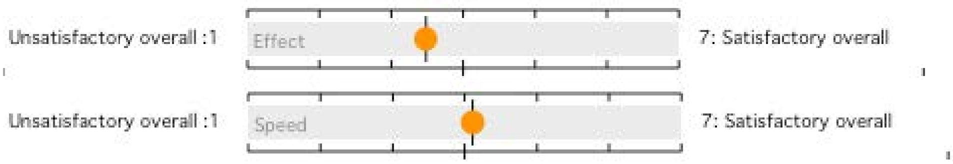


Figure 4.14 – Results of the BUS survey at Thamesview School with regards to the effectiveness (top) and speed (bottom) of the facilities management.

4.2.1.2 Thamesview Student survey

The student questionnaire was distributed to one school of students, covering one quarter of the students within the whole school, across each year group (excepting year 11). The questionnaires were handed out over the period of one week, commencing 17th June 2013, with time set aside in the tutorials for the students to complete and return the questionnaires. A total of 156 students responded, out of maximum of 751 (including the year 11), with a roughly even mix of boys and girls (47.5% girls to 52.5% boys).

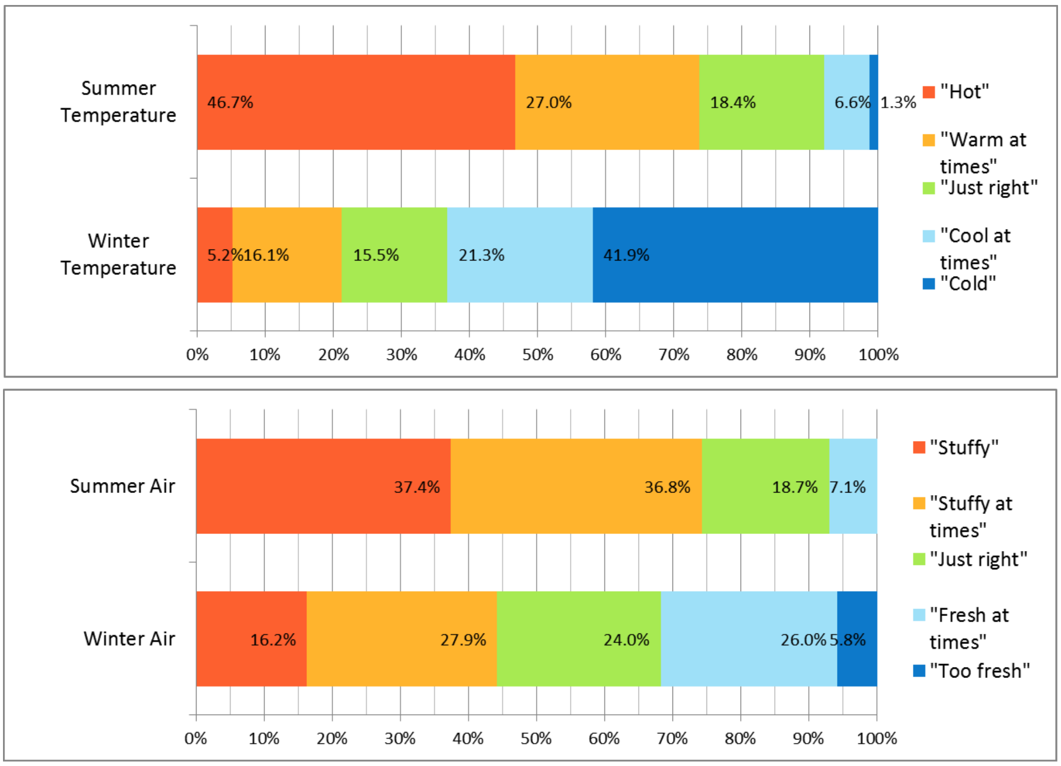


Figure 4.15 – Graphs showing the students' response to the winter and summer internal environment

The responses from the students to their internal environment, in Figure 4.15 below, show that the during the summer months the school was felt to be hot and stuffy. Conversely, during the winter they found the temperature too cold, but the air quality just right. This suggests that although the ventilation is working acceptably during the winter months, when the temperature rises, the rooms are quite stuffy. This is likely related to the heavy dependence on mechanical ventilation in a number of spaces, where it may not be working optimally. It is important to note that while the students have shown clear responses to the winter and summer environments, there might be a possibility that a certain portion of students might be giving the answer that they expect, rather than the answer they feel. During the winter, the spaces have not been particularly cool, so some of the results may be down to the students giving expected answers.

The students gave a mixed review of the building, with both good and bad aspects of the building identified, giving a mean average of 2.46, slightly less than 2.5 mid-point for the scales used. The overall results for the student survey are given in Figure 4.16 below, with the median response given at the 50% point shown on the graph. As can be seen, the students were very positive about the way-finding, dining area, utilisation of the circulation spaces during breaks and being able to hear the teacher. It is interesting to note that the students found that they were able to hear the teacher well, given the open-plan teaching areas and the poor acoustics within these areas. This is in contrast to the responses from the teachers, who felt that the open plan spaces made it difficult to teach. It is also encouraging to observe that the students found the school easy to navigate and used the break-out spaces and the dining areas well.

However, the students also found that there was excessive noise from outside of the class, the furniture was uncomfortable, the building is crowded during breaks, and the toilet was unpleasant. It is of interest that although the students felt that there was excessive noise from outside the class, they did not feel that they could not hear the teacher, perhaps indicating that the noise is a distraction rather than an issue of comprehension during lessons. The furniture was rated as uncomfortable, with many noting that they found it uncomfortable in the comments. Despite the extensive use of the circulation spaces during breaks, the students still felt that the school was too crowded during these breaks, particularly when the weather was inclement.

The students also noted that the breakout spaces weren't widely used during lessons for additional learning activities, despite this flexible teaching approach been part of the designed use of the building. There was also little clear response as to whether the school had a positive influence on them as students, although this may be just due to a lack of understanding of the question rather than a true lack of positive influence.

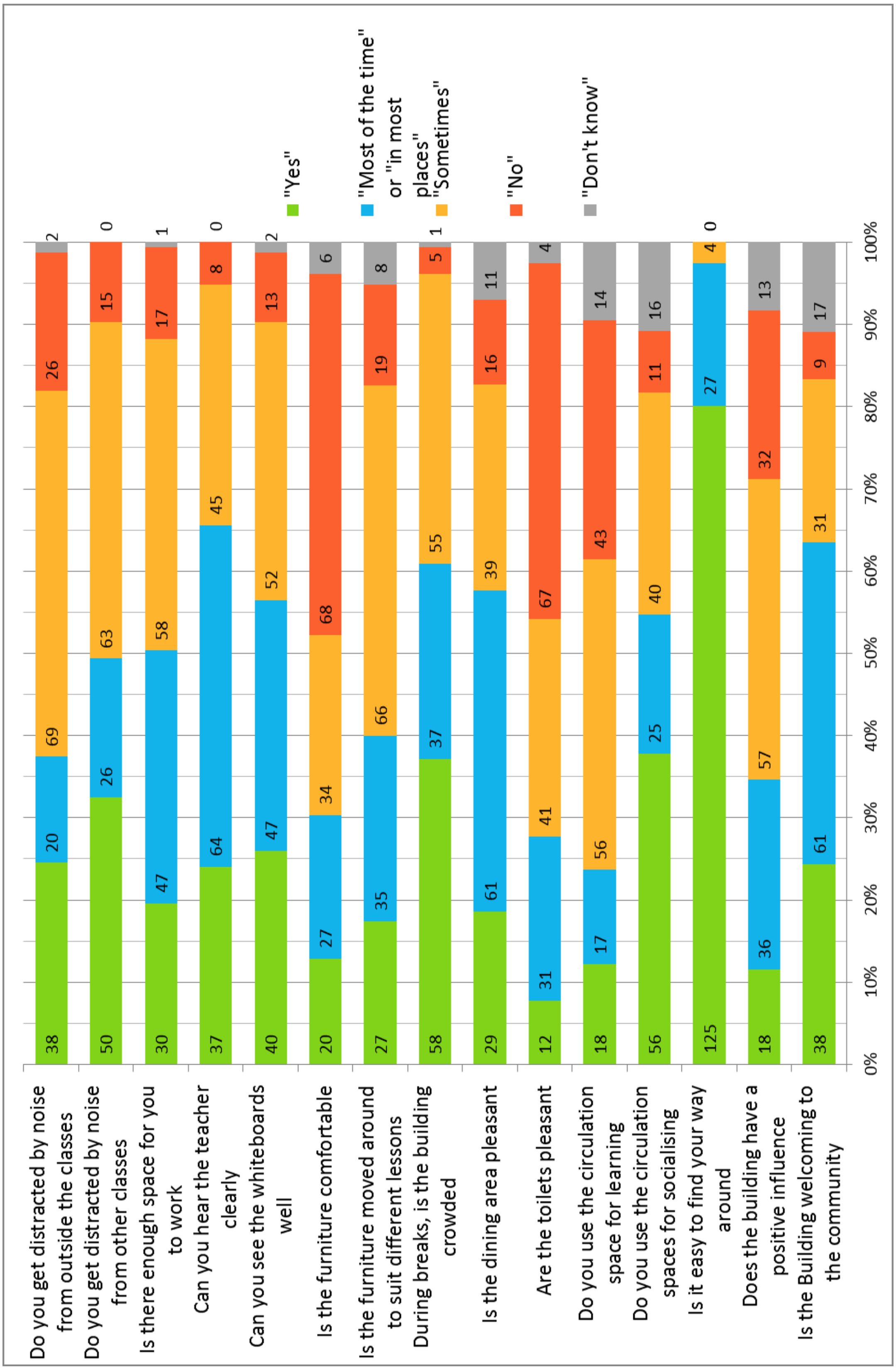


Figure 4.16 – Breakdown of the responses to the general aspects of the schools given by the students (note the numbers on the bar represent the number of responses, not percentage)

4.2.2 BACA Staff Survey

BACA staff were asked to complete an online bespoke questionnaire regarding their, building, based on the successful BUS survey developed by the Usable Building Trust by adding aspects of aesthetics and teaching to the survey. At the request of the school, the survey was developed online and sent out in a daily bulletin to all members of staff on the 20th June 2012. The full report can be found in Appendix B2. Despite the wide circulation, only 24 members of staff completed the questionnaire fully, too few to enable full correlation analysis of the questionnaire.

Overall, the occupants of the building have given a mixed review of their building, with the occupants keen on the aesthetics and layout of the building, but there are clearly issues with the internal conditions, particularly the temperature and the air quality.

The layout of the building was rated as both intuitive and clear, with many of the respondents noting that the routes are relatively clear during transition periods. The open spaces assisted the feeling of spaciousness and brightness, but in the comments the occupants described how these spaces were under-utilised. The teaching staff should be encouraged to use these spaces in addition to their standard classrooms, allowing much more flexible teaching approach.

From the comments, it is apparent that the layout of the science classrooms is not optimal, with many comments highlighting the science services are located around the edge of the classroom. This caused the students to work with their back towards the class and the teacher, disrupting supervision. Future designs need to ensure that science classroom services are equally spaced throughout the class, allowing for simple supervision.

Within each department, the staff seemed pleased with the level of interaction the building encouraged. However, the level of interaction between the departments was felt to be difficult due to the lack of a dedicated staff space. This difficulty can be reduced through encouraging teacher interaction across department, perhaps by putting in place a formal structure to support this open discussion in addition to any that currently exist.

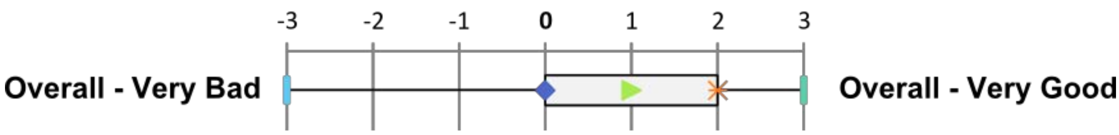


Figure 4.17 - Overall satisfaction with internal aesthetics

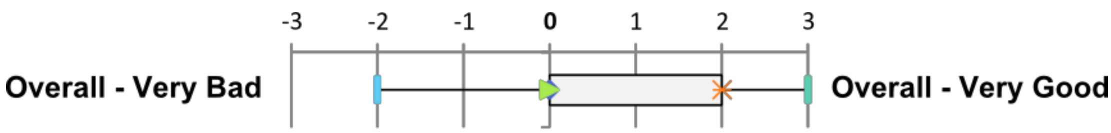


Figure 4.18 - Overall satisfaction with the external aesthetics

With regards to the building aesthetics, the occupants thought that the interior and exterior are pleasant and beautiful, with the building appearing bright and friendly. The interior was felt to be predominantly colourless, attributed to the plain white walls and the lack of students work on display

Overall, both the internal and external building aesthetics were rated as good, as shown in Figure 4.1 and Figure 4.2. Enabling the display of the students work will brighten the space and a number of the occupants thought that this would also make the building look friendlier. This appears to be a key feature for the staff and should be implemented in future school designs, enabling the building users to take greater ownership of their building.

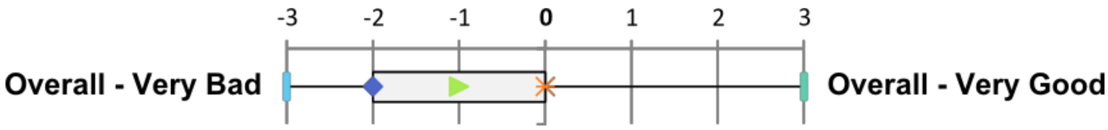


Figure 4.19 - Overall satisfaction with internal winter conditions

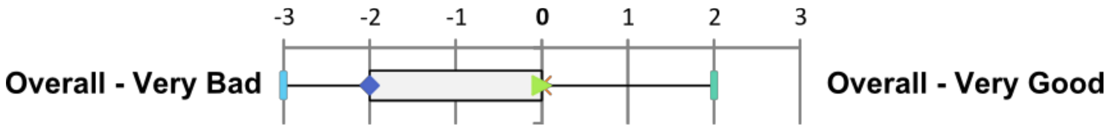


Figure 4.20 – Overall satisfaction with internal summer conditions

Holding the building back is the poor performance of the internal conditions, caused by the settling-in period of the building and the on-going defect rectification. This has manifested itself in the summer, winter and overall internal condition ratings shown in Figure 4.3, Figure 4.4, and Figure 4.5 respectively. This, coupled with the facilities management team still learning the new systems, has led to difficulty in controlling the internal temperatures and air quality. Further time is required to investigate the control systems and encourage the team's confidence with the systems they have currently installed.

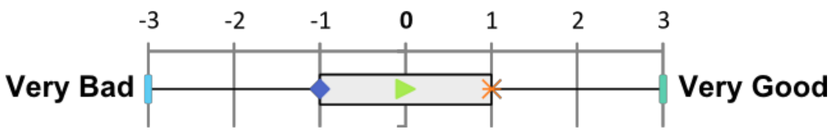


Figure 4.21 - Overall building satisfaction

4.3 Summary

With both schools, the overall feeling towards the building is split, with feelings towards the layout and aesthetics generally good, but the internal environments as not performing well. Thamesview in particular was rated overall around the 50th percentile within the BUS database (see section 4.2 in appendix B). In both schools the layout were found to be intuitive and easy to navigate, with the wings within the school appearing to work well. Both buildings were found to be appealing to visitors, but it was felt that the school could be more colourful and bright, particularly at BACA. This would be assisted by providing more space for students to display their work, encouraging ownership of the spaces and the affinity that brings with it.

Despite the overall positive feelings towards the layout, the open plan teaching areas in both schools produced some negative feedback; in fact BACA has converted the open plan area to a bilingual free school due in part to the difficulty teaching in those spaces. These deep plan spaces were felt to be too noisy and created distractions from neighbouring classes. This is hindered by the poor acoustics and the change in teaching style from the design; moving from a central class with distributed group working spaces to multiple classes using the space concurrently.

The science classrooms were felt to be laid out incorrectly at BACA, with the science apparatus (gas taps, sockets, etc.) laid out along the perimeter wall, which causes issues when used as it is difficult to monitor the students when conducting experiments. At Thamesview School, the science equipment was felt to be 'flimsy', with not enough space in the science preparation room. Building on the issue of fixtures, fittings and equipment, the occupants at Thamesview, both the staff and students, felt that the furniture was inappropriate, either uncomfortable or not suited to teaching (for example odd shaped tables), despite the rigorous selection process with the school.

The internal conditions through both schools were felt nearly two thirds of occupants to be too hot and stuffy in summer, and too cold in winter. While there is always a bias towards the extreme temperature events when remembering conditions, this is still a considerable amount of each school. Overheating is common in new schools due to the high-levels of insulation, but when this read in conjunction with the perceived stuffiness is an indicator that the ventilation systems are not working correctly. This may be through a misunderstanding of the how the fresh air systems work, but even so the mixed-mode ventilation systems should provide the correct environment. In contrast, the cold temperatures in winter indicate that the heating system is not functioning correctly. At BACA much of this is related to the difficulty of the fresh air supply and the underfloor reaching a suitable temperature. At Thamesview this is linked to particular zones, notably the art room on the second floor and the drama studio. In the art room this is caused by the low flow in the LTHW system serving this area and the poor AHU service, similarly the drama studio has issues caused by poor heating and ventilation, compounded by poor quality external doors. At both schools, Kier is actively investigating both the heating and ventilation systems to improve their performance.

Apparent from the surveys at Thamesview is that the attitude has not changed considerably over the study period, with outstanding issues still apparent. It should be noted that the majority of the aspects rated poorly were those managed by Kier FS rather than the school. While it was generally found that the school and the Kier FS work well together, further collaboration would be beneficial to reduce any feelings of separation and hence negativity.

5 DETAILS OF AFTERCARE, OPERATION, MAINTENANCE AND MANAGEMENT

This section examines the day-to-day running of the building, aiming to understand the relationship between the design and the end-use.

5.1 Thamesview School

Thamesview School is operated and maintained by Kier FS as part of a PFI contract with two other local schools. The facilities team is spread across the three sites, with one permanent member of staff based at Thamesview and the central office based at Northfleet Academy. Any changes to the school environment requested by the school, have to be passed through the helpdesk, located in Northfleet Academy, with items for procurement necessitating sign-off prior to purchase. Any changes to the building that are not directly related to the on-going maintenance of the building are re-billed to the school as an extra cost.

5.1.1 Maintenance

Maintenance logs for Thamesview School are not available due to confidentiality reasons, but from discussions with the maintenance team and examination of the O&M manual, the maintenance appears to be conducted well. The FM team at this site also maintain two other local schools and Thamesview School is considered to be the easiest to maintain of the three, due to a combination of build quality and the accessibility of the systems installed. The maintenance schedule is logged in a central system, using the O&M maintenance schedule as a start point, which generates the required maintenance activities as required. In addition, the FM office has a daily schedule on a notice board covering the weekly maintenance requirements and one-off events (such as changing the layout of a room).

As there is a very formal process for requests from the school, it is encouraging to see the good working relationship between the school and the FM, with the flexibility of the FM staff helping considerably. It is often seen that the responsiveness of the FM is directly linked to the occupant satisfaction, which is likely more extreme in PFI buildings where there is separation between the working groups. It is encouraged that the FM and school carefully maintain this relationship to ensure the success of the building.

Despite the general accessibility of the services installed, a serious concern is that a number of the ductwork fire-dampers have limited accessibility due to poor coordination with other services, hindering the required regular maintenance. This has been exasperated by the use of internal fire dampers rather than externally accessible dampers, necessitating clear space to get into the access hatches. In addition, the use of access hatches into the ductwork to service the fire dampers have led to hatches been left open, preventing the fresh air reaching its intended destination. This has significant implications on the integrity of the building fabric and has since been rectified to ensure that they are all serviceable. It should be noted that the decision to use the internally accessible dampers rather than externally accessible dampers has greatly reduced the maintainability of these critical systems.

As this is a PFI project, there is a close relationship between the construction and facilities management aspects of Kier. There are still a number of issues that are being repaired as a defect by Kier construction rather than as a maintenance issue by Kier FM. This situation has created a confusing, and sometimes, protracted maintenance process in places, with variable results. It is suggested that the current procedure for identifying/rectifying defects could be simpler to ensure that the building takes priority, or perhaps formally ending the defect period to bring the process within the FM team's responsibility. This is particularly difficult for the school, which appear to have little control over the defects process other than raising the issue initially.

5.1.2 Operation

The services within the school are operated using a central BMS system, which is discussed in more detail in section 7. Generally, the system is used by only one member of staff, the mechanical specialist that works across the three sites that form part of the Kent BSF programme (Northfleet Technology College and St John's Comprehensive School are the other two schools), with the other FM staff unsure of its operation. As such, it does not change unless a specific request is made to the Kier helpdesk. While this does not create a responsive system, it does ensure that all issues are logged in the central system. It is not known whether this log of requests is analysed for trends as it was not available, but it would provide a good insight into the type and frequency of issues encountered.

In spite of the lack of interaction with the BMS, the services timeclocks are setup to closely resemble the occupancy pattern found from the occupant questionnaire (see Figure 5.1). These timeclocks controls all the mechanical services; constant temperature and variable temperature heating, hot water and ventilation, with each teaching wing and central plant set to the same profile. It should be noted that although the different zones are set to the same profile, they are not linked, with each zone able to be set to a different profile. In practice, this has not been implemented, with any effective zoning of the heating system preventing the zones to be run truly independently. Outside of the heating season, when the external air does not need tempering, this zoning could be implemented to reduce the energy consumption. In addition, the services profile could be reduced to switch off at 17:00, rather than the current 17:30, reducing heating use by up to 5%. The temperature profiles of the building show that the temperature typically only drops by 2°C overnight (see Figure 5.2), thanks in large part to the good insulation and air tightness, so a reduction in heating operation by half an hour would have no adverse effects.

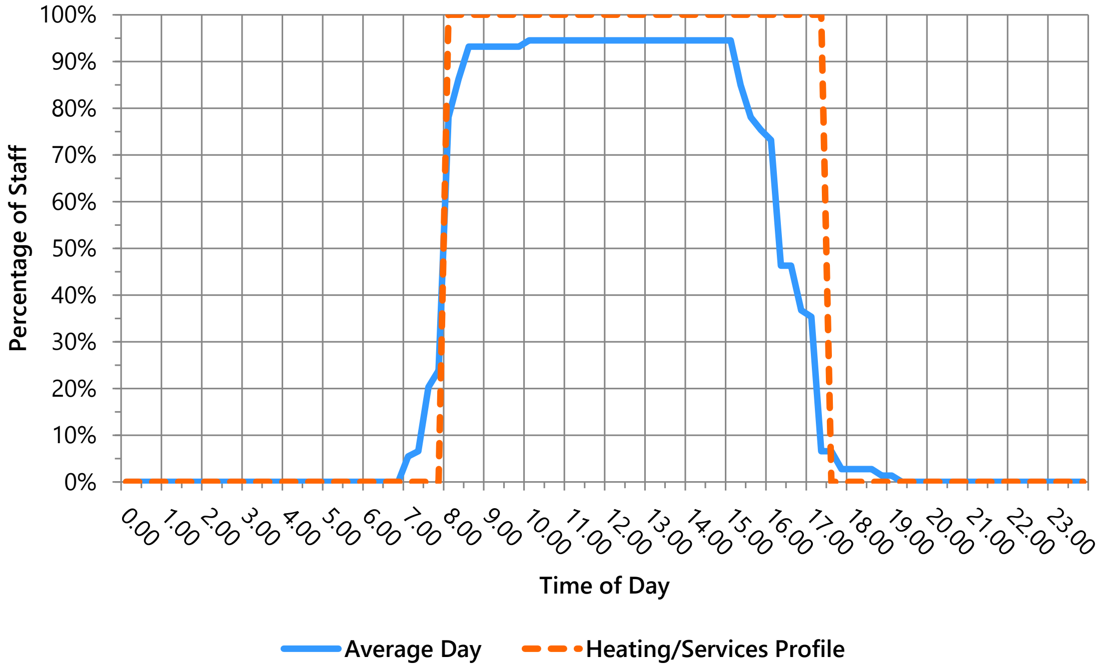


Figure 5.1 – Graph illustrating the occupancy profile from the occupant questionnaire compared to the BMS services profile

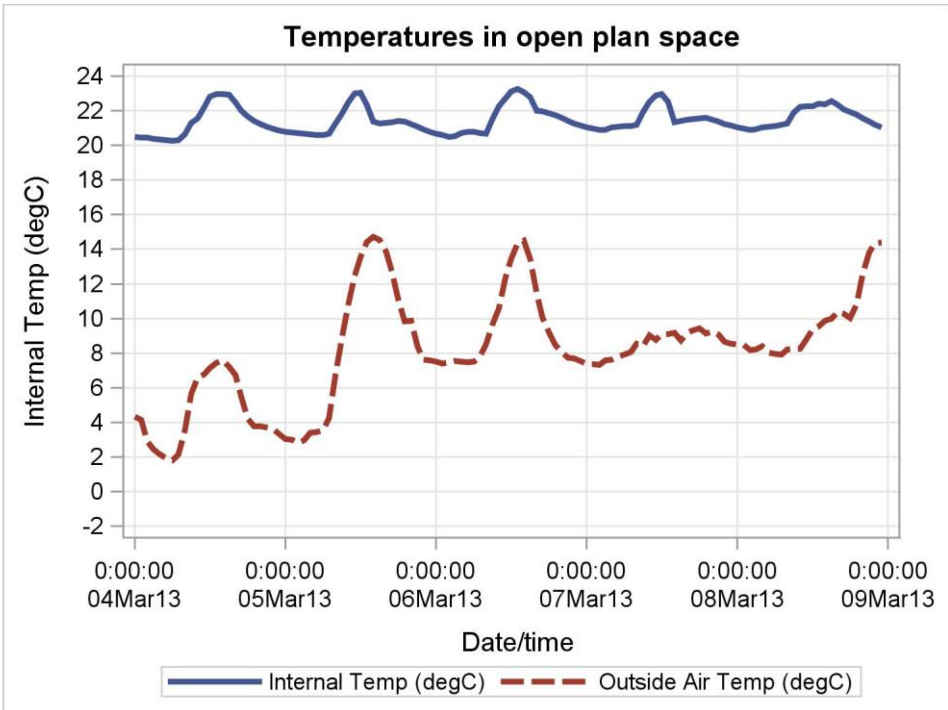


Figure 5.2 – Typical temperatures across a working week within an open plan teaching space

As part of the investigations into the internal temperatures, it became apparent that the timeclock profile is for the occupied time, with an optimiser to ensure that the building is up to temperature by the occupied time. However, the optimiser has been operating the ventilation systems and heating systems at the weekend, when the building is largely unoccupied. While it may be beneficial to heat the building briefly during the weekend, it is not necessary to bring in fresh air as there are no occupants. The optimiser is largely there to ensure that the building is up to temperature prior to occupation and as such it is general not necessary to use optimise the ventilation systems. As such, the optimising system is currently under review, along with the rest of the BMS, to ensure that it is correctly optimised and interrogatable remotely.

5.2 BACA

BACA is operated and maintained by the academy trust, with assistance from Brighton and Hove City Council. Onsite maintenance staff are led by a facilities manager that joined four months after the new school opened. The original facilities manager left the academy following the handover, having been through the whole design and construction process, including the handover training.

5.2.1 Maintenance

BACA has a specialist maintenance contractor that assists with scheduled and emergency maintenance of the services on site. General site maintenance is carried out by the on-site caretakers, overseen by the facilities manager. The specialist contractor works to a predetermined maintenance schedule, reflecting the maintenance schedule supplied by the main contractor and the experience of the specialist maintenance contractor. This contractor was appointed prior to the handover and was able to attend the training sessions, improving their knowledge of the systems and thus the effectiveness of their maintenance. Due to the complexity of the services installed at BACA, it is important that the systems receive specialist support from the very start of occupation, ensuring that the warranties of the equipment remain valid.

Overall the building has not required excessive maintenance, but there have been a number of key problems that are maintenance issues; namely the white walls throughout the school. It has not been possible to clean marks left on these walls, instead they have to be repainted when the marks get too much. This is a particular problem in the hall where the chairs rub the wall and no protection has been provided.

Another recurring issue in the school are the doors along main corridor on both the first and second floor. These large double doors swing in both directions, but when locked only lock at high level. There have been a number of these locks breaking due to the doors being pushed when locked, with the single point of locking not enough to prevent the door moving.

There is an on-going defects rectification process that is addressing many of the problems identified. However, this is an extended process that is taking prolonging some of the issues with the building, such as the BMS. Where issues are identified as urgent, such as the legionella risk, or clearly an error, like the overall timeclock, the aftercare team have been quick to intervene. For larger issues, as with Thamesview, the solution can take considerable time to be forthcoming.

5.2.2 Operation

BACA is predominantly operated from the central BMS located in the FM office. However, this system has a number of deficiencies, noted in section 7.2 and there have been a number of problems with maintaining the correct conditions in the building, most notably in the main hall. This area is heated by the underfloor heating system, and fresh air is supplied from a central AHU that also provides make-up air to the kitchen. It was found that there was competition of the services, with the fresh air supply unconditioned as it was labelled as serving the kitchen only, and the underfloor heating running at as high temperature as possible. This has been manually rectified with the thermostat for the underfloor heating set to match the incoming air temperature.

There was a significant legionella risk surrounding the domestic hot water temperature, with the systems incapable of maintaining the temperature above 60^{o}C, despite the system being commissioned and checked. In order to rectify this, the system now routinely heats the whole system up every week, early in the morning (3am), to prevent any legionella risk. Without adequate metering of the boiler gas usage or heat meters recording the domestic hot water, it is difficult to comprehend the energy implications of this strategy. However, it is likely more efficient than running the system at a higher temperature throughout the day and using the thermal-mixing valves blend the water to a lower temperature.

Of greater operational concern is the operation of the underfloor heating, which in order to heat the spaces (the corridors and the hall), needs to operate at 3am, enabling suitable pre-heat. However, the whole heating system at this point becomes operational, using a substantial amount of energy. As with the rest of the heating system, it was not possible to analyse the energy use due to the poor metering, however it is possible to estimate the additional energy used as a consequence of the underfloor heating strategy. The heating is needed for 9.5 hours a day, starting at 7am for preheat of the variable temperature circuit (serving the radiators). This translates to an additional 4 hours of heating when the underfloor heating starts preheating, or 42% longer than otherwise. Assuming that the underfloor heating accounts for 25% of the overall heating load (based on the floor areas only), this means that 31% of the overall heating load is unnecessary (i.e.: the four periods where the rest of the heating system runs). As such, should the underfloor heating be separated from the rest of the system, a reduction of up to 31% could be expected on heating energy.

Due to the addition of the bilingual free school in one of the teaching wings, there has been a knock-on effect on the automated window openers. It is necessary to shut the windows when the free school pupils are outside at break to prevent distractions to the ongoing academy classes. Unfortunately, the BMS does not have the necessary flexibility to prevent the automated windows from opening, necessitating manual intervention by physically disconnecting the window actuators. This is an unforeseeable scenario, but the latent complexity of the systems makes adapting the systems prohibitively difficult without specialist assistance.

5.3 Summary

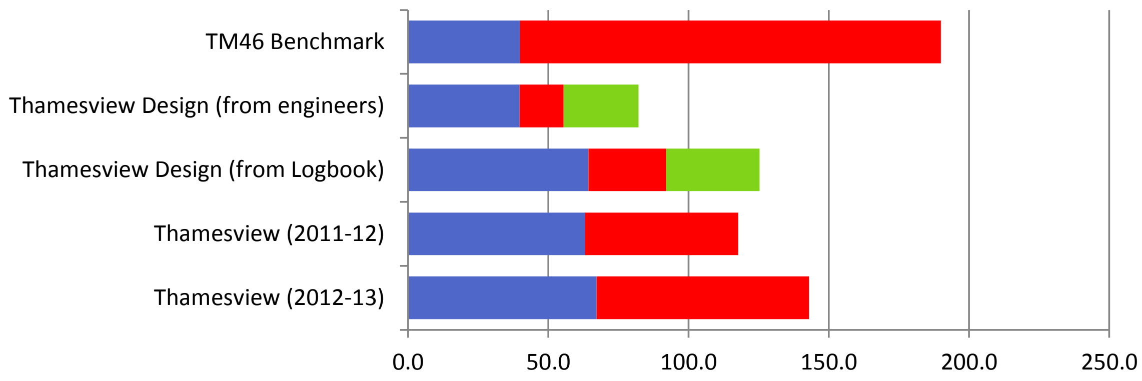
Both buildings have suffered from issues relating to the defects period, with extended rectification times hampering the overall building quality. While significant work has been undertaken at both schools to rectify underlying issues, the process of apportioning fault and then commencing work for non-urgent work has impacted on the attitude towards the building from the occupants (particularly at Thamesview School) where the PFI arrangement has compounded the issue. An improved solution would be to extend the handover period, through a process similar to Soft Landings, where the defects can be dealt with entirely by the contractor, reducing the need to establish fault. It should also be clear that the FM at each school needs to rigorously log changes to the building that they have made, so as to facilitate simple causality of problems as they occur.

In terms of building operation, Thamesview School is largely working well, but is hampered by the lack of zoning within the heating systems. The decision to run the ventilation systems at the weekends to ensure the building is at optimum internal conditions on Monday morning does not appear to be the most efficient method, and different methods should be explored. .Similar to Thamesview School, the heating systems at BACA are not sufficiently separate to enable the underfloor heating to preheat without heating the whole building. While this was designed to specification, it has a clear knock-on effect to the overall energy usage that future designs should avoid. At both buildings, the sheer complexity of the systems has presented operational problems in situations that should be straightforward; setting when they switch on and off. While both schools are actively improving their systems and controls to reduce their energy use, future designs should sufficiently account for the complexity of controls needed.

6 ENERGY USE BY SOURCE

6.1 Thamesview School

At Thamesview School, energy data was collected for two year, covering the period of the DPE study. Figure 6.1 shows how Thamesview School compared against the CIBSE TM46 benchmark, used within the Display Energy Certificate (DEC) methodology, and the design calculation from the engineers and logbook. In both years of the study, Thamesview School used less energy than the benchmark, but more than the engineers designed energy use. Two sets of design data were provided; one from the logbook (their operational targets), and one from the M&E engineers. The initial design data from the engineers showed substantially lower energy use that the data from the building logbook. It is not known where this discrepancy has arisen from, although the design data from the engineers was from dynamic simulation, whereas the logbook broke down the energy by sub-meter, indicating that it had been calculated using a different method. It is also noticeable that during this study, the energy consumption of Thamesview School increased compared to the initial year, largely caused by the harsh winter during the second year.



	Thamesview (2012-13)	Thamesview (2011-12)	Thamesview Design (from Logbook)	Thamesview Design (from engineers)	TM46 Benchmark
Elec kWh/m2/annum	67.3	63.1	64.3	39.8	40.0
Gas kWh/m2/annum	75.7	54.7	27.7	15.6	150.0
Biomass kWh/m2/annum	0.0	0.0	33.4	26.7	0
Total kWh/m2/annum	143.0	117.8	125	82.2	190.0

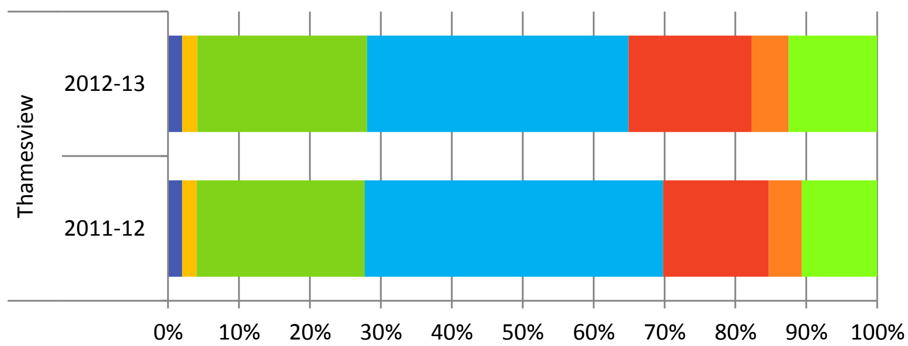
Figure 6.1 – Graph showing the actual and design energy use for Thamesview School

In the period July 2011-12, the were 1880 heating degree days, compared to 2369 heating degree days for the period July 2012-2013 for the South East. Assuming 20% of the gas is used for domestic hot water, a predicted gas usage of 66.1 kWh/m^2/annum, still lower than the actual usage of 75.7 kWh. This additional gas usage was not reconcilable due to the lack of metering within the building, but is believed to be linked to the difficulty in balancing the LTHW system following some changes to radiator layouts. The system has since been recommissioned to ensure all the areas do get hot, as required.

6.1.1 Energy Breakdowns

At Thamesview School, sub-metered electrical energy data was available, with no reliable sub-metering for the heating systems (either gas or heat meters). As such, this section will focus solely on the electrical usage, which has the largest influence on the carbon emissions. A full report into the energy use at Thamesview is available in Appendix A4, along with the TM22 workbook. The electricity readings from the submeters at Thamesview have been verified, ensuring that they are matching the incoming utility meter. At Thamesview School, the individual submeters were checked physically and from the BMS head end, ensuring that the meters were being read correctly. The data from Thamesview was from the BMS head end, following verification

In both years of Thamesview School's data, it clear that the largest end use of energy is lighting, followed by services and then small power, as seen in Figure 6.2. Given that very few of rooms have no access to natural light, and circulation areas being well served by roof lights, it is somewhat surprising that the lighting is the main energy use. However, each circulation space is controlled by daylight monitoring and presence detection which is not correctly set-up, with lighting being operational when not needed. In addition, some of the rooms do not have over-rides for the lighting circuit, relying on the presence detection to control the lights, as per the design brief. In the open plan areas, which are very deep plan, many of the teaching areas are separated by large screens and furniture, inhibiting the daylight in those spaces.



	Thamesview	
	2011-12	2012-13
Fans kWh/m2/annum	2%	2%
Pumps kWh/m2/annum	2%	2%
Services kWh/m2/annum	24%	24%
Lighting (Internal) kWh/m2/annum	42%	37%
Small Power kWh/m2/annum	15%	17%
ICT Equipment kWh/m2/annum	5%	5%
Catering - Central kWh/m2/annum	11%	12%

Figure 6.2 – Electrical energy use by end-use at Thamesview School

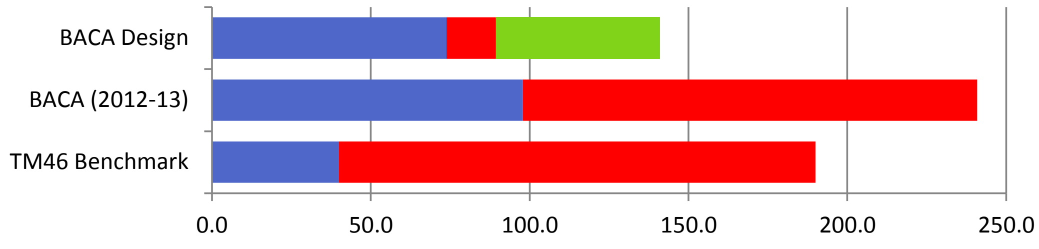
The services, along with the fans and pumps, use 28% of the overall energy use. This is largely due to the mechanical ventilation system and its associated components. It should be noted that there was little change between the years, as these systems are directly controlled by the BMS, which has remained largely unchanged. The mechanical ventilation routines are designed to operate during occupied hours, regardless of the internal environment, with only the supply air temperature modified to meet the demands. Although an optimiser is installed within the BMS, little evidence of its operation exists, with the only noticeable change occurring during the weekends, where the air-handling units have been operating unnecessarily. Despite inverters been installed on all fans and pumps, the BMS treats these units as typical pumps, with no attempt at modulation, increasing unnecessary energy use.

ICT has little impact on the overall energy load, with only one main server room, and much smaller network points distributed in each school. However, there is no separate monitoring of the ICT suites or laptop charging points, which instead are covered by the small power load. This small power load accounts for between 15% and 17%, with considerable scope for reduction through simple management of energy users, such as reducing the usage of laptop charging points though the installation of time-clocks to the plug.

The slight increase in electrical energy usage during the second monitored year is attributable to the increase in small power load, with the cold winter requiring the use of electric heaters in addition to the main heating.

6.2 Brighton Aldridge Community Academy

Energy data for BACA was collected during this BPE study with one year for BACA of electricity and gas data collected. Figure 6.3 shows how BACA compared against the CIBSE TM46 benchmark, used within the Display Energy Certificate (DEC) methodology, and the design calculation from the engineers. BACA was found to be using substantially more than both design and the benchmark, caused by the significant gas usage compared to the design (compounded by the lack of available biomass for much of the operation period). This high gas usage is due to the necessity to run the underfloor heating for extended periods, while at the same time the rest of the constant temperature circuit is heated.



	TM46 Benchmark	BACA (2012-13)	BACA Design
Elec kWh/m2/annum	40.0	97.9	73.8
Gas kWh/m2/annum	150.0	143.0	15.6
Biomass kWh/m2/annum	0	0.0	51.6
Total kWh/m2/annum	190.0	240.9	141.0

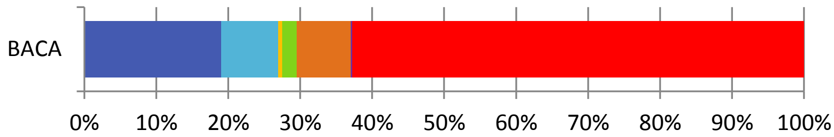
Figure 6.3 - Comparison of actual and design energy use

6.2.1 Energy Breakdowns

At BACA, due to inadequate sub-meter monitoring by the BMS, manual electrical meter readings were taken over a 6-month period to enable further understanding of the energy consumption. As such, this section will focus solely on the electrical usage, which has the largest influence on the carbon emissions. The electricity readings from the submeters BACA have been verified, ensuring that they are matching the incoming utility meter. The data from BACA was collected by manual weekly inspection of the meters, which were subsequently entered into a spreadsheet.

6.2.2 BACA

Energy usage at BACA has been difficult to understand given the nature of the metering strategy, with no separation of the lighting and small power. Figure 6.4 shows that almost 63% of the energy is unaccounted for, being split between small power and lighting. At Thamesview school a similar figure of 66% of the energy use was for small power and lighting, so it not unusual for such a high energy load to be associated with these systems. Again, BACA uses automatic controls (both daylight and occupancy sensing), so it has the same control issues. With the large amount of external glazing and rooflights, it is unfortunate that the lighting is using so much energy. Throughout the school are a large number of PCs that remain on throughout the day and evening, with no automated shutdown. There are four ICT server rooms, each with air conditioning and large server racks, supplying the intensive ICT requirements of the school. Given the scale of the ICT, it is apparent just how much the rest of the building for this to be such a small contribution.



	BACA
Services kWh/m2/annum	19.0%
ICT kWh/m2/annum	7.9%
External Lighting kWh/m2/annum	0.6%
Plant room ancillary kWh/m2/annum	2.0%
Kitchen kWh/m2/annum	7.5%
CIBCAS Centre kWh/m2/annum	0.2%
Other kWh/m2/annum	62.8%

Figure 6.4 – Electrical energy use by end use at BACA (It should be noted that the CIBCAS centre is a neighbouring centre that provides adult education)

In order to target high energy use, the energy usage was mapped onto the layout plans of the school to see if there were particular hot spots. The overall contribution of each zone can be seen in Figure 6.5, with the kitchen clearly visible (marked 01), and the entrance lobby and first floor library area clearly using more than the other areas (marked 04 and 24 respectively). It is not known why these areas use so much more than the others, but these are continuously occupied areas with a large number of PCs and large areas of circulation lighting. As seen within the Thamesview energy data, the lighting accounts for a considerable amount of the overall energy usage, so it likely that lighting is the root cause of the high energy usage. It should be noted that the kitchen uses a considerable amount of energy largely due to the number of refrigerators present, which operate continuously throughout the day.

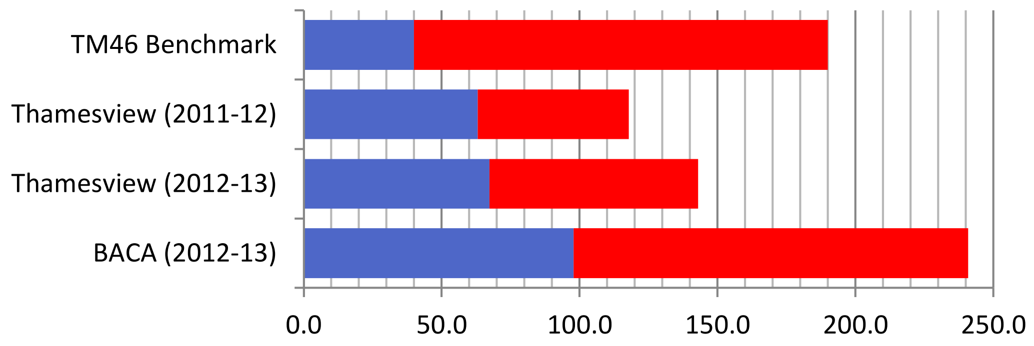
Further investigation into the energy usage of the PCs was undertaken, with the PCs in one zone switched over night (zone 21 in Figure 6.5), and then compared to a night with the PCs left on standby. With the PCs left on (although going into sleep mode after 30 minutes of idle time), the zone used 37 kWh overnight (between 1500 and 0700), and when turned off the zone still used 34 kWh. This is concerning as the considerable amount of energy usage within the building is from either small power or lighting. This zone was chosen due to the high number of PCs and high energy usage. The very small difference to the overnight energy suggests that there is something else within the zone using the energy. Given the high energy use by the lighting at Thamesview, it is likely that the lighting is contributing to the high energy use during the day, but in the evening it is difficult to determine what is using the energy.

The services at BACA are not being controlled appropriately, with no modulation of inverters on fans or pumps through the BMS. This is of key concern for the fresh air supply to the kitchen, main halls and the first floor offices above the entrance, where there are two extract units connected to the one supply. In order to operate the supply to the hall and the offices, the kitchen extract has to be operated even when not needed. This is a design issue, with no automated dampers or speed control on the supply fan to ensure that the supply and extract are balanced. This is further compounded as the AHUs for these areas were commissioned to run at duties less than designed (as the motors were at the full-load current).

Figure 6.5 – Layout plan showing the areas using the most energy at BACA, top: ground floor and bottom: first floor

6.3 Comparing the Schools

Figure 6.6 below shows how both schools compare against the CIBSE TM46 benchmark, used within the Display Energy Certificate (DEC) methodology, showing that Thamesview School in both years performed better than the benchmark, and BACA performed worse. It is also noticeable that during this study, the energy consumption of Thamesview School increased compared to the initial year, largely caused by the harsh winter during the second year. The energy data was sourced from the incoming utility meters at both schools, ensuring relative accuracy.



	BACA (2012-13)	Thamesview (2012-13)	Thamesview (2011-12)	TM46 Benchmark
Electricity kWh/m2/annum	97.9	67.3	63.1	40.0
Gas kWh/m2/annum	143.0	75.7	54.7	150.0
Total kWh/m2/annum	240.8	143.0	117.8	190.0

Figure 6.6 – Bar chart comparing energy performance relative to the TM46 benchmarks for schools

Both buildings were found to be consuming more electricity than the benchmark. Likewise, both schools were found to be consuming less gas than the benchmark (although only marginally in the case of BACA). The benchmark itself was based on a limited number of schools, but includes a range of schools of different types and construction age. However, since, the latest version of TM46 was published in 2008, it excluded recently completed school buildings. In order to compare how the buildings performed relative to a larger dataset, the DEC dataset from 2009-10 was analysed with the results shown in Figure 6.7 below. While the dataset is not for a corresponding year and no correction for weather has been undertaken, it does indicate how the two schools compare to the larger set of schools (1091 of roughly 3500). This is of particular importance for the heating at both schools as they are non-electric heating systems and the winter of 2012-13 was particularly harsh compared to previous years.

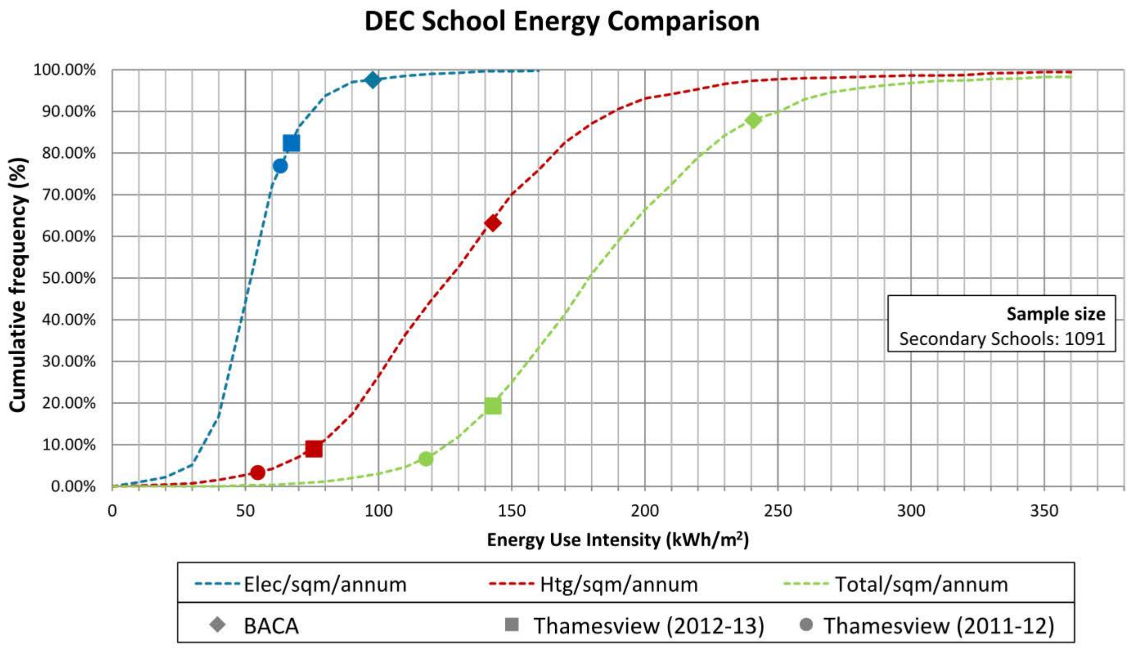
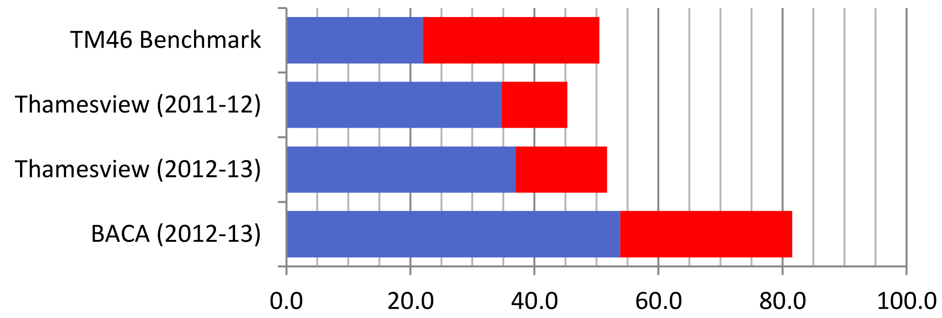


Figure 6.7 – Comparison of studied schools compared to the DEC dataset from 2009-10

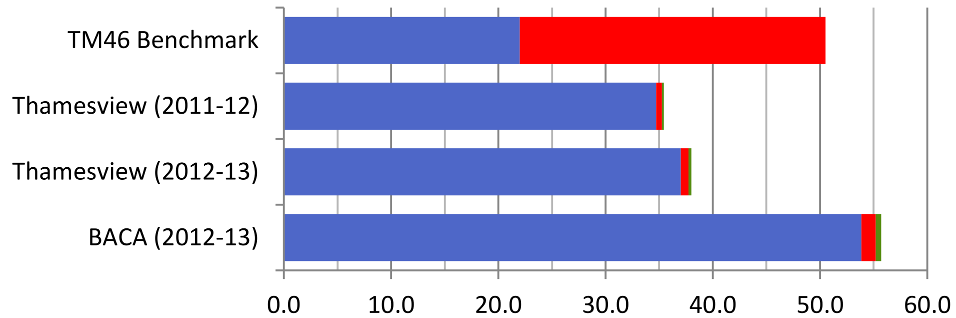
As can be seen, the electricity use of both schools is in a very high percentile of electricity use, over the 75th percentile, with BACA ranked as 97.5%. Heating energy for Thamesview is in the best 10%, and BACA is 63%. This shows that at BACA, there is clearly an issue with the heating control strategy, particularly given the high-performance building fabric compared to the wider building stock of secondary schools. Although both schools were using less than the TM46 benchmark for heating, it is clear that BACA is using more than the mean of the DEC dataset.

With the high electricity use at both schools, it is clear that both schools will have a large carbon footprint, given the higher CO_2 emission rate for electricity than gas. Figure 6.8 shows that although Thamesview School consumes much less energy compared to the benchmark (see Figure 6.6), its carbons emissions are similar to those of the benchmark. This is solely down to the much higher amount of electricity usage. BACA, not surprisingly emits considerably more CO_2 than the benchmark, with both gas and electricity usage more than the benchmark. However, both schools have biomass boilers installed that were not operational during the study period, which if used would reduce the amount of CO_2 emission resulting from heating and hot water generation (see Figure 6.9).



	BACA (2012-13)	Thamesview (2012-13)	Thamesview (2011-12)	TM46 Benchmark
Electricity kgCO2/m2/annum	53.8	37.0	34.7	22.0
Gas kgCO2/m2/annum	27.7	14.7	10.6	28.5
Total kgCO2/m2/annum	81.6	51.7	45.3	50.5

Figure 6.8 – Bar chart comparing CO_2 emissions relative to the TM46 benchmarks for secondary schools (carbon Emission rates used; electricity: 0.55 $kgCO_2/kWh$, gas: 0.194 $kgCO_2/kWh$)

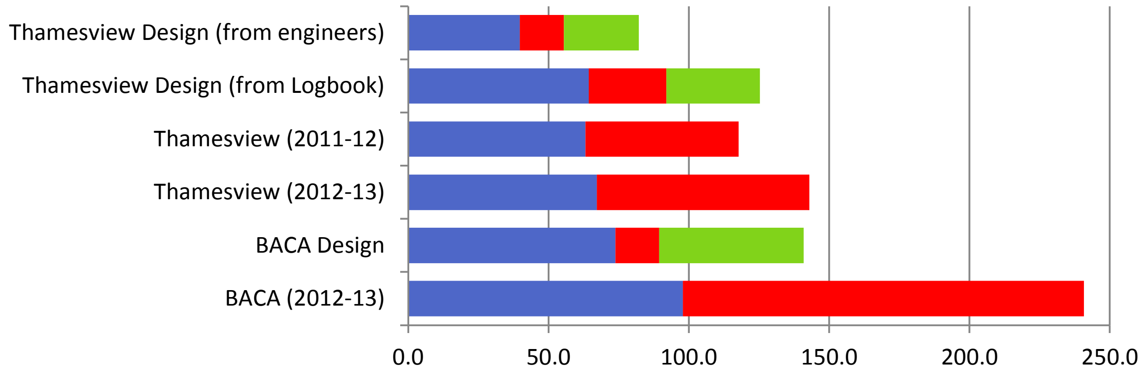


	BACA (2012-13)	Thamesview (2012-13)	Thamesview (2011-12)	TM46 Benchmark
Elec kgCO2/m2/annum	53.8	37.0	34.7	22.0
Gas kgCO2/m2/annum	1.3	0.7	0.5	28.5
Biomass kgCO2/m2/annum	0.5	0.3	0.2	0.0
Total kgCO2/m2/annum	55.7	38.0	35.4	50.5

Figure 6.9 – Bar chart showing the CO_2 emissions relative to the TM46 benchmarks if the biomass was used for 75% of heating (carbon Emission rates used; electricity: 0.55 $kgCO_2/kWh$, gas: 0.194 $kgCO_2/kWh$, biomass: 0.025 $kgCO_2/kWh$)

By using the biomass boiler for 75% (as per the design intent) of the heating load, the CO_2 emissions for BACA could have been reduced by 32%, and up to 27% for Thamesview. It is immediately obvious that although the emission rate could substantially be improved by using the biomass, the electricity usage is the key to reducing the CO_2 emission rate effectively. The high use of gas at BACA is caused by the requirement to operate the underfloor heating at 3am to ensure that the temperature reaches the optimum level by occupation. However, due to the initial control difficulties, the rest of the building was also unnecessarily heated at this time. As noted in section 5, this additional preheat time could add as much as 31% to the overall heating energy usage. This has since been corrected by Kier and the academy, with significant work undertaken on the control strategy.

Both schools had full analyses undertaken by the design team to determine the operational energy use. Figure 6.10 and Figure 6.11 show the relative performance of the school compared to their designs, with both schools using considerably more than designed. This is not surprising given that few buildings in the CarbonBuzz[1] database use less energy than designed, with many using 2-3 times the designed amount. The design data for BACA was received from the engineers, generated from their dynamic simulations of the building. At Thamesview School, two sets of design data were provided; one from the logbook (their operational targets), and one from the M&E engineers. The initial design data from the engineers showed substantially lower energy use that the data from the building logbook. It is not known where this discrepancy has arisen from, although the design data from the engineers was from dynamic simulation, whereas the logbook broke down the energy by sub-meter, indicating that it had been calculated using a different method.



	BACA (2012-13)	BACA Design	Thamesview (2012-13)	Thamesview (2011-12)	Thamesview Design (from Logbook)	Thamesview Design (from engineers)
Elec kWh/m2/annum	97.9	73.8	67.3	63.1	64.3	39.8
Gas kWh/m2/annum	143.0	15.6	75.7	54.7	27.7	15.6
Biomass kWh/m2/annum	0.0	51.6	0.0	0.0	33.4	26.7
Total kWh/m2/annum	240.9	141.0	143.0	117.8	125	82.2

Figure 6.10 – Bar chart showing design and actual energy use at BACA and Thamesview

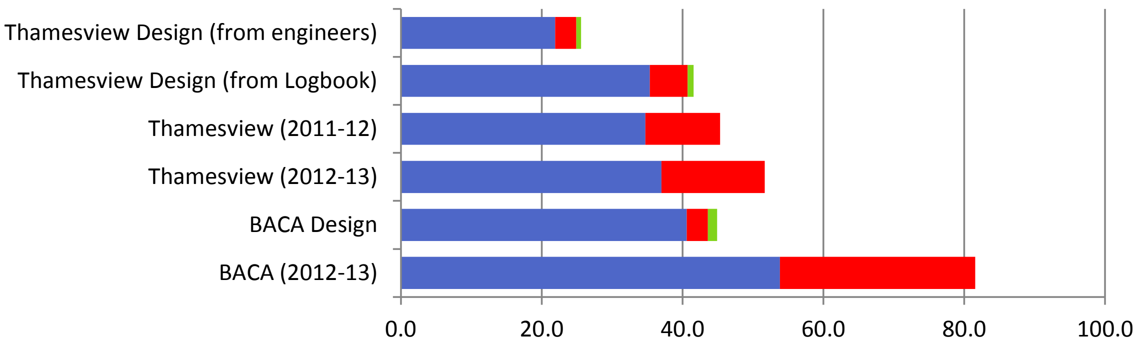
As noted above, without using the biomass boilers at each school, there is a significant increase in the CO_2 consumption at each school, with BACA producing 82% more than designed, and Thamesview using 77% and 102% more than designed by the engineers. The heating aspect of the energy consumption should be closer to the design than the electricity usage, with the heating controlled centrally by the respective BMS systems. At Thamesview School, the heating energy is similar to the overall heating energy from the logbook (adding the biomass and gas usage together), but this

[1] Visit www.carbonbuzz.org for more information.

reflects the much higher gas usage anticipated in the logbook compared to the engineers. The difference in energy use between the engineering design and the actual usage indicates that the designed control strategy is not being implemented or was not attainable in practice. The logbook heating data for Thamesview is much closer to the actual usage, suggesting that there may have been a significant change between the engineering design and the final completion of the services.

The electricity use is also higher in practice than the engineering design, which is much more common due to the high diversity in small power that can occur. Conversely, the logbook design electricity usage is much closer to the actual usage at Thamesview, with the end-uses of the electricity usage clearer at the end of construction. The increase in heating and electrical use at Thamesview was predominantly down to the cold winter, with the use of electrical fan heaters and supply of additional heating.

When examining the CO_2 emissions of both schools, it is quickly apparent that the lack of biomass has a significant impact on the sustainability, particularly at BACA where the heating load is already considerably higher than design.



	BACA (2012-13)	BACA Design	Thamesview (2012-13)	Thamesview (2011-12)	Thamesview Design (from Logbook)	Thamesview Design (from engineers)
Elec kgCO2/m2/annum	53.8	40.6	37.0	34.7	35.4	21.9
Gas kgCO2/m2/annum	27.7	3.0	14.7	10.6	5.4	3.0
Biomass kgCO2/m2/annum	0.0	1.3	0.0	0.0	0.8	0.7
Total kgCO2/m2/annum	81.6	44.9	51.7	45.3	41.6	25.6

Figure 6.11 – Bar Chart showing design and actual CO_2 emission at BACA and Thamesview

6.4 Conclusions

The investigation into the energy use at both schools has found that both schools are using too much energy. At BACA the high heating usage is caused by the need to preheat the underfloor heating, which is not zoned separately from the rest of the building. Additionally, both schools are consuming considerable amounts of electricity for small power and lighting. These are both classed as unregulated loads, determined by the occupants' usage patterns. However, it is believed that the main causes of the high lighting loads are the presence and daylighting sensors not functioning optimally.

The timers for the presence detection need to be reduced in circulation areas to reflect that the spaces are transient. In addition, the locations of the daylight sensors need to be representative of the whole zone controlled, not in a dark corner. At BACA there is significant concern over the zoning of the fresh air provision, with the kitchen extract linked to an office supply system, requiring them to both be run when the office is occupied. This is clearly unnecessary, but is difficult to rectify.

7 TECHNICAL ISSUES

7.1 Thamesview School

While the building is generally well constructed, there are a few underlying issues that prevent the building from operating optimally. Of paramount concern is the BMS, with its important position as the controller for all the services, it has a large influence on the efficiency of the installed systems. While the system does have an optimiser, the system is designed with the AHUs running during the weekend despite the building occupancy set to zero. During the winter this was found to be running, with low external temperature, and considerable heating was needed to raise the incoming air to a suitable temperature. Fresh air was not needed during the weekend, particularly when it is so energy intensive. There is no evidence of seasonal commissioning of the BMS, which is important to ensure that the systems are meeting the current requirements and to ensure that the optimiser is working to the correct parameters.

There is no clear logging of energy meters, with only daily totals logged every 15 minutes, taking up valuable memory with no discernible gain. This significantly hampered the discovery of the optimiser working incorrectly, with it only spotted due to the incoming gas locking-out due to a power cut and the subsequent drop in temperature caused by the fresh air brought in by the AHUs. There is also no automated output of data, such as sub-meters, with complex navigation of sub-menus and alarming pop-ups preventing casual users from finding the stored data. While improvements to this system have been undertaken, such as repairing meters, there has been little improvement. However, as a result of this study the BMS at this site and the other two schools are in the process of being replaced, fixing many of the underlying problems. It would be beneficial for the new system to be more intuitive, as currently the staff largely avoid the BMS, due to a lack of confidence in its operation. This improvement in interface needs to be balanced with differing access levels to prevent uninformed changes to the system.

In the main reception area and connected central heart space, there have been concerns over the draughts that occur during the morning as the students and staff arrive. This appears to be caused by a number of factors; stack effect in the heart space due to the high-level louvres, opening of the door across the heart space from the main entrance creating a through-draught, the operation of the automated doors, and potentially the building form. This has been partially alleviated through blocking the high-level louvres and by adjusting the automated door opening. The design had not intended this to be the sole entrance for the pupils, instead the many external doors between the teaching wings being used instead.

Throughout this study, there have been reports of cold temperatures in the drama studio, see Figure 7.1 for logged temperatures, with a number of fixes implemented to improve the space temperatures. The main cause of the cold temperatures appears to be the poor thermal performance of the external door, coupled with difficulty heating in the space. This is compounded by the double height ceiling, with warm air pooling at high level, where the ventilation strategy has to overcome the buoyancy of this warm air. In order to improve the conditions, a radiator has been fitted over the external door, with the supply air louvre lowered to push the warm air down. However, this has not been successful, with 15°C commonly occurring in the morning prior to classes, and the additional radiator un-balancing the LTHW system, preventing flow to neighbouring rooms and has since been decommissioned. There is no zoning for the heating in the school, despite the zoning of the AHUs, so balancing issues can easily affect the whole system, not just a specific zone/area. In order to permanently resolve this issue, Kier are planning to install an overdoor heater and rebalance the system in the summer of 2014.

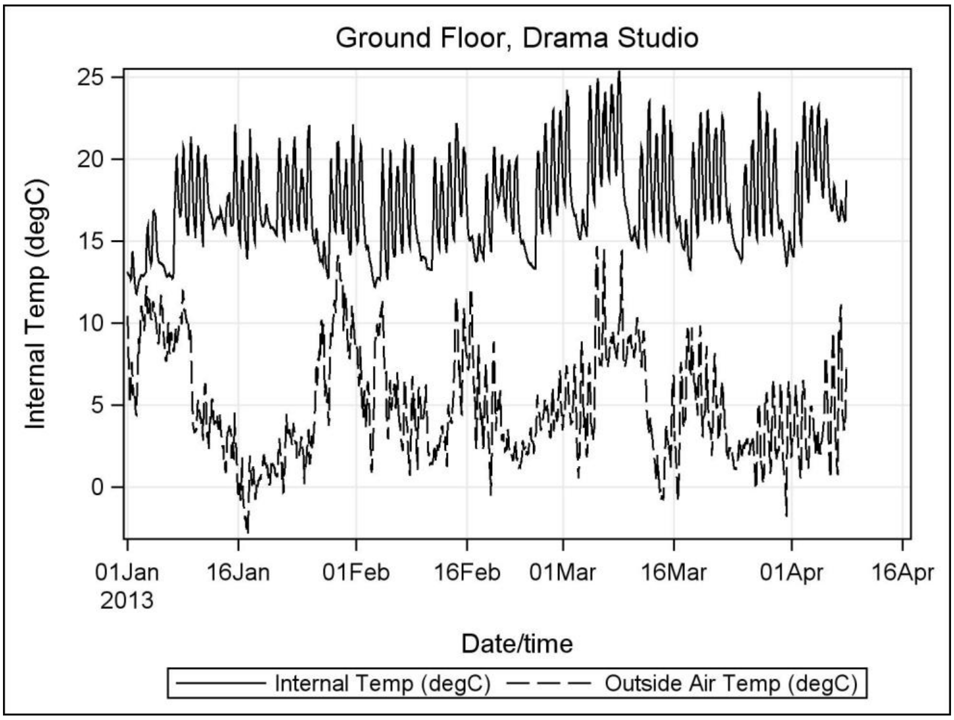


Figure 7.1 – Graph showing internal and external temperatures in the drama studio at Thamesview

As previously noted, the biomass boiler has not been operational for much of the study, with initial issues due to accidental activation of the plant room sprinklers, soaking the woodchip and the ignition coils. In addition, the lining bricks in the furnace became loose, preventing use of the boiler. There are also problems surrounding the delivery of the wood chips, with the initial delivery mechanism a blower-type, which raised noise complaints from the neighbours at the other schools and posed a significant hazard for those using the system. At Thamesview School the system did not raise complaints due to the landscaping and acoustic fence installed. Despite the lack of complaints at this site, the fuel delivery system has been over-hauled to utilise a complex screw-feed system, which should be more reliable and considerably quieter.

7.1.1 Thermal Imaging

Thermal Imaging of Thamesview School was undertaken on 14th February 2012, using a mix of both internal and external imaging to capture the quality of the fabric installation. The thermal imaging revealed a thermally tight building, with few thermal bridges that would allow heat to escape the building. However, it is apparent that there are few areas that need attention on future projects.

Figure 7.2 shows an indicative movement joint between two windows, with a small amount of heat escaping (note that this image also shows the left window open due to high internal temperatures). The small amount of heat escaping from this detail is not a large concern; however, due to the length of this joint, it could have had a far greater impact on overall energy use. This is more apparent in Figure 7.3, where two movement joints meet next to the plant room door.

Figure 7.2 – Infrared image of offices at Thamesview School, showing the bond between the window frames and the building fabric. Note the top windows on the left are open, despite the cool external temperatures.

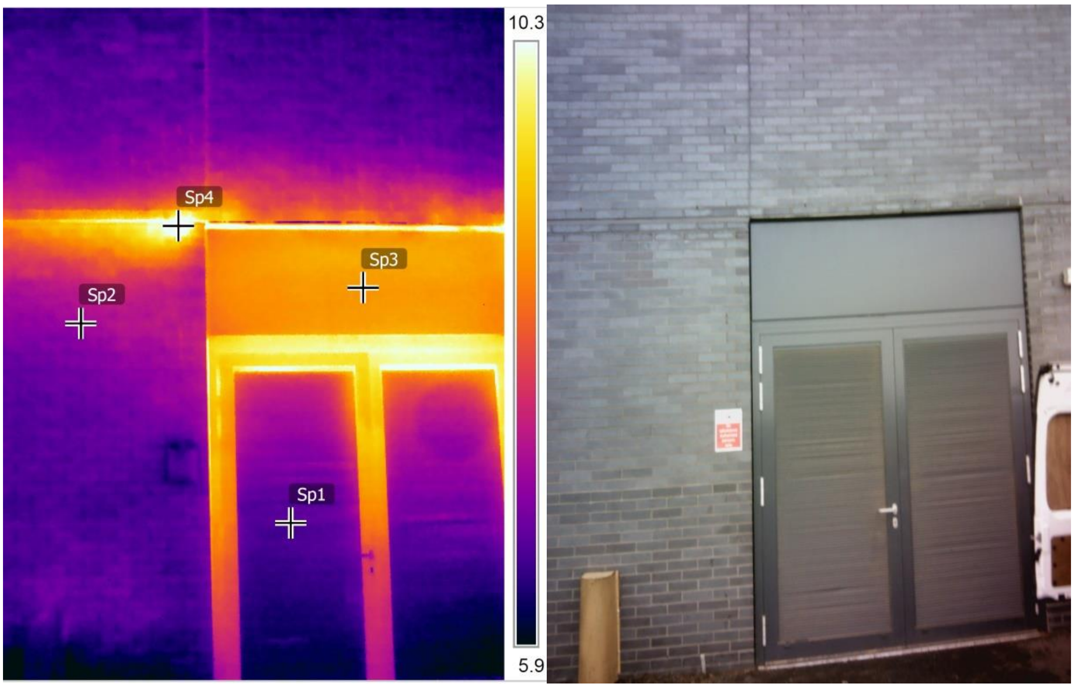


Figure 7.3 – Infrared image of plant room door at Thamesview School, showing the heat escaping from the movement joints to the top left of the door.

Elsewhere with the building, other movement joints have been shown to be 'thermally-tight' with little evidence of heat escaping through the joints, as shown in Figure 7.4.

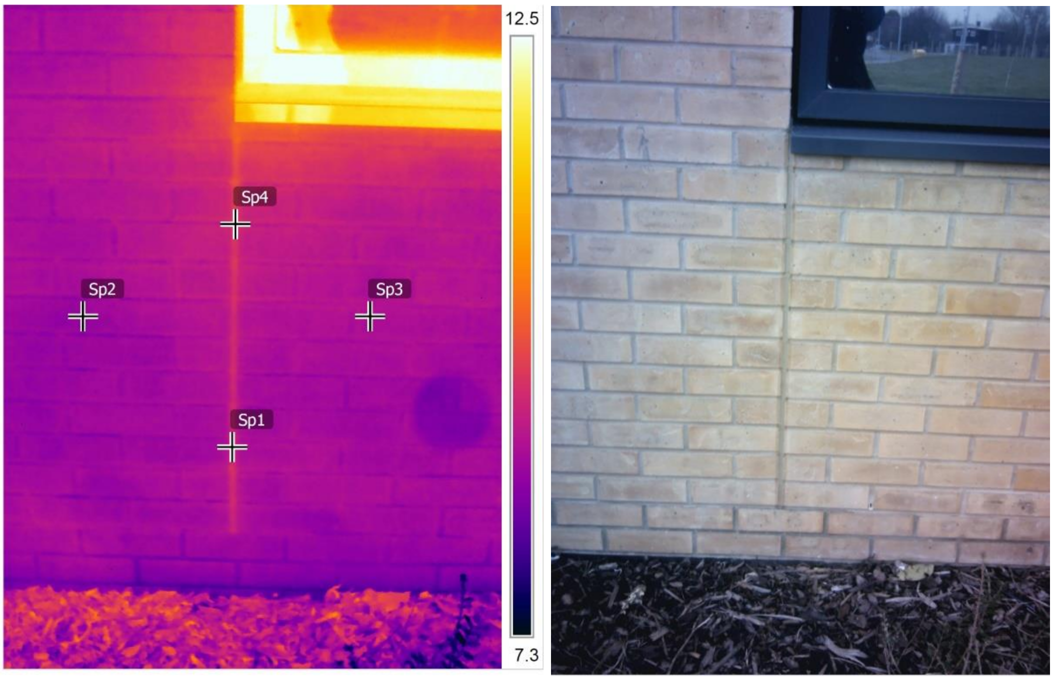


Figure 7.4 – Infrared image at Thamesview School showing the movement joint beneath the windows, with little heat escaping.

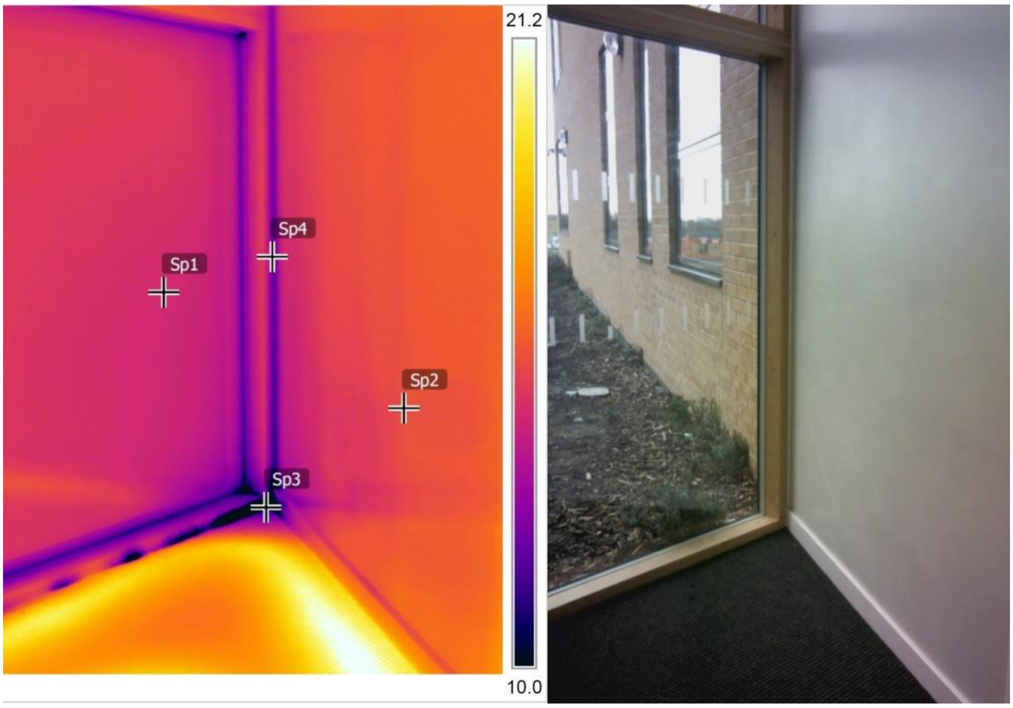


Figure 7.5 – Infrared image at Thamesview School showing the thermal bridging between the window frame, wall and the floor

Another area that gave rise to issues of thermal bridging is through the acute angles that occur within the building. This is particularly evident in Figure 7.5, where there is a substantially cold spot underneath at the corner between the window frame, floor and wall. Under the rest of the frame, there are small cold spots, but the corner shows where the most extreme thermal bridge has occurred. This has since been rectified by Kier to improve the thermal performance of the building. The difficult angle has created a more complex detail, which may have been overlooked during installation, resulting in a severe thermal bridge. Similar cold spots were found in the corners of the teaching wings, where the soffit/roof met the top of the walls. Future designs should seek to either avoid such unusual angles, or to ensure that the details for these sections are designed and installed carefully.

The full report can be found in Appendix A5.

7.2 BACA

The over-riding issues at BACA result from the poor BMS, which lacks basic functionality required to operate the system as designed. The final installed system was different from the one specified by the designers, with less metering and little zoning control. Initially, all of the systems were operated from one time clock, resulting in all the ventilation, including the kitchen extract, operating while the underfloor heating pre-heated at 3am. The ventilation systems have been zoned out and improved; individual time clocks for each system, the wind-catcher units now ensuring the outside temperature is above a set-point before operating, and a dead-band installed on the automatic window actuators to prevent 'fluttering'. In addition, the outside air sensor was moved from its location above the ventilated plant room door, under the metal roof, to a more exposed position to ensure that the temperatures recorded by the BMS were accurate. However, only the ventilation has been zoned, with all the heating operating together, a particular problem when the underfloor heating starts.

Figure 7.6 – Outside air temperature sensor located above the plant room doors at BACA

The monitoring of the sub-meters was significantly different from the specified, with only 14 of the 46 installed electric meters connected to the BMS, with only four reading correctly. This is a serious oversight, with no simple way of determining how the building is performing the facilities manager's job is significantly tougher. Unfortunately, due to the size of BMS boards installed, there are few spare points to connect additional meters into the BMS, with high costs associated with installing new boards.

There have been a number of spaces reporting cold temperatures, particularly those heated exclusively by underfloor heating or with heated fresh air. This has been caused by a number of problems, such as faulty valves on the underfloor heating manifold (see Figure 7.7 below), but appears to be closely linked with the low flow temperature of the constant temperature circuit. This supplies the heating coils in the AHUs and the underfloor heating and is currently set to 50^{o}C, which is unusually low for a heating circuit. It is not known what the design temperature was, but there is concern that the heating coils will not receive enough heat at such a low temperature. Each item of equipment connected to this circuit have protection in the form of mixing valves, so it is recommended that the temperature be increased and the valves deal with any high temperatures.

Figure 7.7 - Underfloor heating manifold to principal's office with cold pipework at BACA

The biomass boiler has had many issues preventing its use, mainly caused by the auger and confusion over the correct chip size. It appears that the screw is incorrectly sized for the size of auger, and there have been issues with the supplier's chips. In addition it is prohibitively difficult to load the storage hopper as the truck used cannot get close enough to the hopper to deliver a full load. When the biomass has been running, the first floor classrooms near the external plantroom have reported flue gases entering the rooms, requiring the windows to be closed during its operation. This has not been investigated as the biomass has not been working, but needs careful investigation once the issues have been rectified.

A serious concern regarding the ventilation at BACA was caused by the joining of one supply AHU with two extract units, one for the general offices and the other for the kitchen. These systems are balanced so that when the one area needs to be run, such as the office in the morning or early evening, both extracts also run, despite the kitchen being closed. The supply air also goes to the main hall area during the occupied time for the offices, regardless of the occupancy of the hall. This is a design issue, with no simple design solution besides the addition of a separate supply fan, or modulating the supply and installing actuated dampers to deliver air only where needed.

Despite the concerns with the services, there have been few issues surrounding the building fabric, with a high quality finish apparent. The main issue found with the building fabric is due to the white walls in the circulation spaces, which are prone to scuffs and marks during use. These white walls have been difficult to clean, necessitating regular repainting to cover the marks.

7.3 Summary

From both schools, it is clear that the main issue facing both schools is the complexity of the services. With the increasing complexity of the services, such as in mixed-mode ventilation, it is of great importance that the BMS manages the services correctly to produce the optimum environment with minimum energy use. Both systems have issues surrounding the metering, preventing understanding of whether the requirement for energy efficiency is being met, with only the building-wide meter providing reliable, half-hourly data. Clearly the importance of monitoring has been overlooked during the commissioning and handover, with the focus on ensuring operational performance and the metering purely ancillary. It is just as important that the systems be robust and user-friendly, allowing simple interrogation where the data exists. This is particularly true at Thamesview, where only one person regularly operates the system, with specialist engineers making significant adjustments when necessary. Where improvements to the interface are made, it recommended that differing levels of access are implemented to prevent any unintentional/ill-advised adjustments to the systems.

Towards handover, priority is regularly placed on architectural and visual completion, with the building services installation and commissioning only loosely monitored. The services and commissioning are less visible and more difficult for a ley person to judge, thus requiring a dedicated person that is familiar with the systems to ensure the design intent is met. Soft Landings may be used as a framework to address issues with managing commissioning and would additionally provide support to the building occupants as they learn the complex new systems.

The design and layout of the systems plays a significant part in enabling management of the energy, as systems should be tailored towards the zones they serve, with the flexibility to reduce the energy consumption where possible. At both schools, no zoning of the heating systems was apparent, as per the brief, creating a situation where the demand for heating in one area requires the whole system to be heated, whether the demand exists or not. At BACA the joined kitchen extract and office supply require that when the office is in use, the kitchen extract has to be run. This setup makes it very difficult to control this system in an efficient manner, but cannot be rectified without installation of actuated dampers and modulating the flow rate of the supply air.

8 KEY MESSAGES FOR THE CLIENT, OWNER AND OCCUPIER

At each school, the key messages arising from this investigation are similar and have been joined together. Where it applies to one school only, then this is explicitly mentioned.

1 The over-riding aspect of the building that needs to be improved is the BMS.

As noted, both schools use relatively complex systems, which need careful management and monitoring to understand whether they are working correctly. Neither system provides the level of monitoring necessary to ensure that the building is operating in efficiently. At both schools, there is little confidence in the BMS, partially created by the lack of understanding of the complex systems. While the BMS does not have direct control over the significant aspects of energy use, the unregulated usage, the buildings need a reliable BMS to allow the services to be controlled in an efficient manner.

2 BMS time clock on/off control checking

In order to reduce energy use, it is important to first understand where the energy is being used, checking that systems are operating at the correct times.

BACA - it is still not clear whether the time clocks relate to occupancy hours, or to on-times for equipment. Good sub-metering would allow this to be determined easily.

3 BMS metering

Both schools have solar thermal arrays but with no clear indication of how their use is addressing the schools' carbon emissions. If this was rectified, it would enable the carbon footprint of the school to be robustly reduced.

4 BMS verification/interface

It is very important that the BMS points are verified to increase trust in the system, but just as important is improving the user interface, allowing all users to find information quickly and easily (as has been done at Thamesview school since this study).

Thamesview - in particular is difficult to navigate, with the logged data prohibitively difficult to find by all but the most experienced user.

BACA - is better to navigate, but with too many dead-links and buttons that do not work, again, discouraging interaction and lowering trust in the system.

Both systems feel focused on a static situation, where the systems are initially setup and not designed to be changed. In reality, these systems need to be checked in each season, ensuring that they are working optimally.

Both systems currently need specialists to make significant changes, this should be rectified where possible to allow users to take ownership of the systems. With any improvements to either system, further training should be encouraged, acting as simply a 'refresher' or highlighting the capabilities of the services supplied. Where different levels of control are implemented, remote access should be implemented to allow those who can change parameters to make alterations in an emergency.

5 BMS zoning

With both schools separated into distinct zones through the layout, it unfortunate that the systems do not reflect this layout well, particularly given the changes to the end use of some spaces.

Air handling units can be controlled fairly independently, however heating circuits do not reflect the same zones, with both buildings treated as one large zone. This is hugely inefficient, particularly where zones have different operating hours (such as offices and classrooms). By introducing automated valves, small pipework changes and adjusting the speed of the circulation pumps, the heating could be modified to reflect the zones.

Where possible, the zones should be made to match the ventilation, ensuring that there is no conflict of temperature settings.

BACA – the underfloor heating is driving up the energy use associated with heating, which could be mitigated through separation of the heating systems. This is something that should be investigated by the school, with potentially quick payback.

6 Fresh Air supply

As many of the occupants feel the buildings can be stuffy, it would be very beneficial to have the fresh air supply systems re-balanced, particularly where the systems have been modified. This would ensure that the rooms are receiving the correct amount of fresh air and increase confidence in the systems. BACA has since re-balanced the ventilation systems to ensure the rooms are receiving the correct amount of fresh air.

7 Heating systems balance

In parallel with the fresh air rebalancing, it is recommended that the heating systems be balanced as well, particularly the circuits serving the air handling units, again ensuring that the system is capable of delivering the air as needed. As part of this process, the design flow and return temperatures needed to be verified, particularly at BACA where the constant temperature circuit seemed very low. Since this study, the constant temperature circuit temperature limit has been increased, with improved supply air temperature as a direct consequence.

8 Biomass

Biomass units at both schools have had a chequered past, but these units are integral parts of the carbon management strategy and should be reinstated.

Thamesview School - has been extensively improved, but it is important that the staff receive training in the new equipment to reduce chances of failure.

BACA - the whole delivery system needs revisiting, from access to the hopper, to the auger mechanism itself before it can work (this was being investigated and remedied at the end of the investigation by Kier and their sub-contractors).

9 Unregulated energy

The carbon emissions of both schools are higher than hoped, with the electrical loads contributing the significant portion of overall emissions at both schools. Of this electrical load, the unregulated energy usage is by far the largest contributor, accounting for roughly 66% of the overall usage. Both schools have considerable ICT equipment, but this needs to be carefully managed, either through the use of remote software, such as wake-on-lan systems. These are freely available and would enable the PCs to be switched off at night or during holidays when not being used. This would have a significant impact on electrical use, with a single computer potentially drawing 22W of power while on standby[2].

10 Lighting

Thamesview School had significant lighting loads, and it is suspected that BACA has similar energy usage due to the similarity of the controls used. Where presence detection is used in corridors, the timers should be reduced further, particularly given that there are very few spaces in either school that do not have ambient light roof lights or glazing. In all rooms, lighting should have manual over-rides, as found in many of the rooms in Thamesview, to enable the occupants to switch lights off when not needed. Sources of daylight should be encouraged, with any obstructions reduced to allow the greatest amount of light into the spaces. This particularly apt in Thamesview, where the open plan spaces have poor light penetration caused, partially caused by the schools use of screens and bookcases to delimit the teaching areas.

11 Communication

At Thamesview School, effort should be made to reduce the gap between Kier FS and the school. From the occupant interviews it is clear that the aspects Kier FS directly manage were thought to be poorer than other aspects. Through closer relations it is hoped that the school staff will become more understanding, enhancing the working environment for both teams. While it is appreciated that any additional services provided by Kier FS have an additional cost associated, perhaps a discretionary budget provided by Kier FS to meet the changing needs of the staff would assist good will between the two. As previously noted, the relationship between the two parties at Thamesview is considerably better than at other schools, but this would further improve the relations.

With regards to maintenance, both schools have complex systems that require an engineering background to understand. At Thamesview the mechanical aspects are predominantly dealt with by one person across the three schools managed under one contract with backup from specialist contractors where necessary. Additional general M&E training to all staff would help spread the work and assist with any immediate issues that arise.

[2] Source: http://standby.lbl.gov/summary-table.html

In both schools, there have been a number of items that are flagged as defects, whether through design or installation, however the process to rectify these has been fraught with issues, particularly at BACA when the lack of continuity of FM introduces doubt as to the origin of the problem. Once an issue has been raised as a defect, then at both schools it was felt that the defect process took more time than necessary. While the issues being dealt with were complex, particularly attempting to understand the root cause and the most effective fix, there needed to be greater dialogue with the school to ensure transparency of the rectification process. At both schools, the increase in information flowing back to the school would have helped them appreciate the efforts being done to rectify the defect.

The FM themselves should keep a log, in the log book perhaps, detailing all maintenance activities and changes to the system in order to avoid discussions regarding the source of any reported issues. Centrally, Kier FM keep records of all items of work, however, it does not detail the subtler changes, such as to set-points, that have little or no cost associated with making the change. However, these changes do have a significant impact on understanding the building performance and overall efficiency of the systems.

12 Building fabric

A large focus in this study has been on the services installed within both schools, with the occupants noting that these were the most problematic aspects of the building. However, it should be noted that the building fabric of both schools were very good, achieving low infiltration rates and with high quality finishes.

13 Function and overall success

Respondents to questionnaires in both schools noted that both schools are good buildings to work in, praising the aesthetics and the spaces created. While the end use of some spaces is not the same as designed, the form of the buildings has enabled this flexibility with some success. The areas that have been less successful are the open-plan areas, with both schools moving away from the original pedagogy towards more typical cellular offices.

9 WIDER LESSONS

Throughout the study, a focus has been put on producing lessons for future projects, ensuring a virtuous circle of improvement. The main areas for improvement fall into the following six areas:

9.1 System Complexity

Throughout this study, the focus has been on the response of the services to the space that has been provided. They have generally responded okay, but a number of large issues have prevented these from being obvious. In many cases this is due to the sheer complexity of the systems and the inability of the users to comprehend the controls (either through poor interfaces or no clear strategy existing). In order to reduce this problem, the systems should be designed as simply as possible, using conventional technology where possible (such as radiators, manually openable windows, switched lights). In some cases, such as with lighting controls, this may be at odds with other building requirements, such as BREEAM or client requirements. Where this conflict occurs, or where the use of conventional systems will not work, then considerable work will need to be undertaken to educate the occupants on how the systems work. Where systems are controlled centrally, ensure that the occupants know that the systems are running optimally due to the control systems installed. If possible, provide feedback on the current status of the systems to the occupants. It may be helpful to think about a series of questions form the occupants point of view to frame the control strategy:

- What do the occupants do if it is too warm
- What do the occupants do if it is too cold
- What do the occupants do if it is too stuffy
- What do the occupants do if it is too noisy (from any source)
- What do the occupants do if it is too bright from daylight
- What do the occupants do if it is too bright from installed lighting
- Etc.

9.2 BMS Installation

The BMS for future buildings needs to be carefully installed, with the specification used to ensure that the system has the full functionality required to operate the building efficiently, particularly through commissioning. While it is incredibly important that the services are controlled by the systems, they still need to be monitored by the facilities manager, with changes made when necessary. This is often overlooked and seen almost as an optional aspect. All metering needs to be checked for accuracy, with simple interfaces installed to allow quick analysis to historical data for all loggers. As BMS systems are often the final aspect of the building to be commissioned, they are particularly susceptible to compressed commissioning periods. In many cases, the BMS commissioning is not invasive, so could be continued after handover, with the interface developed in partnership with the building owners, such as in Soft Landings.

9.3 Building Zoning

When designing the services, it is useful to zone the services according to end use, particularly where zones have differing occupancy times, such as in offices and classrooms. By zoning according to the end-use, the services can be set to reflect the operating hours of the zone, shutting those not needed down. Where zones will be used outside of core hours, it is beneficial for these areas to be timetabled prior to the event, with the parts of the building not used turned off.

Zoning is also important to the lighting, but with the zones focused also on the amount of available daylight. Circulation areas in particular need to be zoned carefully, with any daylighting sensors placed in areas that will sense a representative amount of light in the zone. The design of the buildings should where possible utilise daylight to light the spaces, either through glazing or rooflights, providing good uniformity and thus assisting any automatic controls that may be installed. However, it is important that daylight is kept away from interactive white boards and other areas sensitive to glare, to reduce the likelihood of blinds being closed and artificial lighting used instead. In addition, the height of the ceiling is crucial to get the correct quantity of light into deep classrooms, with additional height significantly improving daylight levels. Where this is not possible, light from neighbouring atriums through glazing into the spaces can be used to get daylight into the darkest parts of the rooms.

9.4 Commissioning

Through both the BMS and the services it is apparent that the commissioning is a key step of the construction/handover. Given the timing of the commissioning, at the end of the project, it clear that it will be under pressure to meet the handover date, but it is important to remember the value of the commissioning process and place necessary priority on it. In order to strengthen the importance of commissioning, it is recommended that an independent commissioning authority is employed by the client to ensure that the systems are installed as designed (as shown in Figure 9.1). An alternative is to use the Soft Landings approach, which effectively lengthens the period of handover, allowing system commissioning to respond to the any issues that arise during operation. Soft Landings would also reduce the conflict that arises during defects period, where apportioning fault can take longer than rectifying the fault. The use of Soft Landings, or an extended handover, could significantly improve the services within the building, not only reducing the energy usage, but also improving the internal environments and thus occupant satisfaction.

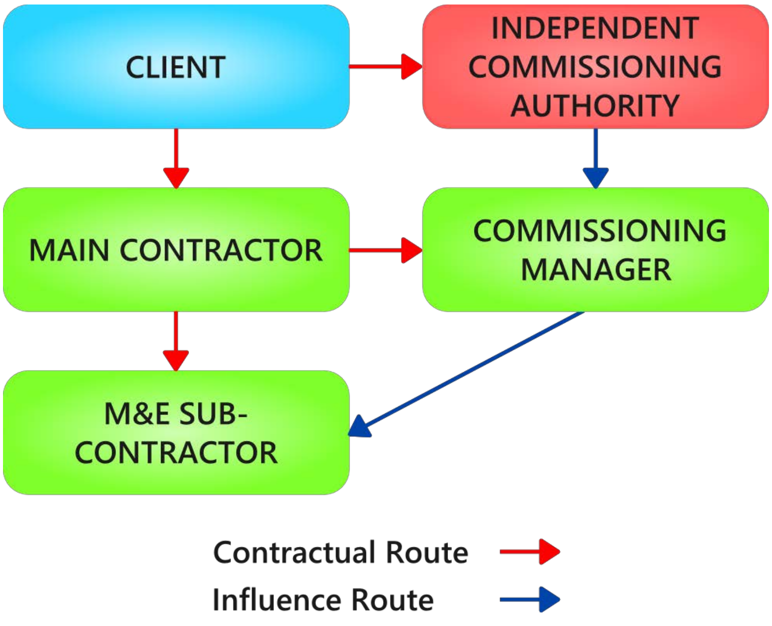


Figure 9.1 - Flowchart showing the influence and contractual obligations during commissioning

9.5 End use of the Spaces

The use of open plan classrooms should be scrutinised, with a clear focus on the teaching pedagogy to be used and the ongoing adaptability of the spaces. Key to the success of the open plan areas is the acoustics and the potential for visual distractions. Where possible, students should be kept facing away from each other, for example back to back classes, with high levels of sounds absorbent material in the ceiling and carpeting. Should ambient noise levels or reverberation become too large then those with hearing impediments will struggle to use these spaces. It is also important to test the layout with the staff, leveraging their experience of teaching to inform layout choices, from furniture to positioning of storage.

9.6 Innovative Technologies

Using biomass boilers is an important method of reducing the carbon emissions of the building, but they are high maintenance systems relative to the gas boilers commonly used. As such, it is of high importance that the systems installed for the biomass, such as the auger or the hopper, are as simple and robust as possible. This aspect of the design has large implications on the future carbon footprint of the building, and should not be underestimated during the design. The costs associated with installation of a biomass system deserves the additional time on the design. This is also true of all low and zero carbon technologies, with the solar thermal installations at both schools lacking sufficient metering to understand their energy contribution. With public buildings required to produce Display Energy Certificates (DECs), it is important that the true energy performance is represented. Also, where government incentives exist, metering is key to claiming back any of these incentives.

9.7 Summary

To reflect the different points of view, the wider lessons have been split into three groups, representing the main parties involved in creating a new school/building; the design team, the main contractor, and the clients/schools. The wider lessons have been found from the final discussions with the groups involved with the each building, reflecting their particular experiences and the findings of this study.

9.7.1 The Design Team

Reduce Complexity of the Services

- There is far less to go wrong with a simple system
- Increased comprehension of the systems will make maintenance and fault finding simpler
- A perfectly set-up BMS will be more efficient than a manual system, but it is less likely to work optimally than a simpler system
- A simple system reduces the amount of commissioning at the end of the project
- Tackle the root causes of complexity early in the design to prevent it becoming necessary

Encourage flexibility in the final design

- Schools are constantly evolving and will be around 30+ years
- Encourage designs that enable obvious extensions or spaces that can be easily changed
- This goes hand-in-hand with complexity, with simpler systems, a complex system may be too complex to offer flexibility, that are much easier to adapt

- Try to balance the running costs and initial costs, clearly stating advantages of the increased flexibility where there are higher costs

Think about how the occupant will use the space

- There is a balance between occupant satisfaction and energy efficiency
- Think about how the occupant is going to control the aspects of their environment (see above)
- Understand the organisation of the school and how the school operates in relation to the control of their environment

9.7.2 The Main Contractor

Keep a close eye on the services

- Recognise the need for specialists to oversee complex installations
- The M&E will need careful attention during commissioning to spot potential problems and ensure the design is being met
- It may be cheaper to ensure the installation is correct than going through defects
- Encourage simpler systems that require less attention from the outset, while still meeting the required contractual internal conditions

Look into providing extended handovers (Soft Landings)

- The extension of the handover period reduces the pressure during this period
- Training, documentation and commissioning does not have to be rushed
- Defects can be easily remedied with greater understanding of the building
- There will be less return visits needed following the extended handover, providing some savings

Make sure documentation is all correct

- This is the enduring record of the building
- Clear documentation can reduce burden on contractors for information
- When things change, issue updated documents to ensure that the documents are relevant.
- If the systems are being simplified, with the control relying on the occupants, clear instructions are needed to ensure correct operation

9.7.3 The Client/School

Think about the needs of the school

- An automated system may not make your school easier to run
- Any centralisation of systems needs to be balanced with a responsive FM to carry through requests
- The ongoing maintenance costs may be considerably higher

How will the teaching pedagogy fit with the building?

- Find out what works in the current building and make sure that this is in the new building
- Make sure that the life of the building is considered before creating too specific spaces
- Think about flexibility of the teaching styles and how spaces could be adapted to meet the ever-changing needs.

Keep on top of the facilities maintenance

- Track the energy use to spot when errors are occurring
- Keep records of all changes to the building and update the O&M.
- Look into seasonal commissioning to keep the services running optimally

Appendix A1 THAMESVIEW SERVICES SCHEMATICS

Schematics provided by the school from the O&M manual.

Appendix A2 Thamesview Occupancy Survey

Appendix A3 THAMESVIEW BUS SURVEY

Appendix A4 ENERGY REPORT AND T22 WORKBOOK

Appendix A5 THAMESVIEW SCHOOL THERMOGRAPHY REPORT

Appendix B1 BACA Services Schematics

Schematics provided by the school from the O&M manuals.

Appendix B2 OCCUPANT SURVEY

Appendix C1 DAYLIGHTING REPORT