Bessemer Grange School Children's Centre

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	450001
Project lead and author	Architype
Report date	2014
InnovateUK Evaluator	Roderic Bunn (Contact via www.bpe-specialists.org.uk)

Building sector	Location	Form of contract	Opened
Schools	Southwark, London	GC Works/1	2010

Floor area	Storeys	EPC / DEC (2012)	BREEAM rating
685 m^2 Childrens centre 3050 m^2 Existing school	2	N/A / C (64)	N/A

Purpose of evaluation

A two-year Building Performance Evaluation (BPE) study of the 1950s Bessemer Grange Primary School, and the Children's Centre and an Early Years Centre extension constructed in 2010. Data collected from the main school building was examined for purposes of comparison, and in order to provide a comprehensive and holistic understanding of Bessemer Grange School. There was a strong focus on embodied carbon and the use of renewable materials in place of petrochemical or cement-based materials, resulting in the very high use of timber for structure, insulation and finishes.

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

In the extension, electricity consumption at 38 kWh/m² per annum was high even in comparison to 'typical'performance benchmarks. Heating energy consumption, at 62 kWh/m² per annum was relatively low,and better than empirical 'good practice' benchmarks published in CIBSE *Guide F* and *CIBSE TM46* (110 – 150 kWh/m² per annum). Values obtained were best obtainable estimates, rather than definitive. Inaccuracies and technical difficulties (hot water bypassing) affected the heat meter readings on the extended heating main, and hampered attempts to be definitive on the split of heating energy consumption between the existing building and the extension.

Occupant survey	Survey sample	Response rate
BUS, paper survey	Whole survey: 76; Centre: 15	72%

All BUS summary comfort variables were significantly above the scale midpoint (4) and higher than the benchmark comparison (a rolling database of school buildings). The existing 1950s building also performed well. This suggested that, despite its age, condition and thermal comfort failings, the old school had fundamental virtues as a teaching facility that its (adult) occupants appreciated.

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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.

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Contents

i. Preamble and Acknowledgements

Preamble

This report on a building project at Bessemer Grange School has been compiled for the Technology Strategy Board (TSB), a government funded agency, and produced by Architype and Chapman BDSP.

Prior to this Building Performance (BPE) study, Architype and Oxford Brookes University worked together in a two-year 'Knowledge Transfer Partnership' (KTP), examining the post-occupancy performance of buildings designed by Architype. This was made possible by the award of the Ashden prize for sustainability to Architype, which provided seed funding which the university matched.

With a prospect of uncovering further useful findings in the course of more research, Architype with the support of Oxford Brookes, put in a bid in a competition published by the TSB. Bids were invited to receive funding from an £8m pot earmarked for building performance evaluation studies, in order to kick-start the systemisation of this relatively new field.

Architype's bid was successful, and Chapman BDSP a well-respected engineering firm were invited to join the research team as contributors and co-authors in order to provide additional expertise and an independent review.

The TSB evaluator Roderic Bunn and monitoring officer Frank Ainscow also reviewed the report.

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1.0 Introduction and Executive Summary

1.1 Report Background - TSB Building Performance Programme

This report presents the findings of a two-year Building Performance Evaluation (BPE) study of Bessemer Grange Primary School and Children's Centre in Southwark, London. It is amongst a wider programme of research, with approximately 100 similar studies led by the Technology Strategy Board (TSB), an agency primarily funded by the government department for Business Innovation and Skills.

The Technology Strategy Board's stated purpose is '*to accelerate economic growth by stimulating and supporting business-led innovation'* (2013) As part of this mandate, the TSB set up the Building Performance Evaluation Programme in 2010, in order to find innovative solutions to a dual challenge: the UK government's commitment to achieving an 80% reduction in carbon dioxide emissions by 2050 (HM Government, 2010: p23) and the well-known and significant, gap between design predictions and actual performance in new and refurbished buildings constructed in the UK.

The Building Performance Evaluation Programme defined the following aims:

- Assembling a substantial body of comparable data from across the UK in order to draw out wider lessons about the performance of design strategies, construction methods, build processes, modes of operation, and handover techniques; and aiming to identify potential innovations and improved processes, which can narrow the gap between theory and practice.

- Helping the construction industry to improve the performance and efficiency of buildings, thus making it more likely for the government to be able to adhere to its commitments to cut emissions, whilst also stimulating competition in the industry.

- Building capacity and knowledge in the UK construction industry in the field of building performance evaluation.

The TSB has funded a number of companies to undertake case studies on buildings which they have designed, built, own and/ or operate, using a common set of tools and protocols. Case studies were funded where there seemed to be a potential for obtaining useful insights into innovative methods, techniques or processes. Undertaking such studies generates benefits for the companies involved. Indeed, the TSB's aim of building capacity entails the up-skilling of UK industry, thus enhancing its global competitiveness.

1.2 Project Background - Bessemer Grange Primary School

Bessemer Grange School comprises of a 1950s built school and a new extension built in 2010, housing a Children's Centre and an Early Years Centre. For purposes of clarity, the 1950's built school will be referred to as the Old Building, and the extension will be referred to as the New Building. Bessemer Grange will be used to refer to the whole school. This study focuses on the New Building completed in 2010, but data collected from the Old Building is also examined for purposes of comparison, and in order to provide a comprehensive and holistic understanding of Bessemer Grange School.

Architype chose Bessemer Grange School as a case study for a number of reasons:

- Building an extension to an existing facility typifies a solution frequently adopted in the education sector in view of spatial and budget restrictions; a trend likely to continue for the foreseeable future.

- The New Building provides a good example of the use of innovative materials and construction processes. It is designed to meet high environmental standards and have low embodied energy. It includes a cross-laminated timber frame and a palette of natural materials.

- Stage 4 of the BSRIA Soft Landings handover framework was piloted at Bessemer Grange. This framework is intended to run alongside procurement, and aims to provide the feedback and feed-forward necessary to close the gap between design and actual performance. The framework, published by BSRIA in 2009, which was borne out of the PROBE post occupancy studies and the idea of sea trials[1] for buildings.

- The TSB brief is close to some of Architype's wider concerns and interests. Architype was already collaborating with Oxford Brookes on a two-year programme of post-occupancy studies in school buildings, with the aim of developing a cost effective way of integrating post-occupancy input into the standard professional service.

1.3 Report Structure

The report is structured into 12 chapters, each with numerous sub-divided sections. Chapter 1 provides an introduction, background and an executive summary. Chapters 2 & 3 provide a descriptive explanation of the building including it's design, delivery, systems and services. Chapters 4, 5, 6 and 7 provide analysis of the primary data sets (see details below). Chapter 8 looks in more detail at several technical issues, which were considered noteworthy or interesting. Chapter 9 provides details of feedback given to the client and end user and chapter 10 relates the findings from Bessemer Grange back to the TSB brief and wider concerns. Chapters 11 and 12 provide details of references used, a bibliography and list of appendix information.

1.4 Methodology

This report has tried to add to the body of knowledge in this relatively new field and has been a multi-disciplinary task, requiring the development of new approaches.

The following techniques and primary data sources were used:

- Building User Survey (Arup);
- Thermographic Survey;
- CIBSE TM22 Energy Analysis Tool;
- Electrical Energy Data Logging;
- Heat Meter Data Logging;
- Water Consumption Records;
- Gas and Electrical Utilities Bills and Historical Meter Readings;
- Temperature Data Logging;
- Daylighting Analysis;
- Indoor Air Quality Data Logging, including Carbon dioxide ($C0_2$) & Volatile Organic Compounds (VOC);
- Forensic Walk Through;
- Semi Structured Interviews;
- Embodied Carbon Analysis;
- Air Pressure Testing.

Wherever possible best endeavours were made to ensure the accuracy of information. Hoowever, this new field of study and therefore some inaccuracies may exist due to unreliable equipment, calibration problems and or human error. Further data and details of methodologies can be found in the appendices. Please refer to chapter 12 for further details.

[1] *A sea trial is a term commonly used in the ship-building industry when newly completed vessels are tested at sea for anything up to several years.*

1.5 Executive Summary

Overall, this study shows that the erection of the New Building and simultaneous part refurbishment of the Old Building were highly successful and popular. The New Building scored in the top 5% of all buildings surveyed in the Building User Survey (BUS) by Arup (2013) for overall comfort and performance and scored highly across the overall score index's see Fig.1.5.1 and 1.5.2. The New Building is light, offers comfort and a pleasing aesthetic and an excellent learning environment. It has represented a significant renewal and stimulated plans for expansion. The Old Building's popularity, due to its simplicity and generous space and storage has also experienced a revival. See chapter 5 for more details.

The New Building was designed with high environmental values in mind. Design ambitions have been realised in terms of low gas consumption, see chapter 6, and a low embodied carbon footprint, see chapter 7, as a result of the strategy to adopt a well-insulated timber construction coupled with natural ventilation.

However, there have also been disappointments as well as avoidable shortcomings, such as excessive energy usage within the building because of a convoluted pipe distribution solution for heating and hot water. See section 8.2. New technological systems often did not give the anticipated output. For example, the solar thermal system performed poorly due to its configurations with existing systems. See section 8.3. Also, electrical consumption was higher than expected because of over specification, longer patterns of use and high base loads. See section 6.1.

The school did not have a strong motivation to take custody of the energy performance of the building. See section 10.1. The building's relative energy efficiency was difficult to ascertain due to a lack of realistic operational targets and transparent metering. There was also little financial incentive to cut energy costs as these represented only 2% of the annual budget. Due to the fact that the Old Building accounted for 80% of Bessemer Grange's operational carbon footprint, it needs to be the focus for significant upgrades in the future if radical reductions in emissions are to be achieved.

In retrospect, several shortcomings were identified which are applicable to many buildings. Effective natural ventilation and ensuing comfort levels were not fully realised because of counter intuitive and fragile controls, as well as a lack of user-friendly in-situ information. Indeed, the flow and survival of the information essential to the operation of the school was problematic.

Insufficient storage and congested draught lobbies frustrated users in the New Building. The reception office in both the New Building and the Old Building overheated and experienced congestion. This led to the retrofitting of a less than desirable reception area in the New Building. See section 5.3. The facilities management team also felt that the maintenance of 'green technologies' were too costly and onerous with certain accessories being too fragile for a school. See section 4.7.

A number of persistent problems and reasons for dissatisfaction only came to light as a result of the 6-week Soft Landings (Bunn:2009) residency and this BPE study. This included identifying the origins and source of energy wastage.

It became clear that an improved process was required that could incorporate user feedback to solve persistent problems. This process would ensure that such problems were avoided or corrected and that the knowledge gained could be fed back into future design. Soft Landings provides such a process, the wider application of which will create a suitable bank of knowledge and a reference point to raise standards. Soft Landings needs to be 'operationalised' so that it can become more accessible and affordable; it should be applied from a project's inception right through to post occupancy and have an appropriate financial contingency in place.

This study has resulted in significant up skilling of all who have been connected to it. It shows that if we are to significantly reduce the environmental impact of our buildings, this study shows that standards can and need to be raised in the design, construction and operational management of a building.

A summary of key findings and metrics follow overleaf; a more comprehensive discussion of the wider learnings is given in chapter 10.

1.51 Summary of Key Findings Relating to the School Sector and Beyond:

1. Consultation served to provide crucial information for the design team and helped create more appropriate designs. Streamlining user involvement as suggested in the James Review (2011) may be to the detriment of the quality of design, construction and as-built performance;

2. Developing a knowledge bank of case studies based on built construction projects could be highly useful in order to inform clients and designers of some of the problems that can occur and may improve value engineering processes as well as the quality of future designs;

3. The importance of good storage in schools was highlighted;

4. The need to manage a complex stop start design and construction process with a high turnover of staff was highlighted. Utilising techniques such as BSRIA BG27/211 Pit stopping (Bunn:2011) and 're-briefing' could assist in this;

5. Energy saving was not seen as a day-to-day priority for the school. Further incentives or penalties will be required if schools are to reduce energy consumption;

6. The Old Building at Bessemer Grange had many positive attributes and was well liked by staff. If the environmental performance could be upgraded then retaining the facilities may offer good value for money. This may be the case at other schools. In education projects more strategically targeted funding, time and the use of user feedback to assess what is worth retaining and what requires replacing is needed;

7. Better predictions of operational energy usage are needed if schools are to be empowered to take control of their energy use;

8. The range of different environmental programmes and assessments (EPC's, DEC's, BREEAM, CRC etc.) was seen as highly confusing. Simplifying regulation and ensuring better enforcement could help to reduce energy consumption;

9. Greater focus is needed on the design of metering strategies so that they are understood clearly and can be related back to predictions. Consideration should be given to linking readings to visual displays and linking them to mobile devices;

10. Electrical consumption was high in both buildings studied. Reducing consumption in new buildings with a high density of equipment is a challenge. As lighting was the biggest consumer – more research and careful design is needed in developing passive design strategies which maximise and balance natural light, avoid overheating and incorporate daylight dimming.

11. A high proportion of electricity is consumed when no-one is using the building. Further research is needed into reducing consumption of electricity from base loads;

12. The solar thermal system at Bessemer Grange had numerous problems and could not be monitored. On future projects the useful yield output with graphical displays for renewable systems should be included as a minimum to ensure systems such as this are to be operated and maintained effectively;

13. Technology needs to be employed with discrimination. Only appropriate technology should be used in schools where maintenance support is limited. In general simple-to-operate and robust controls should be installed and fragile automatic systems should be avoided;

14. The impact of high occupancy/density areas on ventilation design should be considered, particularly in reception and office areas. 'Reality check' overheating results;

15. Designers must prioritise the design of windows, their controls, signage and shading. Getting the intricate detail right has a far reaching impact on the environment of the building including glare, overheating, good daylight and CO_2 levels;

16. Greater emphasis needs to be placed by engineers on designing MEP systems for simple control and 'commissionability' – rather than just considering capacity and cost;

17. Manufacturers need to work to simplify systems and provide more standardised components in order to improve quality in the industry;

18. Information provided to users at the end of a project is often very poor. There is a need for better and clearer information provided, such as a suite of linked documents and signs, so that users can be empowered to control and maintain their systems effectively;

19. The cost of maintenance of buildings needs to be given greater importance by designers with estimates produced at design stage;

20. More training and support needs to be given to facilities managers if they are expected to manage the reduction in energy and carbon in the buildings they oversee;

21. If the government is to meet its commitment to carbon reductions, the role of embodied carbon should be given a greater priority as it makes a significant contribution to carbon emissions now, whereas operational carbon savings may occur much further in the future or never be realised.

1.52 Summary of Key Findings Relating to Post Occupancy Evaluations and Soft Landings:

1. Post occupancy studies need to be clearly focused and have specific objectives to avoid brief creep which can make them unaffordable;
2. Designing buildings with monitoring in mind and equipment in place would significantly reduce the cost of post occupancy work;
3. Utilising post occupancy tools such as CIBSE TM22 and TM54 as design tools would help reduce costs, as post occupancy could become a verification process rather than a laborious data entry process;
4. Using a few well-focused techniques can reveal the majority of findings. Too many investigations can convolute the process;
5. There is a need to standardise and benchmark post occupancy approaches and techniques to reduce costs and allow greater access;
6. Universities and government should continue supporting detailed post occupancy as it is currently seen as unaffordable by the industry. Universities should also include post occupancy techniques as part of their syllabus.
7. The development of case studies which apply Soft Landings from inception to post occupation, would be very useful to demonstrate value to clients;
8. There is a need to refine the Soft Landings methodology to make it more accessible and include additional tools and resources to assist early adopters;
9. There is a need to persuade clients and funders of the importance of embedding a Soft Landings/post occupancy approach into a project from the outset as a central thread. Designers may have to take the lead on this;
10. Focus should be given to the development of rapid and effective post occupancy methods that can be used in practice. The TSB Building Performance programme has provided a useful start to this process but this needs to be followed up and supported if it is to take route into the industry;
11. There needs to be a development of knowledge sharing platforms to ensure data and lessons learnt from post occupancy studies can be shared with a wide audience. This needs to be supported by institutions and universities.

1.53 Summary of Key Metrics:

The following two pages provide a summary of key metrics collected as part of the BPE study.

New Building- Key Metrics

Date Completed	2010
Construction Cost	~£1.6m
Floor Area	685m^2
Cost per m2	£2,335
Post Occupancy/Soft Landings	6-week residency (Soft Landings Stage 4 pilot) TSB BPE Study
Embodied Energy	491 kgCO_2e/m^2 - Cradle to Gate [Stages A1-3]

Airtightness

Specified @ 50 pa Permeability	**Tested 2010** @ 50 pa Permeability	**Tested 2013** @ 50 pa Permeability
10 m^3/ (m^2.h)	5.7 m^3/ (m^2.h)	6.47 m^3/ (m^2.h)

Monitored Operational Energy & Carbon Performance (2011-2013)

	Energy per annum	**Carbon** per annum	**Energy** per annum	**Carbon** per annum
Gas	42,470 kWh	62 kWh/m^2	8,220 kgCO_2	12kgC0$_2$/m^2
Electricity	26,030 kWh	38 kWh/m^2	15,0070 kgCO_2	22kgCO2/m^2
Total	**65,500 kWh**	**100 kWh/m^2**	**23,290 kgCO_2**	**33kgCO2/m^2**

Break Down of Electrical Energy Usage (From TM22)

Space Heating	**Hot Water Systems**	**Fans, Pumps & Controls**	**Lighting (internal)**	**Lighting (external)**	**Small Power**	**ICT**	**Vertical Transport (Lift)**	**Catering**	
0.4	**5**	**0**	**15.3**	**2.5**	**9.3**	**0**	**2**	**3.3**	**kWh/m^2/year**
~1%	~0%	~13%	~40%	~6.5%	~24%	~0%	~5%	~9%	Percentage

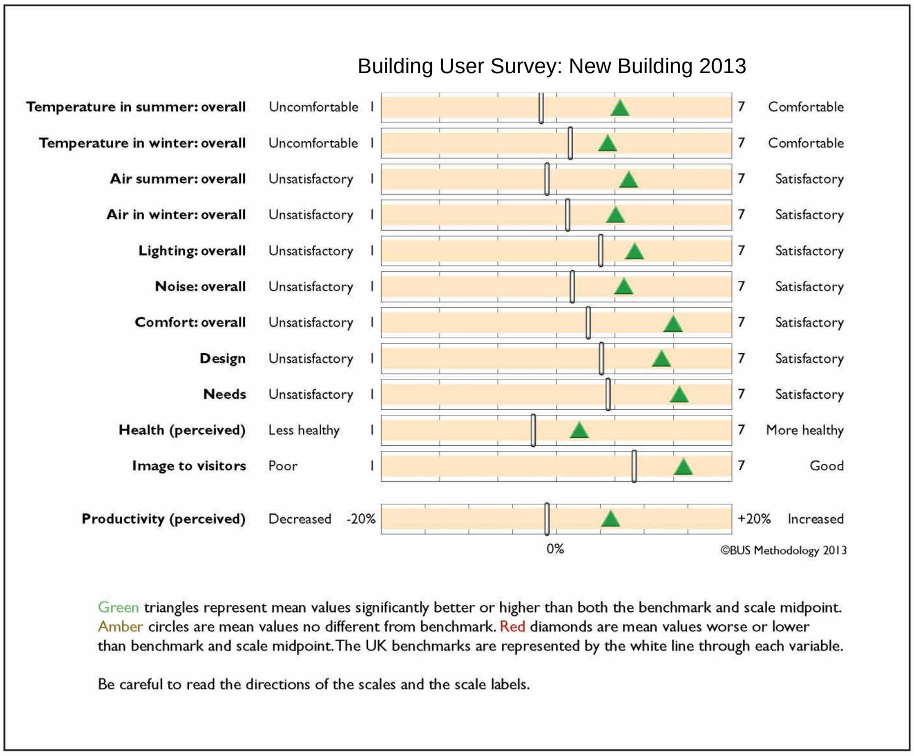


Fig.1.5.1 - Summary of Building User Survey Results- New Building

Old Building- Key Metrics

Date Completed	~1950
Construction Cost	Unknown
Floor Area	3050m2
Cost per m^2	Unknown

Post Occupancy	TSB BPE Study
Embodied Carbon	Not Calculated
Airtightness	Not tested. However, thermal imaging indicated poor airtightness

Monitored Operational Energy & Carbon Performance (2011-2013)

	Energy per year	**Carbon** per year	**Energy** per year	**Carbon** per year
Gas	484,035 kWh	158.7 kWh/ m^2	8,220 kgCO_2	30.8kg CO_2/m^2
Electricity	107, 970 kWh	35.4 kWh/ m^2	15,0070 kgCO_2	19.5kg CO_2/m^2
Total	**592, 005 kWh**	**193.4 kWh/ m^2**	**23,290 kgCO_2**	**50.3 CO_2/m^2**

Break Down of Electrical Energy Usage (From TM22)

Space Heating	**Refridge -ration**	**Fans, Pumps & Controls**	**Lighting (internal)**	**Lighting (external)**	**Small Power**	**ICT**	**Vertical Transport (Lift)**	**Catering**	
2.2	**3.9**	**2.8**	**14.8**	**3.5**	**3.5**	**0.3**	**0.8**	**3.3**	kWh/m^2/year
~6%	~11%	~8%	~42%	~10%	~10%	~1%	~2%	~9%	%

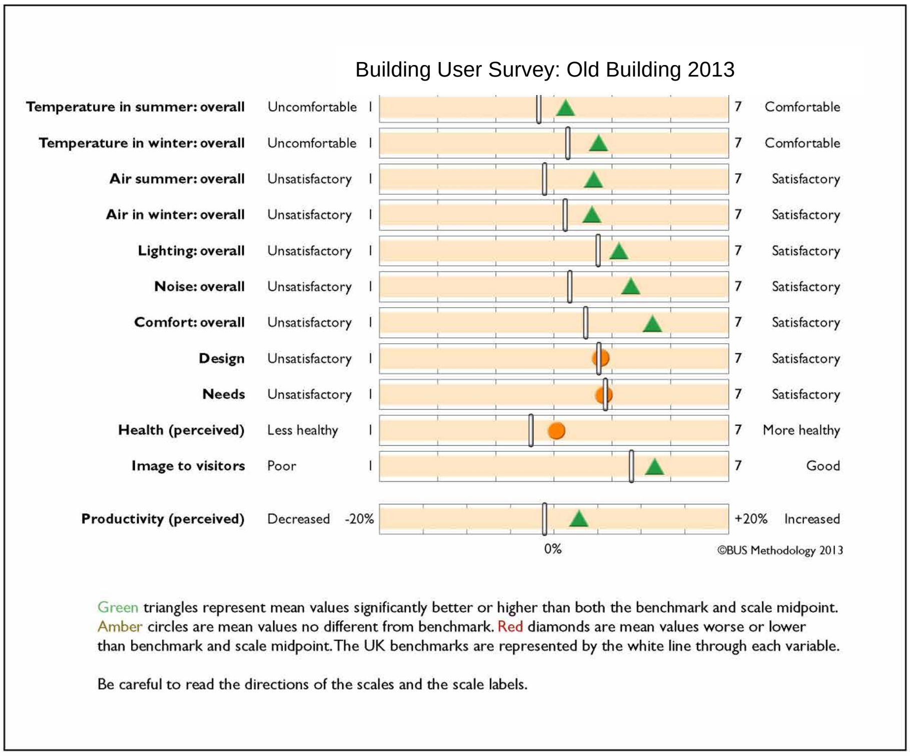


Fig.1.5.2 - Summary of Building User Survey Results- Old Building

2 Description of the Building, Its Design, and Delivery

2.0 Chapter Introduction

This chapter provides a descriptive overview of the project detailing it's location, design, delivery and cost.

2.1 Site and Location

Bessemer Grange School is located off a minor road in a suburban area of South East London in the London Borough of Southwark. The site is surrounded to the South and East by extensive playing fields owned by nearby institutions. To the North and West the area is largely residential. See Fig 2.1.1. The site is mainly accessed by pedestrians, and is located a short walk from North Dulwich and East Dulwich railway stations.

The New Building is a two-storey new build extension completed in 2010 that connects to the 1950's built Old Building and together they now make up Bessemer Grange.

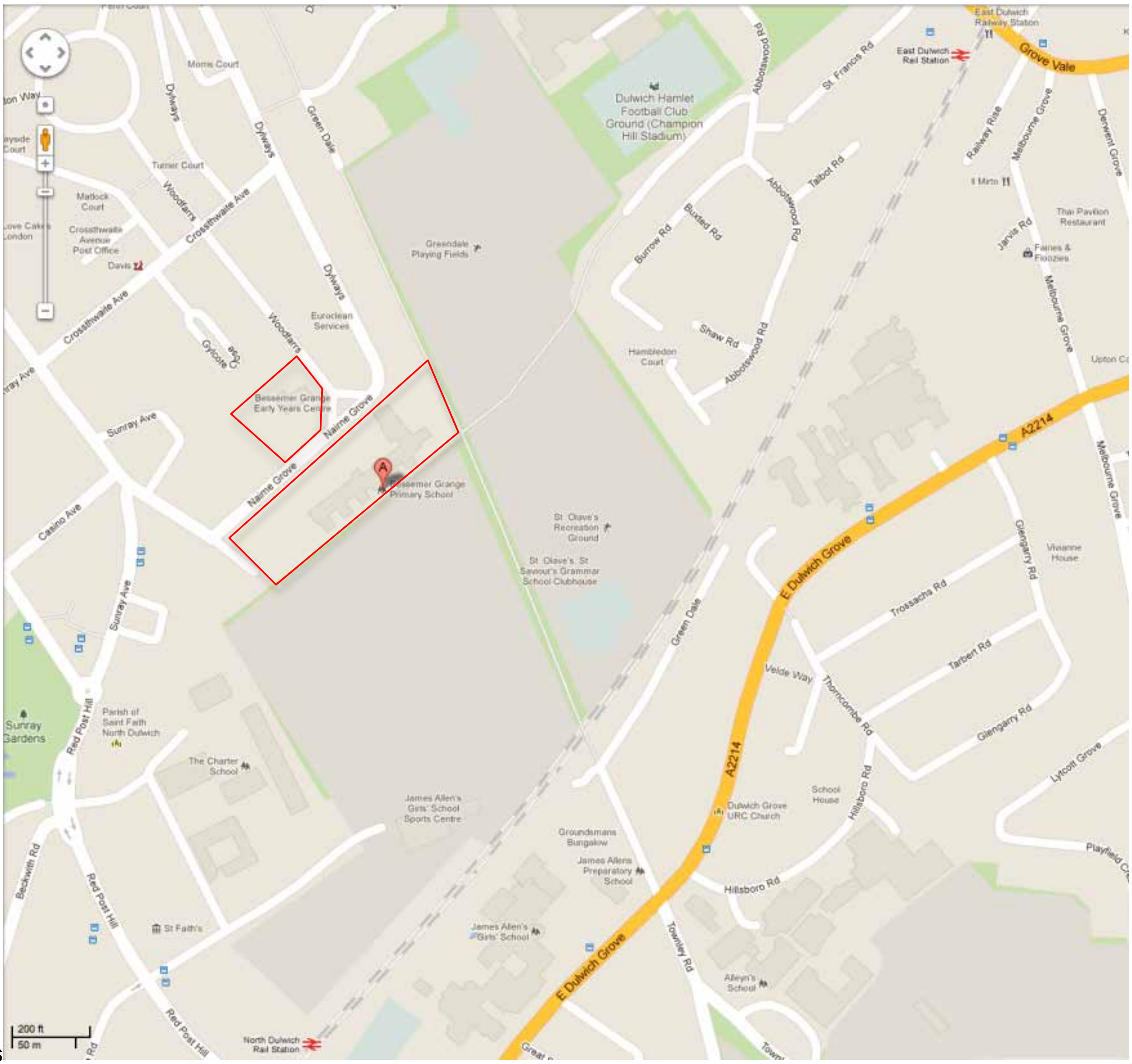


Fig 2.1.1 - Location Map of Bessemer Grange School – The site is identified in red

2.2 Background

Bessemer Grange School

Bessemer Grange is a two-form entry Primary School. It's campus was originally split by a residential road, with the main buildings occupied by Key Stages 1 and 2 on one side of Nairne Grove and the Early Years Centre housing the nursery and reception classes on the opposite side. See Fig.2.2.1. The original Early Years Centre buildings were lightweight constructions erected in the 1950s. In 2007 due to their poor condition, the local authority, Southwark Council, undertook a feasibility study looking at the whole site to consider options for replacing or repairing the Early Years Centre.

This study concluded that the Early Years Centre buildings were beyond economic repair, and that its direct replacement was not desirable because of the road crossing the site. Southwark therefore opted to construct a new extension to the existing school to house this fully. Local authority funds for the project were insufficient to fund the whole project and therefore the council looked to secure further funding via the Sure Start Programme, which attracted central government capital.

The Sure Start Programme

The Sure Start programme was a leading initiative of the previous Labour Government. It sought to deliver the best start in life for every child by bringing together childcare, early education, healthcare and family support. Local Authorities were given strategic responsibility for the delivery of new Children's Centres to house these services.

Southwark identified a gap in service delivery in the Herne Hill ward of Camberwell and Dulwich. As Bessemer Grange was well established in that area the council chose to combine the erection of a new extension for the school with the provision of a new Children's Centre.

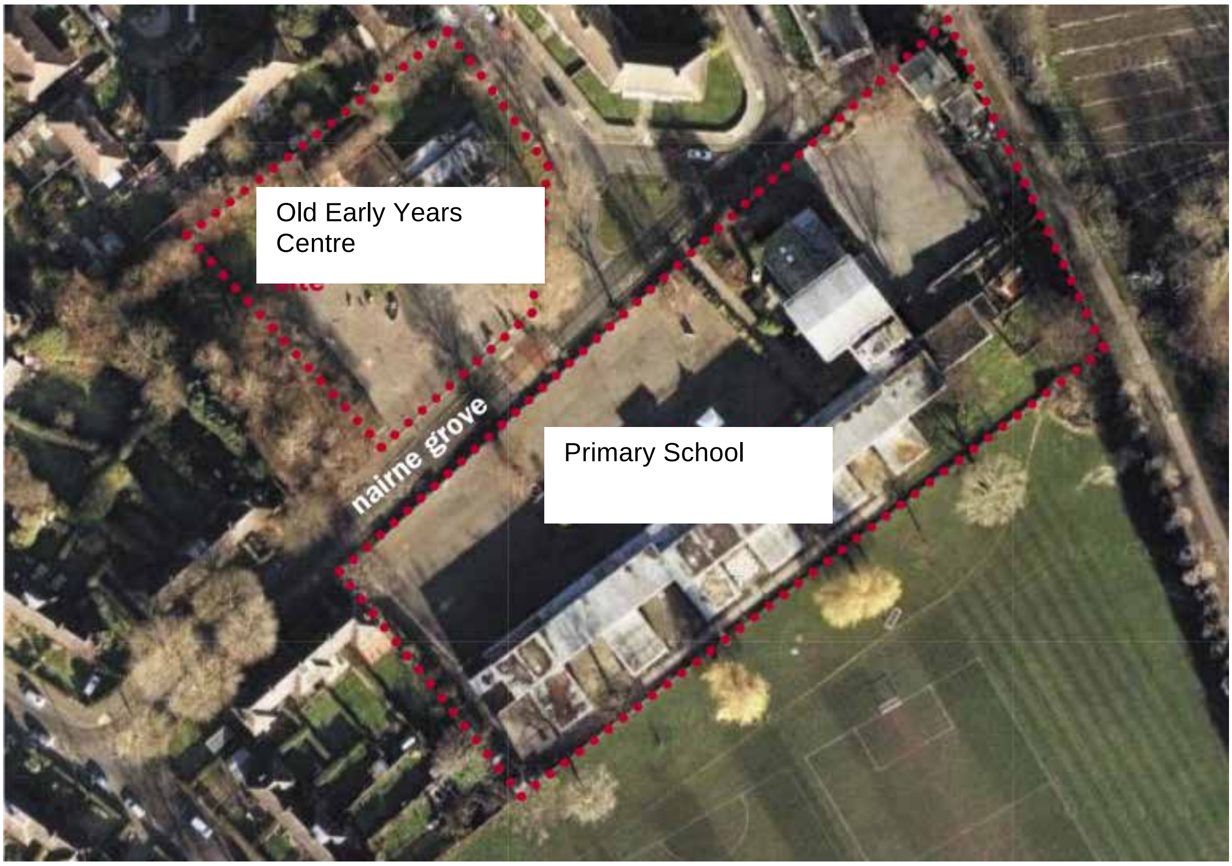


Fig 2.2.1 - Satellite photo of Bessemer Grange, prior to the New Building's erection, showing the two part of the site divided by Nairne Grove.

Fig 2.2.2 - Photograph of the Old Building prior to the erection of the New Building. The image shows the large expanse of tarmac which formed the main playground as well as the 'dreary' concrete panel façades.

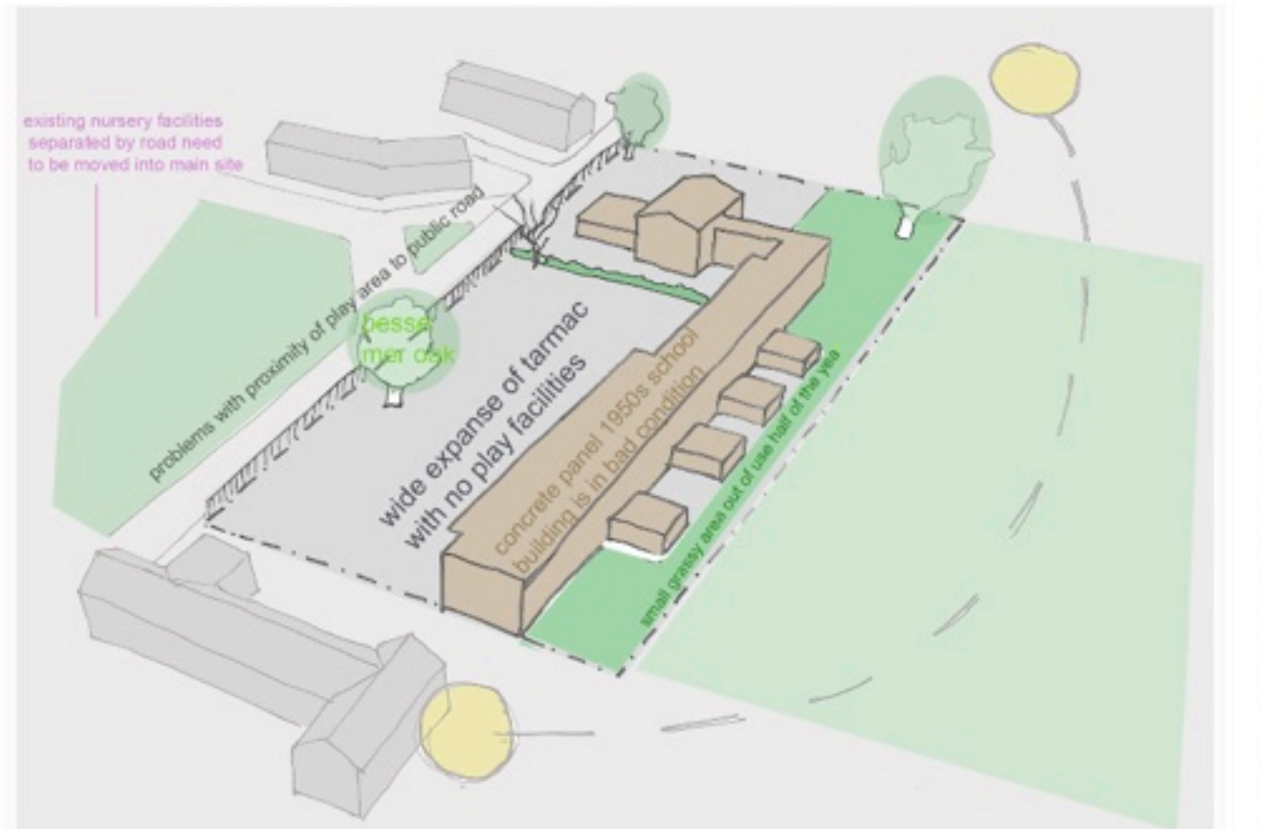


Fig. 2.2.3 - Site analysis diagram of the Old Building prior to the erection of the New Building. The diagram shows the large expanse of tarmac, the location of the Bessemer Oak tree and the East-West sun path.

2.3 Existing Early Years Centre Site

After the erection of the New Building, the council planned to dispose of the site on the opposite side of Nairne Grove, which had previously housed the Early Years Centre in order to raise funds. However, the sale was prevented for legal reasons.

In 2013, with a newfound popularity and the growth in demand for primary school places, this same site was chosen for a one-form entry expansion of the school to house years 5 and 6 pupils. Further details are given in section 9.4.

2.4 The Old Building's Facilities

The Old Building is constructed from a prefabricated steel frame in-filled with concrete panels. It is a two-storey building organised around a 90m long central axis corridor which runs North East – South West in parallel to Nairne Grove. See Fig.2.5.1 and Fig. 2.5.2 overleaf for details. Classrooms and other facilities are located off this route, with a large hall and kitchens at the North East corner. In total it has a floor area of $3600m^2$.

It caters for up to 450 pupils and approximately 50 staff including teaching, support and non-teaching staff. It currently operates as two-form entry school including 12 teaching classrooms, 3 bulge classes, numerous small offices, WCs, music rooms, a library, ICT suites, staff rooms and various ancillary facilities. A number of refurbishment works were included in the contract for the New Building, which are identified in the diagrams overleaf. These included a new entrance area, new doors to provide better external access in several locations, new WCs to replace defunct existing toilets, some new radiators, some redecoration and an upgrade to external landscape areas.

2.5 The New Building's Facilities

The New Building physically divides the Children's Centre on the first floor from the Early Years Centre on the ground floor; both are linked to the Old Building.

The Early Years Centre, see Fig.2.5.1, has two nursery and two receptions classes, accommodating up to 120 children and approximately 15 members of staff including non-teaching staff. Other facilities include a staff workroom, shower room, laundry room, sensory room, toilets and storage facilities.

The Children's Centre, see Fig.2.5.2, houses a Crèche for circa 20 babies, a clinic for health visitors, a training room, some small meeting rooms/offices at the disposal of the public as well as a kitchenette, a plant room and toilet facilities. It's entrance is on the ground floor and is accessed via a covered external canopy. See area highlighted with a pink line on Fig.2.5.1.

Details of the New Buildings' construction are given in section 2.10.

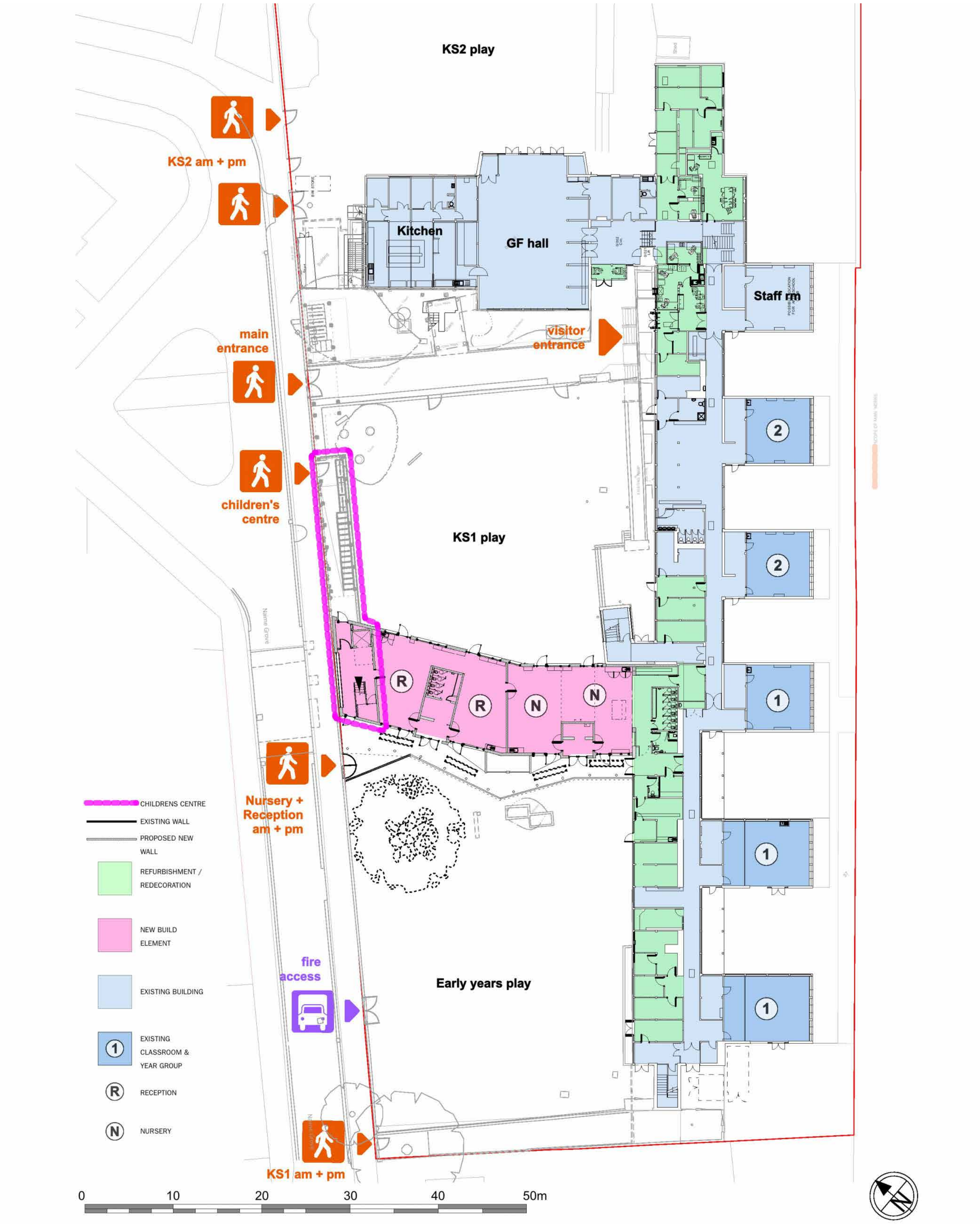


Fig. 2.5.1- Ground Floor Plan of the 'Bessemer Grange' site - showing the New Building in pink

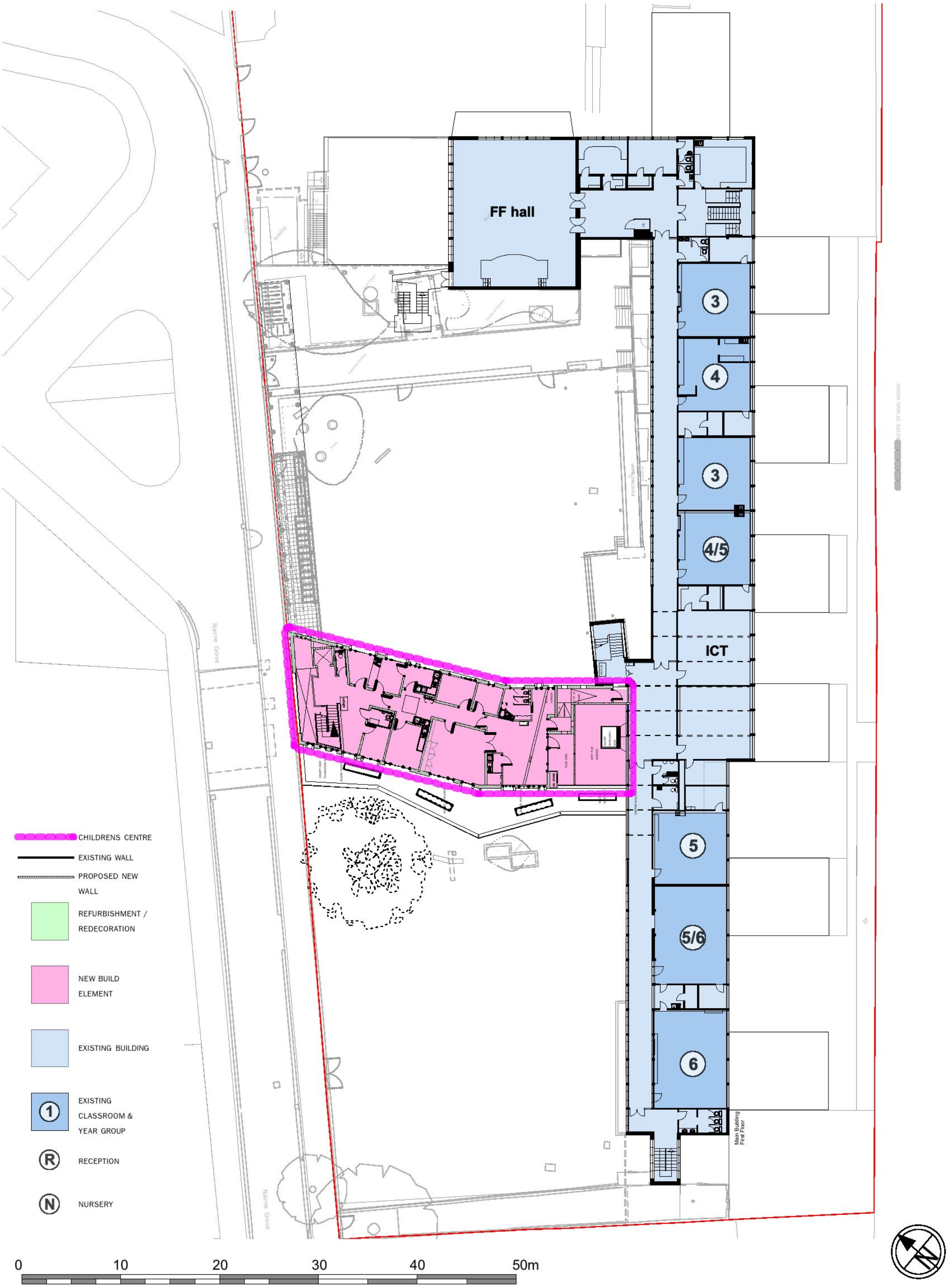


Fig. 2.5.2- First Floor Plan of the 'Bessemer Grange' site - showing the New Building in pink

2.6 Consultation for the New Building

Taken from semi-structured interview with Ben Humphries, project architect (RIBA stages C-G) and from the Design and Access Statement submitted as part of the original planning application.

Fig 2.6.1 – Photographs showing Architype's design consultation with the school children

Consultation was a key part of the design process and was conducted at a number of different levels. As part of the feasibility process, the project team visited a number of different early years environments to see what might be possible, as well as visiting some Architype early years projects. This exercise helped greatly in the development of the brief, and also persuaded the user client that a more healthy, non-toxic, specification should be prioritised.

From these early stages through to detailed design, regular project meetings were convened of the project steering group to review and agree design development. The steering group included members of the design team; Bessemer Grange Primary School, with representatives from senior management, facilities, governing body and early years; Southwark Council's Children's Services Property Team and Early Years and Afterschool and Play Team, as well as Southwark Primary Care Trust.

The consultation process also included more specific workshops with the Early Years manager to ensure that the design conveyed a sense of fun and the material selection was appropriate for early years' environments. Specific consultation was also undertaken with Southwark Primary Care Trust regarding the consultation room within the Children's Centre.

A pupil participation exercise was also undertaken with Key Stage two pupils, which looked specifically at the landscaping proposals for the site. With help from the design team, school staff and a local filmmaker, pupils were divided into groups to formulate proposals and create models for various aspects of the site. See Fig.2.6.1. Some of the ideas generated during this exercise were integrated in the design process.

In September 2007, two major community consultation exercises took place where members of the project steering group presented the scheme drawings, a 3D visualisation and a physical model of the scheme. The local community had previously been leafleted and adverts placed in the local press. Parents, carers, pupils, school staff, governors and local ward councillors were also invited. Attendance over the two days was high and the scheme was very positively received. Attendees were asked to fill out comments sheets and these comments informed the design process.

With regards to statutory consultations, a number of pre-application discussions were undertaken with the local planning authority; in particular with their conservation department, due to the proximity of the New Building to the Sunray Estate Conservation Area. There was some debate as to whether timber cladding was appropriate for the area and quite a strong argument had to be made about its benefits in respect to low embodied carbon and non-toxic environments for children before it was accepted.

2.7 Design Intent for the New Building

Taken from semi-structured interview with Ben Humphries, project architect (RIBA stages C-G) and from the Design and Access Statement submitted as part of the original planning application.

A number of options for the location of the New Building were investigated across the site. The final decision to position the extension adjacent to the Old Building to the South was taken as it was felt that bringing the Early Years classrooms in close proximity to the school's other facilities would create a safer and more accessible environment.

There was also a strong desire to create a vibrant new profile to a somewhat tired school with a dwindling roll. The design had to be an advertisement of 'change' and was design to act as a beacon and hub for the local community. To achieve this, it was felt that the New Building should be clearly differentiated from the existing school; very contemporary in appearance with bold, fun, colours and clad in softer materials such as timber to act as a counterpoint to the 'dreary' concrete appearance of the existing school. See Fig.2.2.2 and 2.7.4. This thinking also led to the idea that the New Building should face directly onto the road, with the back of the building connecting to the existing school to ensure internal connectivity. See Fig.2.7.2. Another key aim of placing the building in this location was to separate the huge expanse of tarmac that was formerly the KS2 play area into two more intimate play areas; one for the Foundation Centre and the other for KS1. See Fig.2.7.1

The disadvantage of this decision was that it created an East-West facing building, which is not the best orientation in respect of overheating. During the scheme design stage, it was felt that this problem could be surmounted by the use of a number of solar control features such as deep reveals, window surrounds and the early years' canopy. However, some areas on the first floor did overheat. For details please refer to Section 5.6 and 8.5.

The two-storey extension was cranked in plan to create a welcoming entrance to the Early Years Centre and to conserve the mature 'Bessemer Oak tree'. This meant that some of the classroom bases were non-rectilinear. See Section 5.3 for further discussion. However, this was deemed acceptable because room sizes met the BB99 (DfES:2008) guidelines applicable at the time and it was felt that an early years environment could allow somewhat more freedom.

Where the accommodation faced into the Early Years play area, the West facade was opened up at ground level, but covered by an extensive and deep canopy containing roof lights. This area was made into a real feature so that it became an inviting entrance to the Foundation Centre as well as an exciting 'outdoor classroom', allowing external play to take place at all times of the year. See Photo in Fig.2.7.4. At first floor level, windows were set into deep reveals in the external fabric, or set back into projecting boxes to control solar gain.

The Eastern façade was designed in a similar way to the Western facade, with opening windows either set into deep reveals in the external timber cladding, or set back into projecting boxes. The glazing to the South façade at first floor level was similarly set back in a deep reveal.

Sustainability was a key concept, both in terms of operational energy use, materials specified and the creation of a healthy environment. Architype designed an aesthetic that showed its use of natural materials through the use of expressed timber. See Fig.2.7.3. Further details of materials are given in section 2.8.

In terms of ventilation, a simple strategy of opening windows and vents was conceived without the need for a Building Management System (BMS) in order to simplify controls. At ground floor level, cross and stack venting was utilised, while single sided ventilation was employed on the first floor. Further details of mechanical and electrical services are given in chapter 3.

For further details on how the 'design' preformed in use please refer to chapter 5.

Fig 2.7.1 - A 3D visualisation of the New Building showing how its siting helps divide the expanse of tarmac in the playground outside the Old Building in order to create a more diverse outdoor play environment.

Fig 2.7.2 – A 3d visualisation showing how the proposed New Building would create a dynamic new frontage facing onto Nairne Grove.

Fig 2.7.3 – A photo showing the expressed timber materiality of the project.

Fig 2.7.4 – A photo showing the external South-West facing canopy which creates and outdoor classroom. The bright colours and use of timber create a bold and welcoming aesthetic.

2.8 Sustainable Design & Materials

Architype, with strong support from the client, set out with the goal of designing a building that performs well environmentally, provides a healthy 'non toxic' environment for children, and uses materials and products which have low embodied energy.

Operational energy:

To reduce operational energy, the scheme was designed with high levels of insulation, high performance windows, and good air tightness; good natural light and natural ventilation.

Under-floor heating was installed to utilise the thermal mass of the slab; a green roof reduced run off and encouraged bio-diversity; and a solar thermal hot water panel reduced the requirement for externally supplied hot water.

For a description of the building's mechanical and electrical services please refer to chapter 3.

For details of how the building performed in terms of operational energy, refer to the energy performance review in chapter 6.

Materials & Embodied Carbon:

Embodied carbon is the accumulated historical carbon used in all stages of manufacturing and marketing a product: from raw materials to delivery to site. See section 7.1 for more details and an explanation of whole life carbon.

With respect to embodied carbon, Architype drew on their experience and consulted with manufacturers in order to specify materials that could be locally sourced and required less energy and carbon emissions to manufacture.

Cladding: Thermowood timber cladding (FSC sourced)
Render: Baumit Lime based render system
Insulation: Steico Special – Recycled wood fibre insulation
Structure: KLH cross laminated timber (FSC sourced)
Internal linings: Exposed KLH and Fermacell board (made from recycled gypsum)
Carpets: InterfaceFlor Transformation tiles – the pile is made from recycled solution dyed nylon
Sheet flooring: Nora natural rubber flooring (None PVC)
Vanity units/Worktop: Smile plastics recycled plastic
Paints: Natural Building Technologies – natural paints
Stains: OSMO natural woodstains

For details of how the building performed in terms of embodied carbon/whole life carbon please refer to section 7.

Healthy Environment & Non-Toxic Materials:

Various reports have shown that toxins used in building products can damage human health and make young children vulnerable to harm (see for example Thornton, 2002). Therefore, Architype specified natural materials, including rubber instead of PVC vinyl floors to avoid concerns over potential carcinogens in PVC products. Additionally natural paints and stains were used in lieu of conventional oil based paints to reduce the amount of toxic chemicals: including Volatile Organic Components or VOCs, which some claim are released as paints dry and which may be harmful to human health.

For details of how the palette of healthy materials performed in use please refer to sections 5.4 and 5.5.

2.9 Performance Targets and Modelling

The following energy models and building fabric performance targets were developed at design stage for the New Building:

Thermal
SBEM (2002 edition), using IES – Apache, BRUKL v2.0), by CBG consultants

This provided the target emissions rate:
15.69 $kgCO_2/m^2$ per annum

Achieved (based on monitoring and TM22 analysis):
33kgC02/m^2 per annum

Target U-values
Architype set the requirements for the u-value of components and ensured they exceed the minimum standards in Part L of the building regulations:

Wall:	0.23 W/m^2 K
Roof:	0.13 W/m^2 K
Floor:	0.13 W/m^2 K
Windows:	1.2 W/m^2 K
Reglit glazing:	1.8 W/m^2 K

Airtightness

- Specified:	10 m^3/ (m^2.h) at 50 pa Permeability/leakage
- Achieved 2011:	5.7 m^3/ (m^2.h) at 50 pa Permeability/leakage
- Achieved 2013:	6.4 m^3/ (m^2.h) at 50 pa Permeability/leakage

Day lighting:
- Daylighting: 3 Dimensional IES model by CBG consultants

Ventilation Overheating:
- CFD & Ventilation: Class Vent & Class Cool by CBG consultants

For details of how the buildings performed in terms of design and environmental conditions including day lighting and temperature please refer to chapter 5.

For a discussion on air tightness detailing refer to section 5.12.

For further details and discussion on how the buildings performed in terms of energy please refer to chapter 6.

2.10 The New Building’s Construction

The New Building at Bessemer was almost entirely constructed from timber and natural materials. The primary structure was formed using a cross-laminated timber frame manufactured in Austria by KLH Ltd. See Fig. 2.10.1. This included timber walls, floor, roof, partitions and glulam beams to support large spans. Cross laminated timber, also known as Glulam, is a type of structural timber product comprising a number of layers of dimensioned timber, bonded together with durable, moisture-resistant structural adhesives *(Wikipedia, 2013).* This method of construction was selected because it promised to improve quality control, increase speed of erection and reduced embodied energy.

The foundations were piled due to poor ground conditions and the ground floor slab was a 225mm thick suspended concrete slab. See Fig.2.10.2. Externally, the building was insulated with Wood fibre insulation and clad with heat-treated timber cladding and lime based render. See diagram Fig.2.10.3. The roof was formed of a timber slab insulated with double density mineral fibre insulation and waterproofed with a PVC free TPE single ply membrane and overlaid with a bio-diverse sedum roof. See Fig 2.10.4.

Fig 2.10.1 – Photographs showing the erection of the cross laminated timber frame in panel form. Due to off site manufacture the entire frame was erected in 10 days.

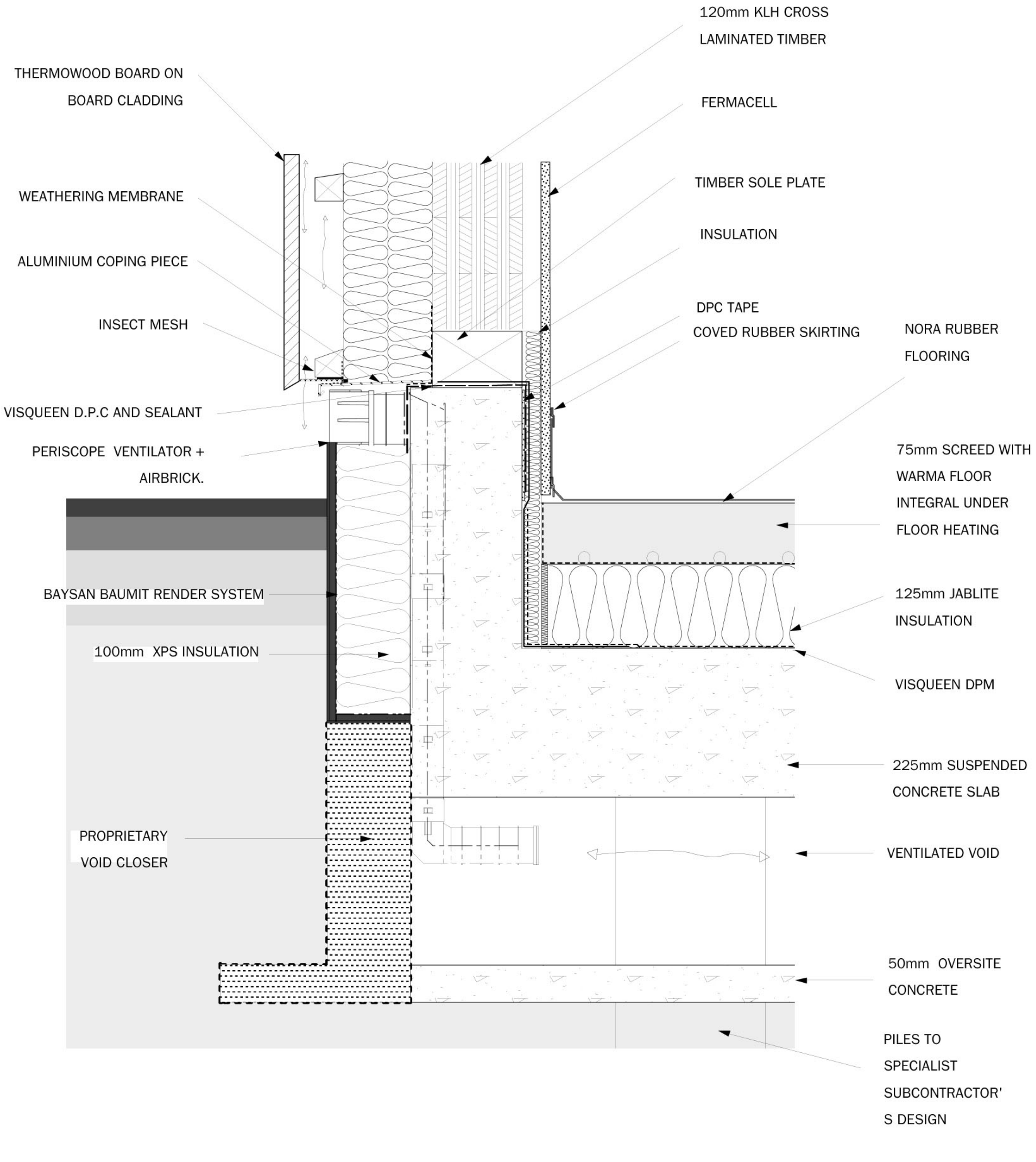
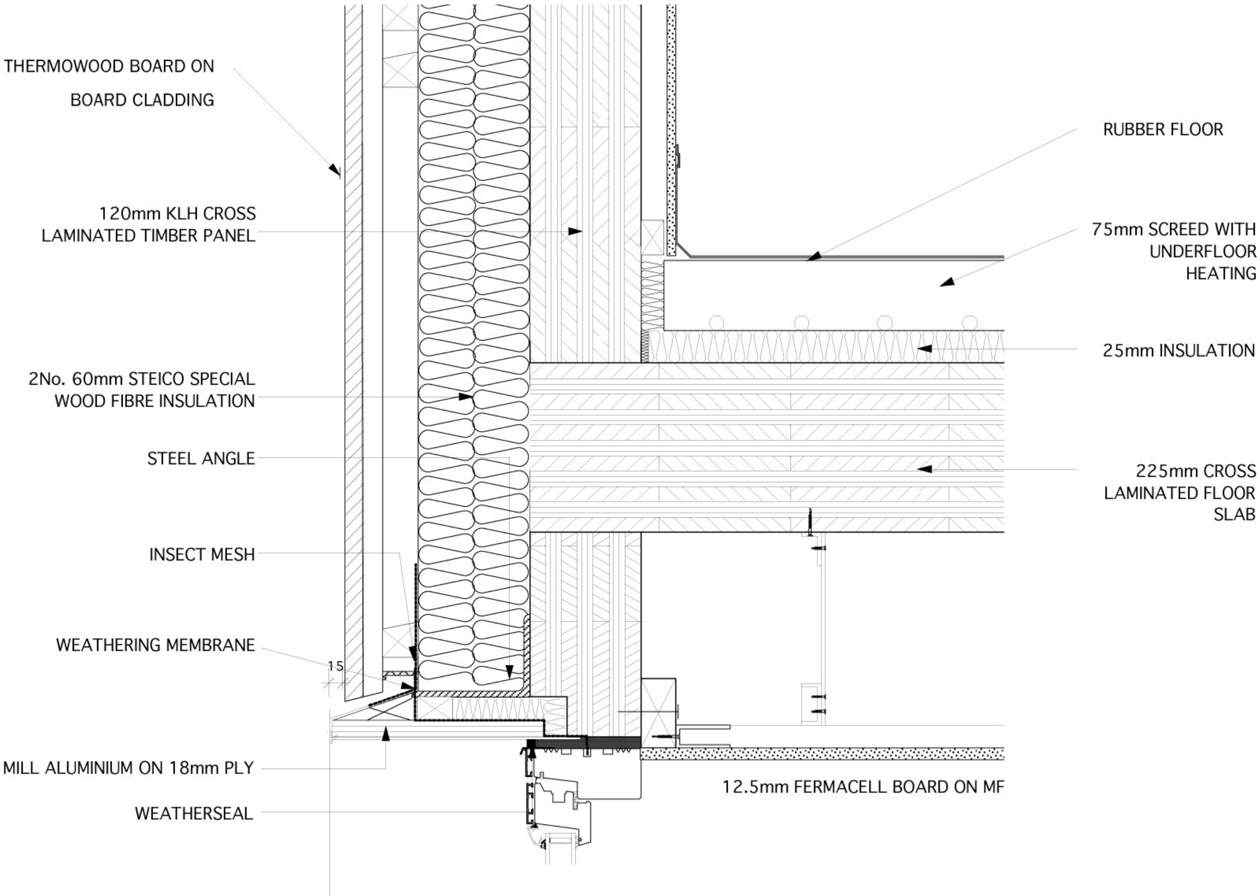


Fig 2.10.2 – Typical Ground Floor Construction Detail – Showing the lime rendered plinth, timber cladding, wood fibre insulation, cross-laminated structure and under floor heating in the screed.

Note- *Some information has been removed from the detail for the purposes of clarity.*



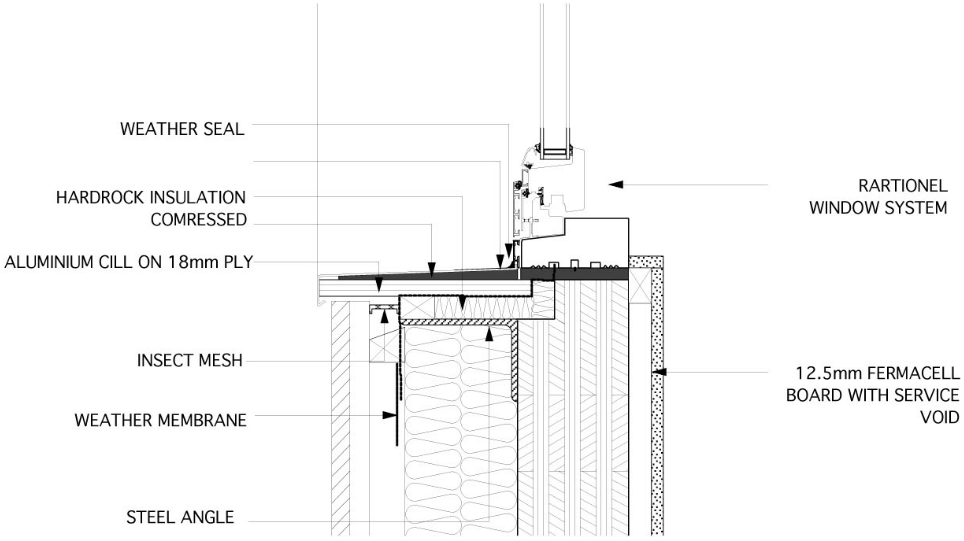


Fig 2.10.3 - Typical Window and first floor Construction Detail- showing timber cladding, wood fibre insulation, Cross laminated timber structure and window installation.

***Note:** Some information has been removed from the detail for the purposes of clarity.*

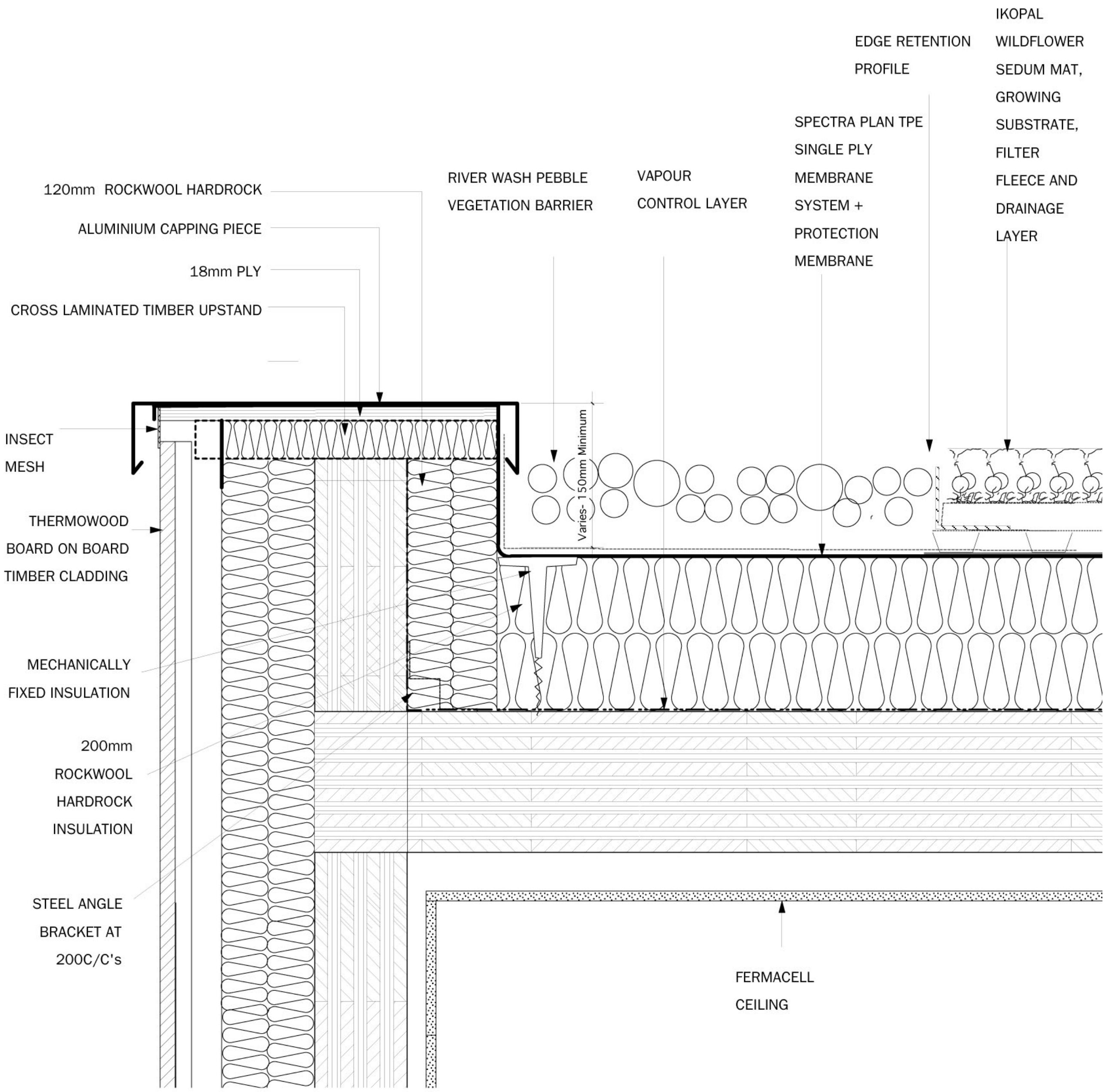


Fig 2.10.4 - Typical Roof Construction Detail- showing timber roof structure and sedum roof.

Note- *Some information has been removed from the detail for the purposes of clarity.*

2.11 Procurement and Cost

The design and procurement of the building assumed a Traditional Contract route.

Contract type:
GC Works /1

New build costs:	~£1.6m
Refurbishment costs:	~£0.6m
Landscaping:	~£0.2m
Contract value:	~£2.3m
Final Account:	~£2.45m

Note. 6% of the 10% project contingency was expended including the agreement of loss and expense for a six-week extension of time.

2.12 Programme & Timescales

Design commences:	April 2007
1st Tender:	February 2008
2nd Tender:	June 2008
Increased funding secured:	June 2009
Construction Started:	July 2009
Construction Complete:	August 2010
End of defects:	December 2011
Extension of time granted:	1.5 months

The project took two years of development before reaching site, twice as long as originally expected. There was a hiatus of approximately one year, during which the project was re-tendered because of cost overruns. However, once on site, the project ran largely on time and was completed within a year.

In all, the project costs overran by 6%, which was within the 10% contingency allowed by the client. This 6% was mainly due to variations relating to unknown risks in the Old Building and costs incurred by delays. The client's quantity surveyor suggested that more intrusive investigations would have led to more accurate design and costing.

Design Development and Tendering

April 2007-February 2008**:**

The project commenced in April 2007 when Architype were appointed to undertake a feasibility study on the site for Southwark Council.

The design development progressed over 6months until a planning application was submitted in October 2007. The detailed design development then followed on and generally progressed well. However, an important issue during this period centred around the upgrading of the Old Building's services. Based on survey information received, the MEP designers proposed replacing all of the internal pipework and pumps for the existing heating system as well as the rewiring of the electrical circuits. The client rejected this proposal on the basis it was likely to cost several hundred thousand pounds. Instead, the client wanted to install new pipework or wiring only where new services were required. This led to later problems due to interfacing between the systems. Furthermore, as part of this drive to reduce cost a decision was made to link the New Building's heating system to the main plant room in the Old Building, as the old boilers had spare capacity. This seemingly sensible decision led to a problem referred to as 'heat creep', see section 8.2.

Following the completion of detailed design, the scheme was tendered in February 2008. The lowest tender came back £363,000 in excess of the £2.3m budget. The client's quantity surveyor reported that the tenders did not represent value for money and recommended that work be re-tendered, with a reduced scope of work and specification in August 2008.

Value Engineering

April 2008 - June 2008:

Over the next three months the scheme was value engineered and many elements of the design were downgraded or excluded. This included the reduction in levels of insulation from 200mm to 120mm, the removal of daylight dimming systems and automated control systems, removal of most of the built-in storage and the omission of extensive sub-metering and display energy metering. Other cost cutting decisions were made such as downgrading the landscaping works, as they were seen as a lesser priority than the new teaching facilities.

The removal of these aspects of the design is implicated in many of the problems identified later as part of this BPE study at Bessemer. This is discussed further in Section 10.

The scheme was then tendered for a second time. Despite a pre-tender estimate of £2.1m, the lowest tender was still £200,000 over budget. Southwark Council then decided not to press for more savings but to approach central government for further funding. This delayed the project for approximately one year.

Funding Secured & Works on onsite

June 2009 - August 2010:

Additional funding was eventually secured in June 2009**.** After a years hiatus many of the original people involved had left the client body or the design team. Once the contractor was on-board, there was an initial rush to agree the design for the KLH cross laminated timber frame. This rush to production meant that several mistakes were made in detailed design and production, which led to disagreements between KLH and the design team. See section 5.5.

In July 2009 the works commenced onsite starting with the refurbishment of the existing reception area and KS1 playgrounds. This continued over the summer holiday and was handed over to the school in September 2009.

Once this phase was completed, the main works for the New Building started. Work continued for just under a year until completion in August 2010. During this period, four smaller elements of refurbishment in the Old Building were also carried out during half terms and holidays in order to minimise disruption to the school.

Figures 2.12.1 to 2.12.6 show the different stages of the erection of the New Building.

Post Completion

September 2010 to current date:

Following practical completion a 6-week Soft Landings Residency took place. Refer to section 4 for further details. Subsequently, Architype applied to TSB to fund a Post Occupancy Evaluation. The application was successful and this research started in January 2011.

Between the end of construction and the period of the POE the management of almost all aspects of the school had changed. Bessemer acquired a new Head Teacher, Head of Governors, Head of Early Years and a new Children's Centre Manager. The main Facilities Manager, who had been closely involved in planning and development, left Bessemer in November 2011. Defects were signed off in December 2012.

Fig.2.12.1- September 2009: The building was formed on a piled suspended slab. The original plan to use an in situ concrete slab was abandoned when soil investigations identified poor ground conditions.

Fig.2.12.2 - December 2009: Photo showing erection of cross-laminated timber frame- This was erected in 10days. Works were delayed due to heavy snow over the Christmas period

Panel shown left in foreground. Note some 'visual grade' panels were later found to be damaged.

Fig.2.12.3 - January 2010: Photo showing external wood fibre insulation and Rationel windows installed.

Fig.2.12.4- March 2010:
Photo showing Reglit glazing and Rationel window installed.

Fig.2.12.5- July 2010:
Photo showing cladding completed. Landscape works progressing.

Fig.2.12.6- Photo of the completed New Building

2.13 Project Team:

Employer/Client:
Southwark Council Children's Services
PO BOX 64529
London, SE1P 5LX
Tel: 020 7525 5000

Architect & Contract administrator:
Architype
The Morocco Store
1B Leathermarket Street
London, SE1 3JA
Tel: 0207 403 2889

Mechanical and Electrical Consultants:
CBG Consultants
151-153 Farringdon Road
London, EC1R 3AF
Tel: 0207 833 8815

Structural Engineer:
Techniker Ltd
Consulting Structural Engineers
13 -19 Vine Hill
London, EC1R 5DW
Tel:020 7360 4300

Cost Consultant/Quantity Surveyor:
Pierce Hill
Warwick House
65/66 Queen Street
London, EC4R 1EB.
Tel: 020 7489 5800

Main Contractor:
Bryen & Langley Ltd
48 - 60 Footscray Road
Eltham, London SE9 2SU
Tel: 020 8850 7775

Mechanical and Electrical Sub-contractor:
Elmec Southern
48 – 60 Footscray Road
Eltham
London, SE9 2SU
Tel: 020 8331 2960

Timber Frame Sub-contractor
KLH UK Ltd.
7 - 9 Woodbridge Street
London, EC1 R0LL
Tel: 020 3031 807

3 Description of Building Services and Energy Systems

3.0 Chapter introduction

This section provides a descriptive overview of the services and energy systems at Bessemer Grange. For details of the in use energy performance review please refer to chapter 6 of this report.

3.1 Building Services Summary

The Bessemer Grange campus is predominantly naturally ventilated with heating delivered from boilers in a central plant room. Mechanical ventilation systems are confined to the central kitchen and a few other areas. The building services are relatively simple throughout, with no BMS (Building Management System) and limited sub-metering.

The New Building, see Fig. 3.1.1 below, has composite double-glazed windows as well as several mechanically actuated roof lights. It is highly insulated. Mechanical ventilation is limited to small local extract fans in toilets, utility rooms and for the cooker hood in a small kitchen. The New Building has under floor heating throughout, with the controls manifolds located in the small plant room on the first floor and in cupboards at ground floor.

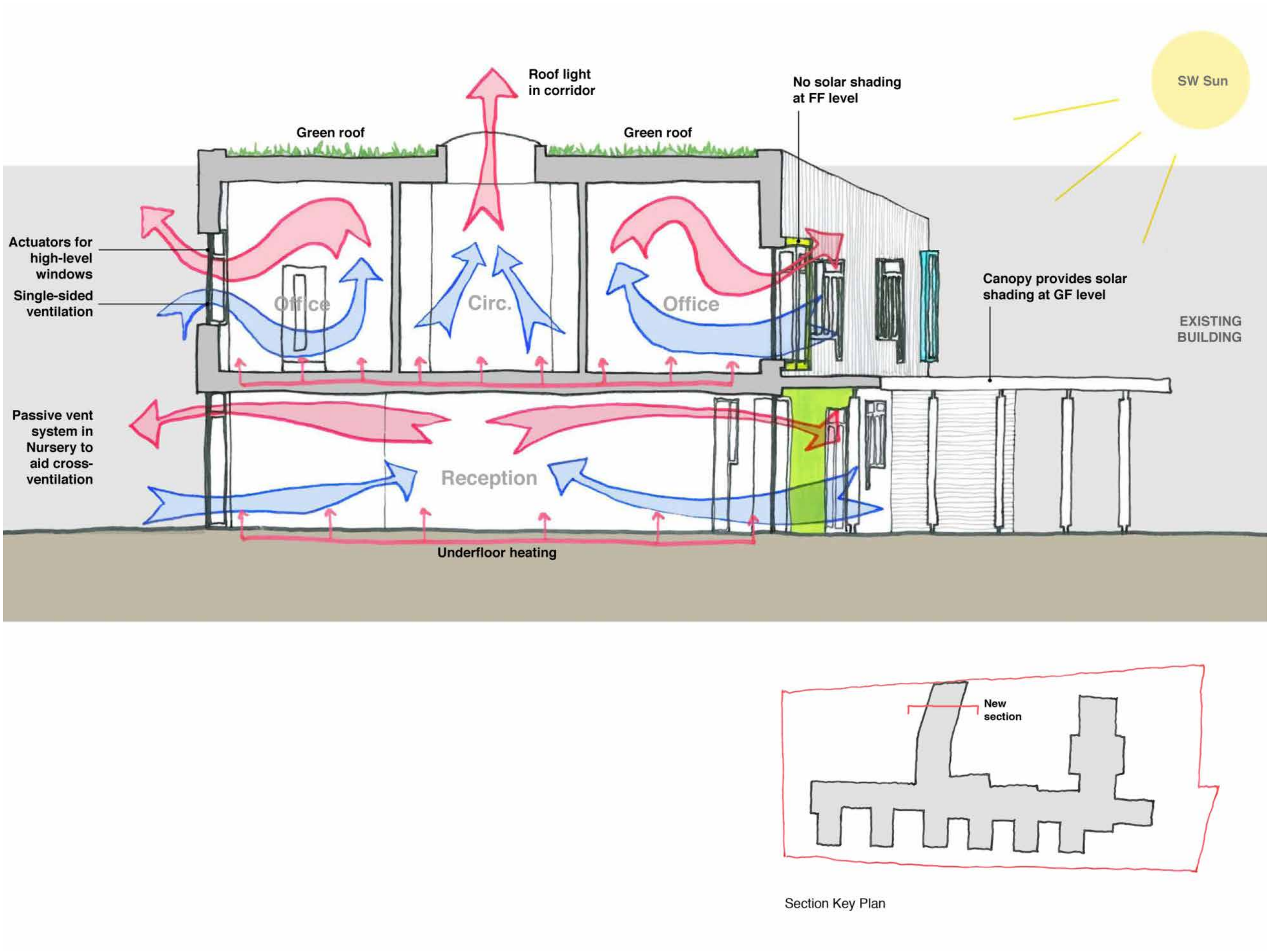


Fig 3.1.1 – The New Building Environmental Section

The Old Building, see Fig. 3.1.2 below, is naturally ventilated by single-glazed, metal framed, predominantly large windows, side-hung and opening outward. It also has some smaller high-level clerestory windows used for summer ventilation. It has poor quality fabric with no insulation in the walls and little in the roof. Mechanical ventilation systems exist in the main kitchen where school meals are prepared, in the underground boiler room and the main school reception and the ICT suite. Space heating in the Old Building is by means of conventional panel and column radiators located in classrooms, rooms and corridors

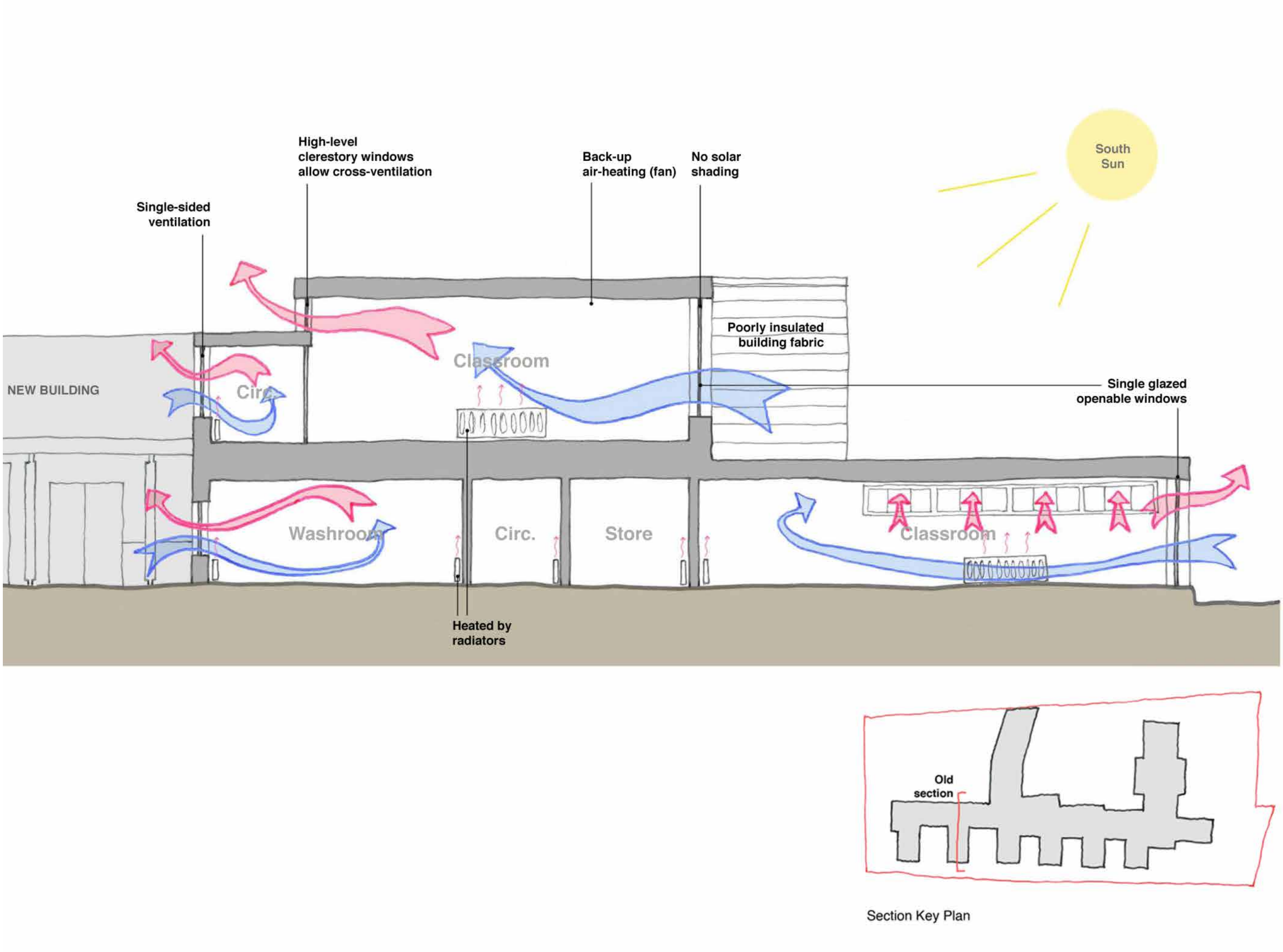


Fig. 3.1.2 – Old Building Environmental Section

3.2 Space Heating Systems

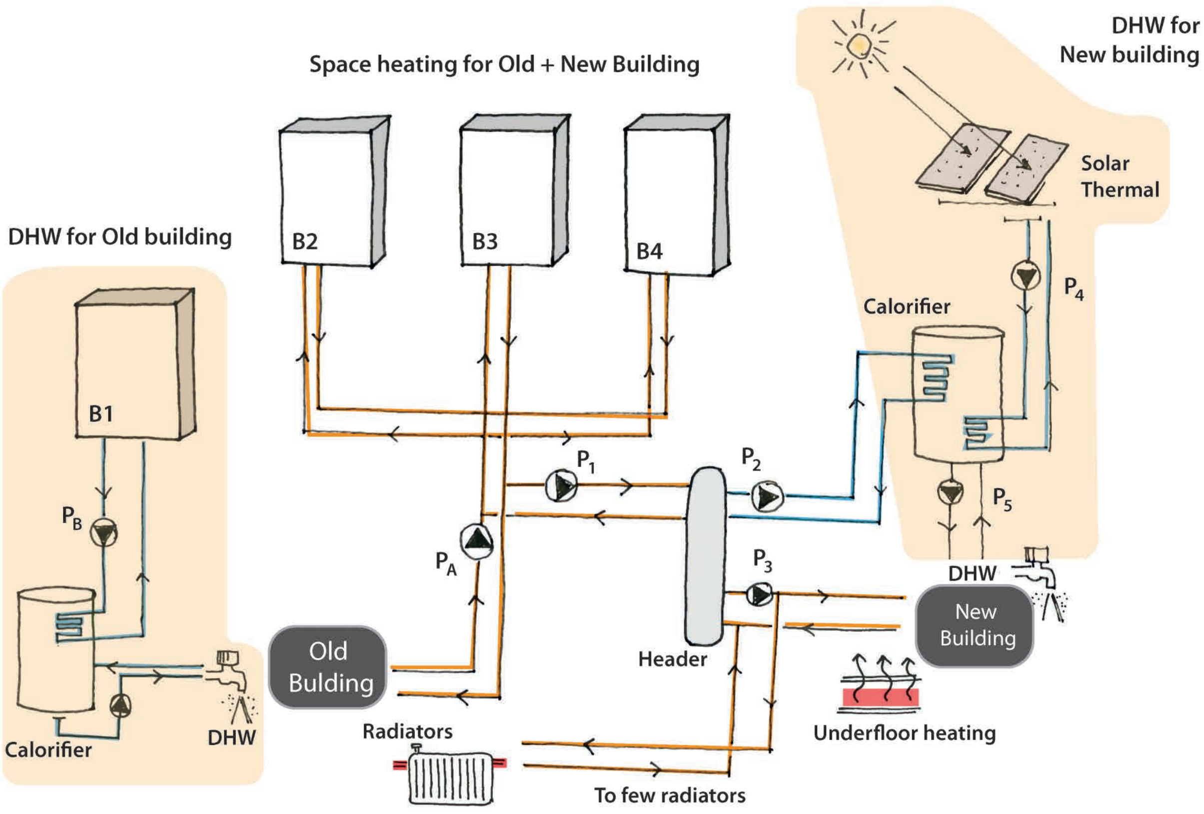


Fig 3.2.1 - Simplified schematic of Bessemer Grange heating system.

An underground plant room in the Old Building contains four Potterton NXR3 gas fired commercial boilers, which provide heating for the whole school. Fig.3.2.1 shows their arrangement; three boilers catering for the space heating of the Old and New buildings and domestic hot water (DHW) for the New Building, the other is dedicated to DHW supply for the Old Building. The boilers are weather compensated, with an external temperature sensor adjusting the supply water temperature downwards on warmer days. A 60m-distribution route takes insulated heating and hot water pipe work through the Old Building to serve circuits in the New Building. See Fig.3.2.2.

These boilers had substantial spare capacity; for this reason, it was decided to extend the existing heating system into the New Building, with the installation of new headers, pump sets and pipe work. There are two separate controls panels for the Old and New Building, both located in the Old Building's plant room.

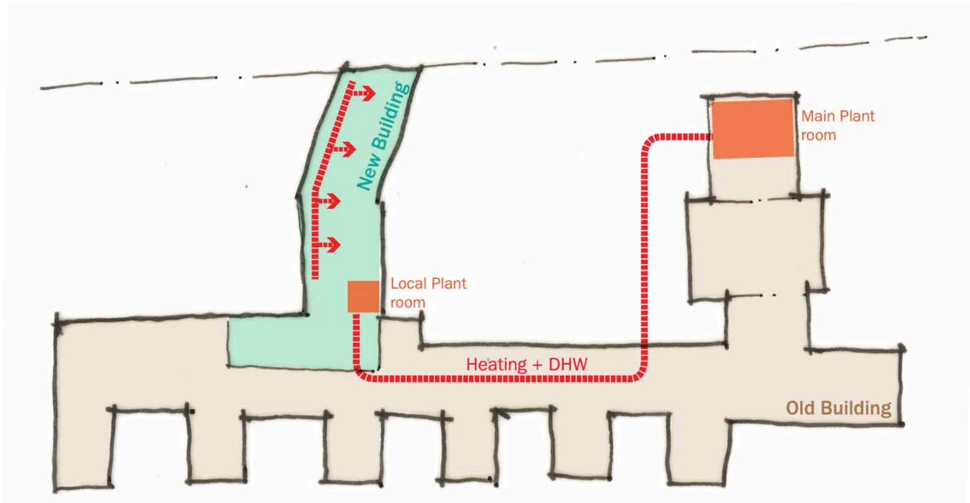


Fig 3.2.2 - Diagram showing the route of the pipework linking the Old Building's plant room to the New Building

New Building

A dedicated control panel with a Satchwell DC1400 Optimizer/Compensator with optimum start function and calendar, controls the space heating and DHW for the New Building and is located in the main plant room of the Old Building. See Fig.3.2.3. The control panel has a mode selection dial that allows selection of 'auto' mode for the heating season and 'summer' mode for DHW supply only during warm periods. In addition, the 'Plant Extension' function on the panel allows manual boosting of the heating for up to seven hours, for example to cover unexpected use at the weekend or during school holidays.

The control panel has:

- Temperature set-points for a reference space in the New Building, including set-backs
- Up to three separate space heating and DHW periods for the New Building for each individual day of the week
- Calendar function to enter annual school holiday schedule
- Display of current reference space temperature, ambient temperature and heating flow and return temperatures

The New Building's under floor heating system is split into a series of control zones with room-based thermostats. A twin head pump circulates low-temperature hot water, at ~80°C flow/70°C return, via a long run of pipe work from the Old Building's plant room to the New Building. The pipe work runs primarily through a false ceiling in the corridor of the Old Building. It feeds the control manifolds in the New Building plant room at first floor level, where mixing occurs for the lower temperatures (~30-35°C) required by the under floor heating circuits. A branch also supplies water at ~80°C to the refurbished toilet block in the Old Building, feeding around ten conventional radiators.

DHW for the New Building is stored in a 300 litre capacity solar storage tank or calorifier. It is located in a small first floor plant room with two sets of heat exchangers - see Fig's 3.2.3 to 3.2.5- linked to a solar collector circuit. The two solar thermal panels located on the roof of the New Building feed this circuit. The circuit has a dedicated circulation pump and controls. Details of problems associated with this relatively complex heating and hot water system are discussed further in sections 6.1, 8.2 and 8.3.

Old Building

A control panel located in the Old Building main plant room, controls the space heating and DHW supply to the Old Building. See Fig. 3.2.5. All spaces are fitted either with conventional panel or column radiators, and most of these have manual TRVs. An old belt-driven pump on the return from the space heating circuits circulates the water in the system. Additionally, one toilet block in the Old Building, refurbished during the building project, is served by the space heating circuit supplying the New Building.

A dedicated boiler and calorifier in the main plant room supply domestic hot water for the Old Building, including the school kitchen.

Fig.3.2.3 DHW calorifier located in the plant room of the New Building

Fig.3.2.4 The roof mounted Solar Thermal Panels on New Building

Fig.3.2.5 Heating manifolds in the New Building plant room

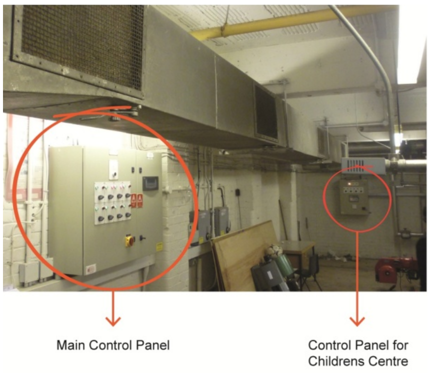


Fig.3.2.6 Control panels for Old Building and the New Building- in the main plant room

Fig.3.2.7 The four boilers in the Old Building plant room

Fig.3.2.8 Reference classroom in the New Building used for setting temperature control in the heating control panel

3.3 Natural Ventilation

Both buildings at Bessemer Grange are naturally ventilated and make use of limited mechanical ventilation.

New Building

The New Building has an open plan layout at ground floor level that allows cross-flow ventilation.

On the first floor, natural ventilation is predominantly single-sided due to the cellular spatial arrangement and the need to keep internal doors closed at all times for safety, security and privacy. Many of these rooms actually face onto an internal corridor, which has a skylight with electrically actuated vents, which could, in principle, allow cross-ventilation.

The main windows are manually operated with restrictors allowing 100mm opening; high-level windows have electronic actuators, see Fig. 3.3.1. Problems associated with these windows are discussed further in section 8.4 of this report.

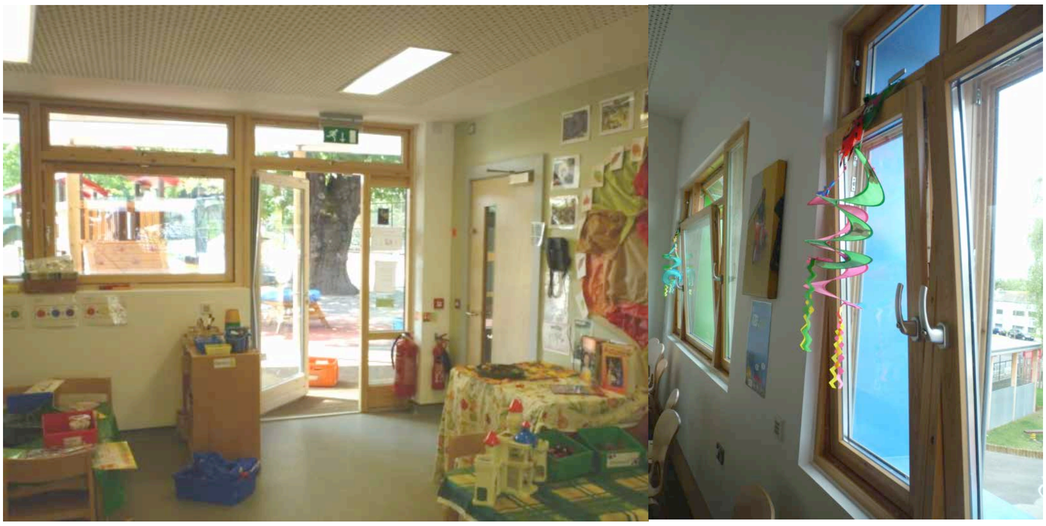


Fig 3.3.1– Doors and windows in the New Building ground floor classroom (left-hand image). New Building First floor windows showing restricted opening (right-hand image)

Old Building

The 1950's building is single-glazed. The photograph in Fig. 3.3.3 shows the main windows on the right and high-level clerestory windows on the left.

Windows are fitted with bolts and traditional casement stays to ensure the safety of small children. The clerestory windows act as high level vents to exhaust hot air in the summer and are opened and closed by facilities staff.

Fig 3.3.3 - Classroom windows in the Old Building

3.4 Mechanical Ventilation and Exhaust Systems

Supply and other mechanical ventilation is provided to all kitchen areas. Toilets are extract-only throughout the whole of Bessemer Grange School.

New Building

A small staff kitchenette is located on the first floor with an extract hood over the cooking hob in order to contain smells. Make-up air comes via natural ventilation.

The toilets are located in the interior of the floor plan, and are therefore mechanically vented, see Fig 3.4.1 The extract system maintains a negative pressure in the toilets, thereby avoiding the leakage of smells into occupied spaces. All toilet room doors are undercut by 10mm to allow air intake from the surrounding spaces in order to balance the negative pressures.

Old Building

The school kitchen provides meals for over 200 students and staff and has commercial extract hoods. Auxiliary storage, commonly referred to as the pantries, adjacent to the kitchen is provided with wall-mounted extract fans, with make-up air drawn in from the main kitchen.

Mechanical ventilation and comfort cooling is provided by a split air conditioning system in the reception area of the Old Building and in the ICT suite on the first floor.

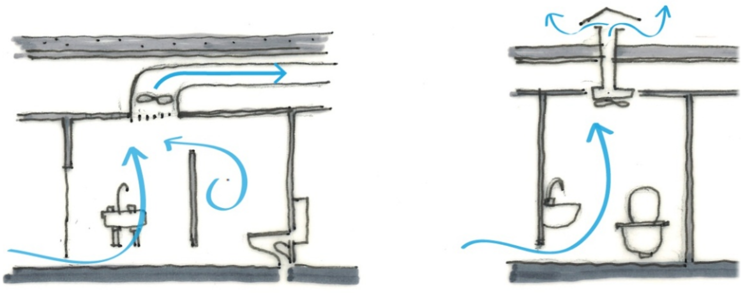


Fig 3.4.1 - Sketch of Toilet Ventilation on Ground Floor, left, and First Floor, right, in the new building

3.5 Lighting Systems

All Internal spaces, except certain storage spaces, are provided with windows for daylight.

New Building

Interior Lighting
The ground floor has recessed ceiling lighting in all spaces. The first floor has suspended lighting fixtures. Classrooms on the ground floor are fitted with single or double linear florescent T8 type luminaires and controlled by manual switches. See Fig.3.5.3.

Planned light zoning is in place, See Fig.3.5.1, allowing the user to use artificial light to supplement daylight as necessary by using manual rocker switches.

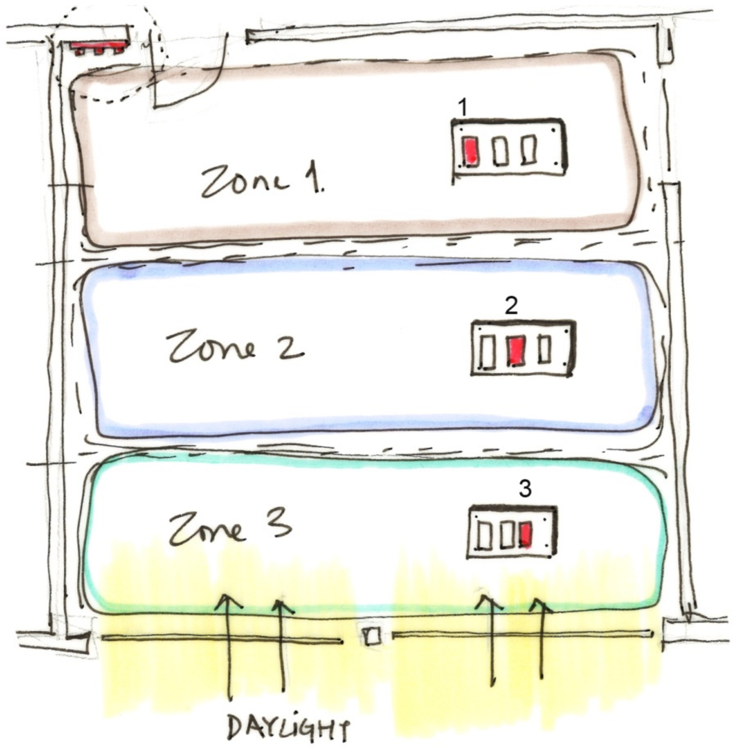


Fig 3.5.1 - Sketch of Lighting Zone
Standard classroom with three zones of lighting with separate rocker switch controls

All toilets are fitted with ceiling recessed compact fluorescent down lights controlled by PIR (Passive Infra Red) sensors. Smaller rooms, such as coat stores, laundry room, kitchenette and staff workrooms are fitted with similar compact luminaires operating on manual switches.

The double-height entrance lobby contains a large number of luminaires to create a bright and welcoming environment for children, parents and staff arriving or leaving.

The high usage of electricity and in particular lighting at Bessemer is discussed further in section 6.1, 6.3 and 8.1 of this report.

Exterior lighting
Wall mounted, low-energy fixtures light external areas of the New Building. The entrance canopy leading from the security gate to the entrance of the New Building, has recessed external floor lights. These also continue inside the building into the lobby area.

Old Building

Interior Lighting
Classrooms, corridors and offices in the Old Building are generally square or rectilinear and lighting layouts follow a traditional grid arrangement of opal ceiling mounted battens with T5 lamps controlled by manual on/off switches, see Fig 3.5.2 below.

Unique spaces such as the school kitchen are also day-lit with both low and high-level windows, and are also fitted with T5 battens.

Refurbished areas of the Old Building, the reception and the toilet block, are fitted with modern energy efficient T8 lighting fixtures similar to those used in the New Building.

Exterior Lighting
Exterior lighting is via halogen floodlights controlled by a timer. It is manually altered by facilities staff depending on the season and the onset of darkness. See Fig.3.5.2.

Fig 3.5.2 – Lighting in the Old Building - left: external Halogen Flood Light; middle: internal T5 lamps in classroom; right: T5 lamps in main kitchen

Fig 3.5.3 – Lighting in the New Building - left: low energy external lighting; Centre: ground floor classroom with acoustic ceiling and recessed T8 luminaires; right: high concentration of lighting fixtures in the first floor lobby/reception area

3.6 Information and Communication Technology (ICT)

The school now has two main servers, one on each floor of the Old Building: a small capacity server on the ground floor and a high capacity server in the main ICT room on the first floor. These servers also cater for the needs of the New Building. See Fig.3.6.1.

Portable laptop charging stations on each floor of the Old Building allow all school laptops to be charged every night between 1am and 4am.

The main ICT room in the Old Building is also used for lessons and has 8-9 fixed computers and portable laptop docking stations to allow for flexibility, see Fig 3.6.2.

Classrooms in the New Building are provided with an individual computer and a digital / interactive white board with a set of audio speakers. Some classrooms also have projectors.

Fig 3.6.1 - Left: servers in ground floor circulation corridor, middle and right: Portable laptop charging stations

Fig 3.6.2 - Photo of main ICT room in the Old Building

3.7 Utilities

Electricity Supply

Figure 3.7.1 shows the electricity distribution system at Bessemer Grange.

The mains supply enters the school at the Old Building's electricity room/cupboard adjacent to the main reception. There are two utility meters: S75A10326, which supplies the main kitchen; and L77A03001, which supplies the rest of Bessemer Grange. See Fig.3.7.2 middle image.

Two distribution boards in the first floor plant room of the New Building serving the ground and first floors respectively incorporate digital meters. See Fig 3.7.2 right hand image.

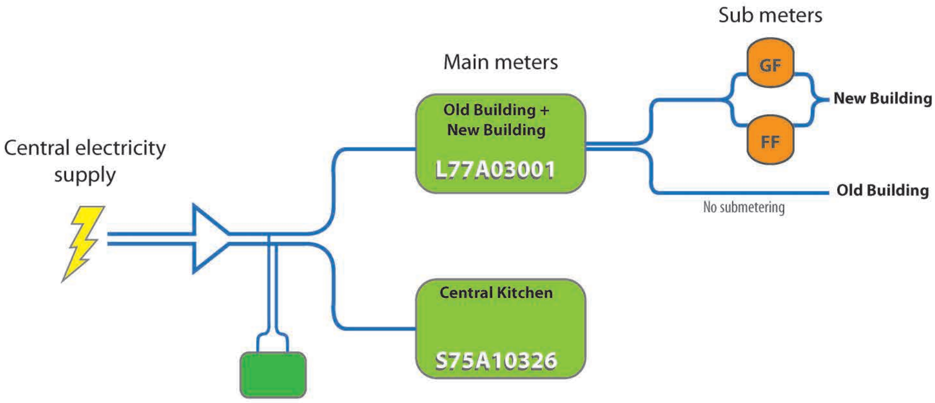


Fig 3.7.1 - Sketch schematic of electrical metering infrastructure

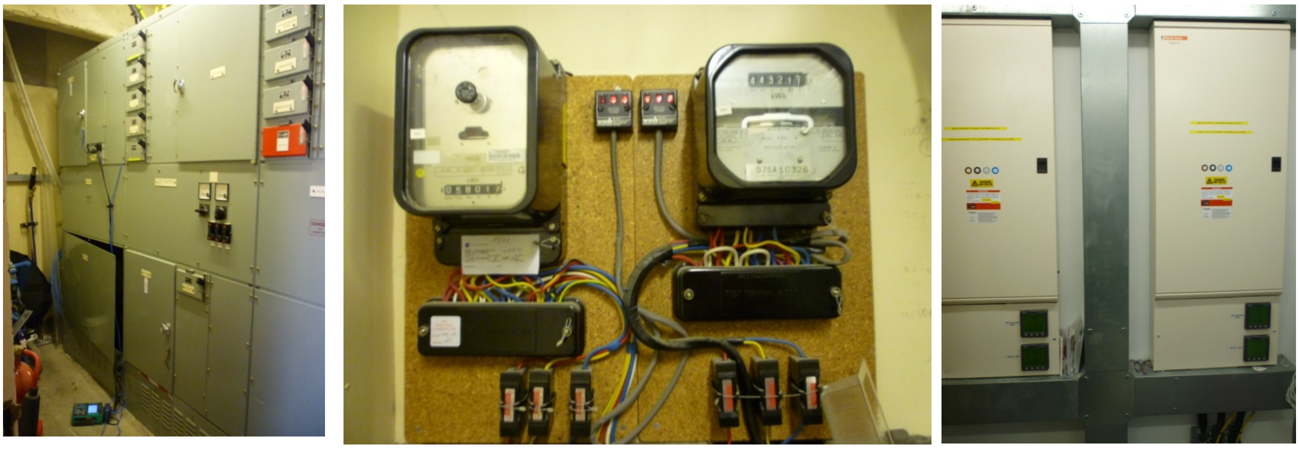


Fig 3.7.2 -
Left: Electrical room in the Old Building;
Middle: main utility meters in electrical room;
Right: distribution boards in New Building plant room

Gas Supply

The main gas supply to the school comes in via the sub-ground central boiler room in the Old Building and also serves the school kitchen directly above.

A separate second supply serves the kitchenette on the first floor of the New Building.

Water Supply

The incoming mains cold water supply enters the site via a manhole adjacent to the central plant room.

From here, the water supply to the New Building travels through a service trench, also routing the gas supply, running to the kitchenette.

As part of simultaneous works carried out at the same time as the construction of the New Building, toilet facilities throughout the Old Building were upgraded with waterless urinals, low flush WCs and percussion taps fitted to reduce water consumption.

Water efficient fittings and equipment, including washing machines, are used throughout the New Building. This includes low flush WCs, percussion taps and a bespoke baby change/wash table in the Crèche. There are no urinals as these are not suitable for very young children.

4 Review of Handover, Aftercare and Building Management

4.0 Section Introduction

This section covers the handing over of the New Building and the management and operation of the building. This includes an overview of pre-handover and handover; initial aftercare; and the subsequent operation and maintenance of the New Building. It also includes a description of the implementation of Soft Landings Framework, (Bordass, Way & Bunn, 2009) stage 4; a summary of the school's budget; as well as some details of improved processes Architype have implemented based on learnings at Bessemer Grange.

A completed copy of the TSB Soft Landings reporting form is included in appendix A.

4.1 Process Summary

A standard handover procedure was specified in the contract. This required a 12-month defect period, the production of a health and safety file, training for staff, but little in the way of aftercare or tine tuning. In view of Architype's interest in improved handover protocols, it was decided to pilot stage 4 of Soft Landings Framework after handover i.e. a 6-week residency, to assess how far this part of the Framework could enhance handover.

4.2 Pre-handover and Information

At the pre-handover meeting, a health and safety file produced by the main contractor was issued. This included 7 A4 lever arch files with details of product data sheets and record drawings, as well as the design team's specifications and a detailed electrical and mechanical services manual.

The information was substantial, but it was not user friendly. There was little to explain the building and its systems in a clear manner that was digestible and easy to comprehend. The mass of the information consisted mainly of general product literature, contact details for subcontractors, drawings and detailed technical information. An electronic version of the same was issued on a CD. For ease of access and to ensure that the information was safeguarded in the long term a 'Word press'[1] website was created by Architype. See Fig.4.2.1. Keys and codes were also distributed and a key box was provided with all keys on numbered or labelled key rings, as per the supplier's schedule.

[1] See http://bessemergrange.wordpress.com/

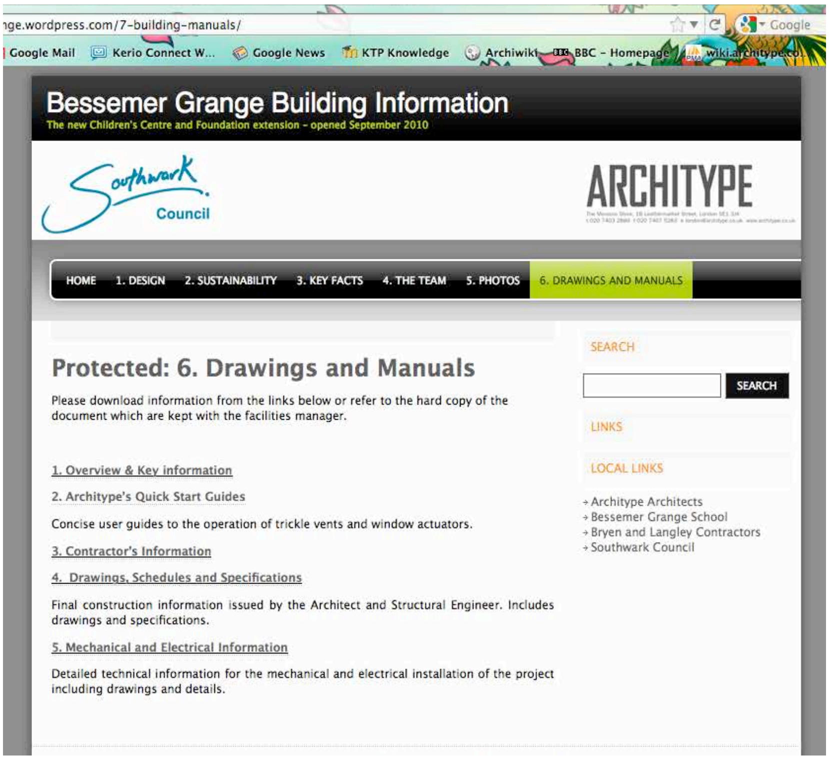


Fig 4.2.1 - Bessemer Grange Building Information Website- setup by Architype to provide electronic information for users. This was not well used to start with – however when hard copies of manuals were lost it proved very useful.

4.3 Handover and Soft Landing Pilot

Handover of the New Building was fairly typical, certificates from sub-contractors and suppliers were provided and the design team and client inspected works and signed off practical completion. However, snagging was protracted as no timescales were contractually specified.

Soft Landings stage 4 was implemented in the form of a six-week residency, focused on helping the users and identifying problems on site. This included weekly visits and the production of a newsletter to keep users informed on efforts to resolve defects. Although fairly useful, its impact was limited because Soft Landings had not been embedded from the start of the project and there was no contingency for addressing any defects that fell in an area between brief, design and installation. Having a contingency available is crucial to overcome persistent issues, which often remain unresolved if they become subject to a dispute.

One of the most significant benefits of undertaking the Soft Landings residency was the up skilling of the people involved. There is a new sensibility and an awareness of how to anticipate and address problems, as well as an understanding of how best to empower others. Specific problems can also be addressed and lessons can be learnt for future projects.

4.4 Specific Findings from 6-Week Residency

Key Handling

Although a key register was provided along with suited master keys, key handling raised some problems. The sheer number of keys that were not included on the master key, such as lift, window and fire alarm keys, were difficult to manage. For example, the keys to the lift and the disabled toilet alarm were both left in the respective devices at handover and could have been stolen or even swallowed by a child. In order to improve handover, design teams could in future include requirements in the contract for the contractor to collate a schedule of all keys including ancillary keys and physically hand them over and sign them off at an agreed meeting.

Window Keys

The client requirement to specify window security keys on the project led to difficulties for users trying to operate windows. This was despite the contractor issuing window keys to the school's Facilities Manager – as staff were not aware that the Facilities Manager had the keys.

The researcher was able to remedy this situation: the window keys were grouped into sets and distributed to staff, with the remaining sets returned to the manager of the Children's Centre housed in the New Building. Nevertheless, the problem persisted and was noted during BPE team visits throughout the project. This issue and possible solutions are discussed further in section 8 of this report. However, where possible, internal keys for windows should be avoided to allow users to easily operate windows.

Window Actuators

Difficulties operating actuators made opening high level windows difficult**.** At the time of the first residency visit, end users had not yet received training on how to operate the manual or automatic windows. No instruction labels were displayed on the windows or wall controls and their operation was counter-intuitive for some users. Better signage and labelling would have improved usability for the end-user along with general orientation training for users.

Keys left in the disabled refuge alarm

Excess of outlet sockets in the creche areas

Low level windows

Anwserphone with no labelling

Fig 4.4.1 - Examples of issues identified during the Residency.

User Manual

A non-technical end-user manual was not specified for this project. However, during the six week residency it became clear that such a document would be very useful for the users. Therefore a prototype end-user manual was started as part of the Knowledge Transfer Partnership and added to a Wordpress-based website for the building, which included basic instructions and 'how-to' information. See Fig 4.4.2 and 4.4.3. Drawing from this experience, Architype are now developing their own standardised user guide templates for users on other projects and encouraging clients to make an allowance for the production of these guides from an early stage in the project.

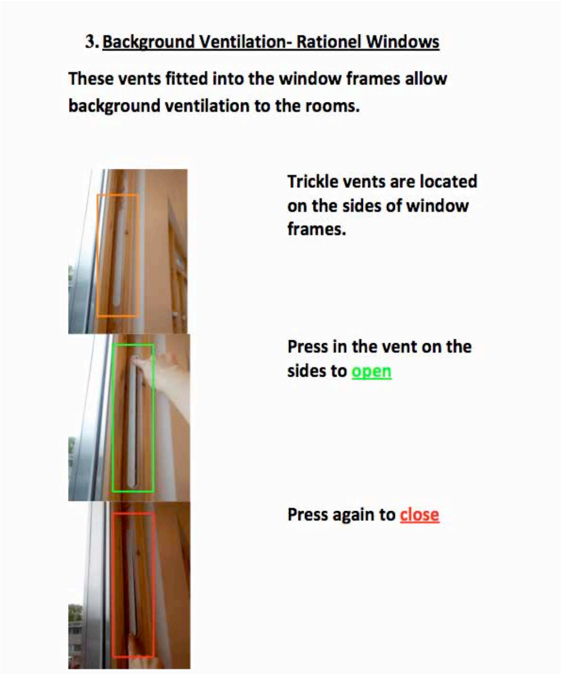


Fig 4.4.2 - Example of quick user guide provided by Architype. It was found however, that users did not use the guide and so Architype intend on replacing it with localized signage in the future.

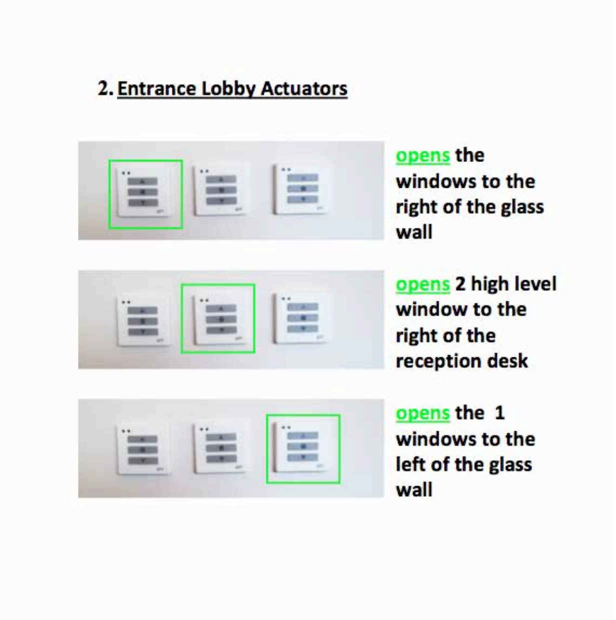


Fig 4.4.3 - Example of quick user guide provided by Architype to assist in understanding standard control packages. It was found however, that users did not use the guide and so Architype intend on replacing it with localized signage in the future.

Door Seals and Closers

Several of the doors which were fitted with acoustic and fire seals were difficult to close for the first few months of occupation. The seals took time to bed-in, requiring multiple adjustments to the door closers to stop doors slamming when windows were open, or having to be pulled shut when the windows were closed. This was particularly problematic in the corridor between the crèche and the Old building, as it is a secure hallway with magnetic locks. The locks failed to engage because it was not possible to pull the doors closed. The Facilities Manager needed to make several adjustments to the door closers in the first few months to resolve this problem. Teething issues such as these could be flagged up to users and Facilities Managers in a welcome letter to allay any concerns. Architype are developing a standard letter to be used as a template for future projects.

Push Plates

Pull bars are placed only on one side of doors, this means that doors cannot be pulled shut once the threshold has been crossed. In one instance the door closer did not function correctly from the start, because door seals need a breaking-in period. As a result, the inability to pull the doors closed during this period, frustrated users and raised fire safety and security concerns. It may be worth designers including pull handles on both sides of doors to avoid this occurrence on future projects.

Off-gassing

The upper floor corridor between the crèche and the Old building was off-gassing heavily. It was releasing smells of the glues used in the laying of floors and needed to be purge-vented. The corridor was designed with no openable windows due to fire safety concerns. To counteract smells, the door was propped open during unoccupied hours when there were no security concerns. Although not required for this space, best practice would suggest providing better ventilation within the corridor space.

Visual Link between Training Room and Crèche

The crèche and the Training Room are adjacent and connected with a glazed double door. If the children can see their parents in the Training Room, the babies tend to cry and the parents cannot focus on their work. During the second week of occupation, the research team noticed that the double door had been blacked out with paper to avoid the distress. See Fig.4.4.4. However, an unfortunate effect of blocking this glazing was that any baby or toddler in the way of the doors would not be seen when the doors swung open into the crèche. A blind or reflective film may have resolved this problem but there was a disagreement between the school and local authority as to who was responsible for providing this item. A small post occupancy contingency fund would have been very useful for resolving minor items such as this.

Fig 4.4.4 - Photo showing window covered up between the Creche and training room.

Fig 4.4.5 - Photo showing external doors prior to a friction stay being fitted.

Outdoor Learning – Door Security

Many of the doors that connect learning spaces to the outside are left open during classroom breaks, lunchtimes or outdoor learning times. The design of the outside doors did not allow them to be secured in an open position. See Fig.4.4.5. Consequently, these doors had a tendency to slam shut unexpectedly in the wind and posed a potential hazard for children. During the defects period, this problem was spotted and friction stays were fitted to the doors.

Remote-controlled Velux

The remote-controlled Velux roof-light attracted complaints from several users after the end of the residency and throughout post-occupation. The remote control went missing on several occasions, meaning that users could not open the roof light windows. See Fig.5.3.2. Users expressed a preference for a wall-mounted switch. Refer to Section 8.4 for more details.

Labels & Design of User Controls

There was a lack of labels or simple instructions on several devices in the Children's Centre Foyer. The telecom system had no labels for the front door or outer gate release buttons. No administrative staff attended the training that was made available. Also, the out of reach windows within the double height foyer required the use of actuators. This, along with the problems of key distribution, the positioning and 'newness' of trickle vents and the absence of clear in-situ signage, meant that users were confused and frustrated. Indeed, the window actuator controller switch was rated poorly in the BCIA report Controls for End User (Bordass, Bunn and Leaman, 2007:p.5) and a different product may be more suitable. This highlights the importance of designers taking an interest in the selection of controls interfaces. Efforts to improve ease of using ventilation are discussed further in section 8.4 of this report. However, generally speaking, this finding points to the need for a greater priority being placed on the design of user control and signage in buildings.

Trickle Vents

The trickle vents in several of the taller windows are located at the very top of the frame and are difficult to reach. The initial window schedule did not specify the positioning of vents. On future projects the maximum height of trickle vents should be specified or pull chord operated trickle vents should be used to avoid this problem.

Crèche Area Small Power Outlets

Within the crèche, there is an area of densely grouped power outlets intended for eventual audio visual facilities. For easy access by staff and disabled users these are about 1m from the floor in the play area, which may not be ideal in terms of safety for toddlers. This is typical of the potentially conflicting needs that must be considered during design.

Pupil and Staff led Energy Monitoring

Following on from the six week Residency, it was intended for pupils to take weekly and monthly readings of utilities to cut costs as well as raise awareness. A member of the BPE team held a workshop for staff and students about energy use and explained data collection principles. This initiative proved to be unsustainable, as teachers and pupils had other priorities. After six months, teachers and pupils stopped collecting data.

Following a review with the BPE team, the Facilities Manager, the Head Teacher and senior staff, new impetus was given to the environmental and financial benefits of data collection. As a result, the Finance Manager was tasked with recording weekly meter readings. These were collected but not uploaded by the school. Therefore the BPE team uploaded the results to the sMeasure website, see Fig.4.4.6.

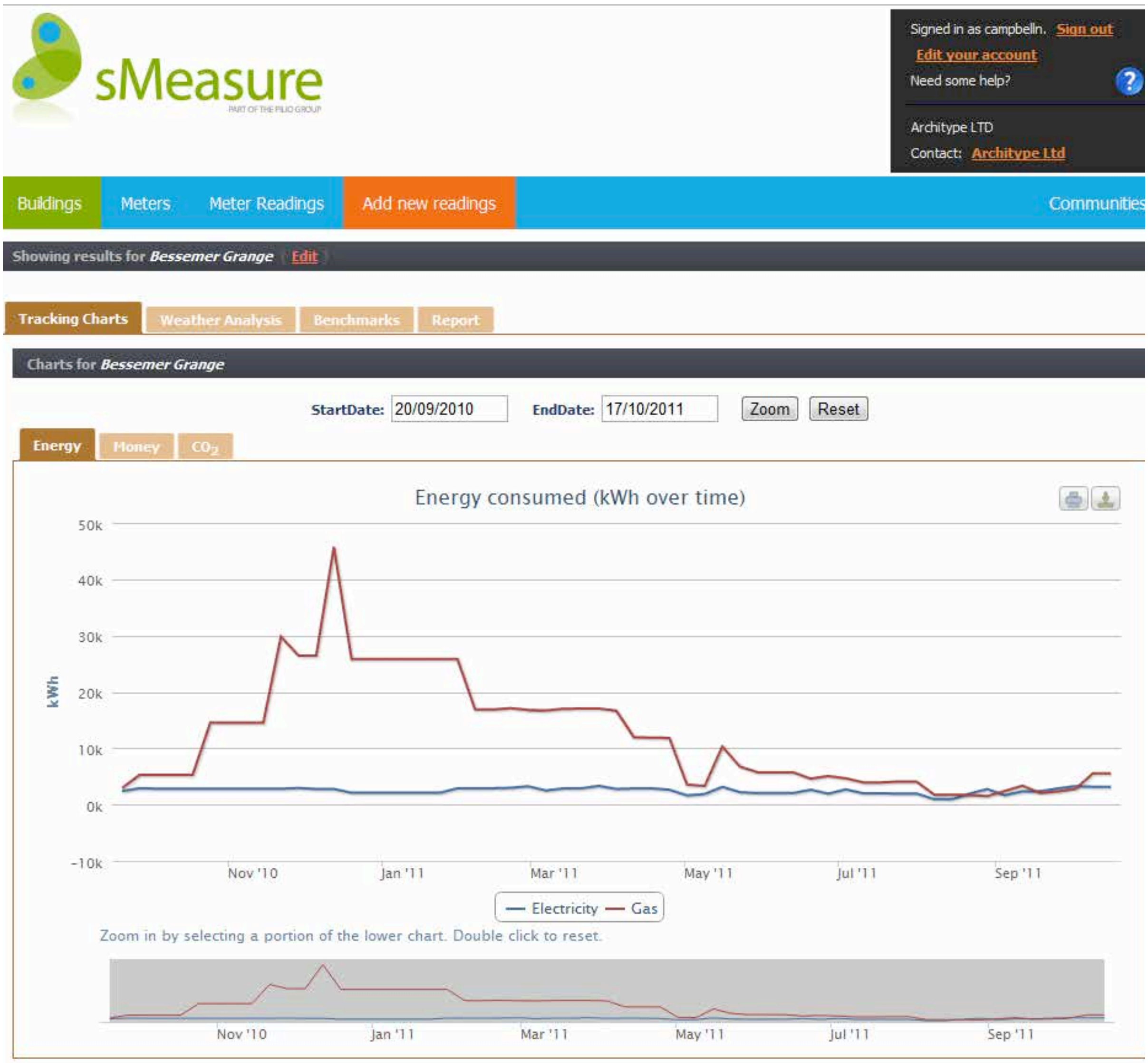


Fig 4.4.6 – sMeasure online analysis tool used by the Researcher showing results for the Old Building. It allows the tracking of energy use and includes estimated costs and a DEC calculator.

4.5 Extended Aftercare

A number of outstanding snags and hard-to-resolve issues continued into the post defects period.

Broadly, these were related either to incomplete works and snagging, or fell into a grey area between design and installation. Architype, as contract adminstrator, withheld a significant sum of money for incomplete works and this ensured the contractor did eventually return to resolve these issues. However, one notable exception, was the problem associated with the heating controls which remained unresolved. See section 6.6, 8.2 and chapter 9 for more details.

Whilst the snags and latent defects were eventually resolved, it often took far too long in the eyes of the users and Architype. Indeed, during the six week Residency there was frustration that the contractor did not resolve issues more quickly. In part, the contractor cannot be blamed for this as they had never signed up contractually to the Soft Landings six week residency. For future projects, Architype developed a set of 'Soft Landings requirements', see Fig.4.5.2, based on their experience at Bessemer Grange and on the BSRIA procurement guide (2013). This document has now been inserted into the preliminaries of new contracts in order to ensure that there is greater control with the builder committed contractually to engage fully with the Soft Landings process. Furthermore, tender forms in these projects have been amended to include an additional item to allow contractors to price for these services over and above their normal sum for preliminaries.

As discussed in this report, a wide range of issues was detected during the BPE study. See summary of findings in section 10. Many of these would have remained hidden without the BPE process. For future projects, Architype has begun to develop a suite of services offering extended aftercare for 1 – 3 years after the completion of the project. This has been successful, with several clients choosing to pay additional fees for this service. However, it remains to be seen whether there will be wider take up of this service. See diagram 4.5.1 below which has been developed to help explain the Soft Landings process to clients.

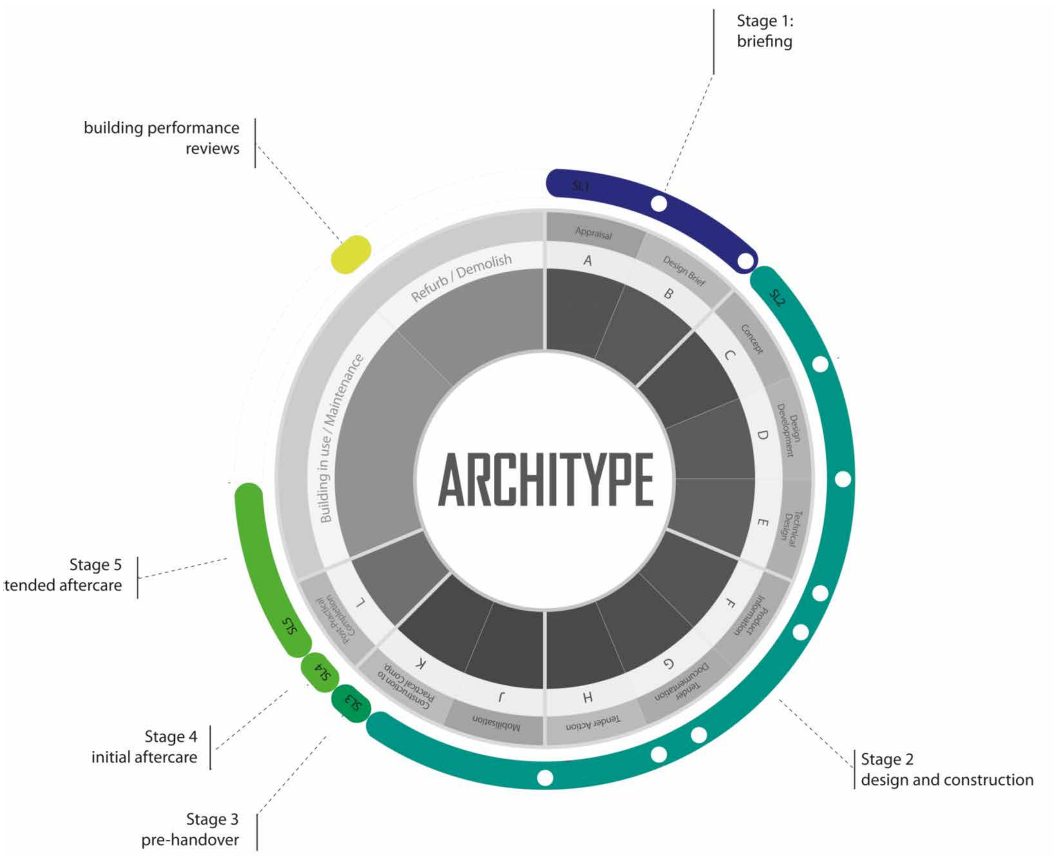


Fig. 4.5.1- Soft Landings diagram developed by Architype to explain how the Soft Landings process fits alongside the old RIBA plan of work. It was found that clients struggled to understand what the Soft Landings process was.

2.3 Requirements for Stage 3- Pre-handover
(in contract requirement)

Timescale: *The Pre-handover period on the Camden projects is defined as a 3month period prior to date of practical completion.*

Meeting attendance: *A min of 4no. Meetings are to be held prior to practical completion to focus on preparations for handover including migration planning, commissioning, key/fob handling and planning the aftercare periods. The main contractor, relevant sub-contractors and controls specialist will be expected to attend relevant meetings.*

2.31 Stage 3 P1- Environmental and energy logging review

Requirement 1 *The main contractor shall provide certification confirming that all metering systems are functioning accurately, are well labelled by end-use, and that their data is accurate and reconciles within five per cent of the main meters prior to handover. Meters shall be set to zero immediately prior to handover. Any non-functioning or inaccurate meters shall be labelled as such and identified as a defect to be resolved during Soft Landings Stage 4: Initial Aftercare.*

Requirement 2 *The contractor shall also be required to provide a brief summary report, prior to handover, which provides details of meter type, location, number, reading and commissioning status.*

2.32 Stage 3 P2: Building readiness programme

Requirement 1 *The contractor shall produce a draft building readiness programme as part of his tender. This should then be updated within 4weeks of the agreed move-in. This shall involve milestones for, and regular reports on, the status of site completion in the run-up to practical completion. It shall include commissioning and training activities, operation and maintenance manuals, as built-drawings, building user guidance, the setting up of a contact phone number/helpline for the end users and the issuing of a welcome letter. The training needs and appropriate timings shall be programmed into the building readiness programme. The contractor shall develop a strategy for managing thorough commissioning, and devise a clear strategy for protecting the commissioning period and the integrity of the commissioning process.*

Requirement 2 *The contractor shall ensure that the commissioning is witnessed by Michael Popper Associates and readings are recorded and issued to the design team.*

Performance tests should verify the ability of the building and its engineering services to deliver and maintain the specified performance outcomes.
*This may relate to criteria such as temperature, humidity, sound levels, and air movement and luminance. Procedures for carrying out performance testing are given in BSRIA BG11/2010 Commissioning Job Book**.***

Fig.4.5.2 - Page 8 of a 17 page 'Soft Landings requirement' document produced by Architype for a new project – based on learnings from Bessemer Grange.

4.6 Maintenance Management

Maintenance at Bessemer has experienced avoidable complications. During an informal interview, the new facilities manager admitted that his previous superior had not given him in-depth handover training or notes for many of the systems. Only with the help of the BPE team were the Operational and Maintenance manuals located.

Moreover, no one at the school site had knowledge of how the controller for the boilers for the Old Building worked. See section 6.6 for more details. This knowledge had been ‘lost’ at some point, either when the boiler plant had been installed or because of changes in facilities staff.

Such issues are typical in this sector. To avoid these problems it is essential to ensure that a hierarchy of key information survives, that this information is clear and user friendly and that it is passed on appropriately. The BPE team found that users were confused by the wide collection of different information that was handed over at the end of the project. To try and assist users in understanding the mass of information provided, Architype have developed a sketch diagram to explain the different types of information provided and for whom they are most relevant. See 4.6.1. This is now used on current projects to explain requirements to clients and contractors with options for online or hard copies.

Architype is also developing standardised templates for guides and signage to improve the quality of information provided and in order to reduce for future clients the costs required to create it.

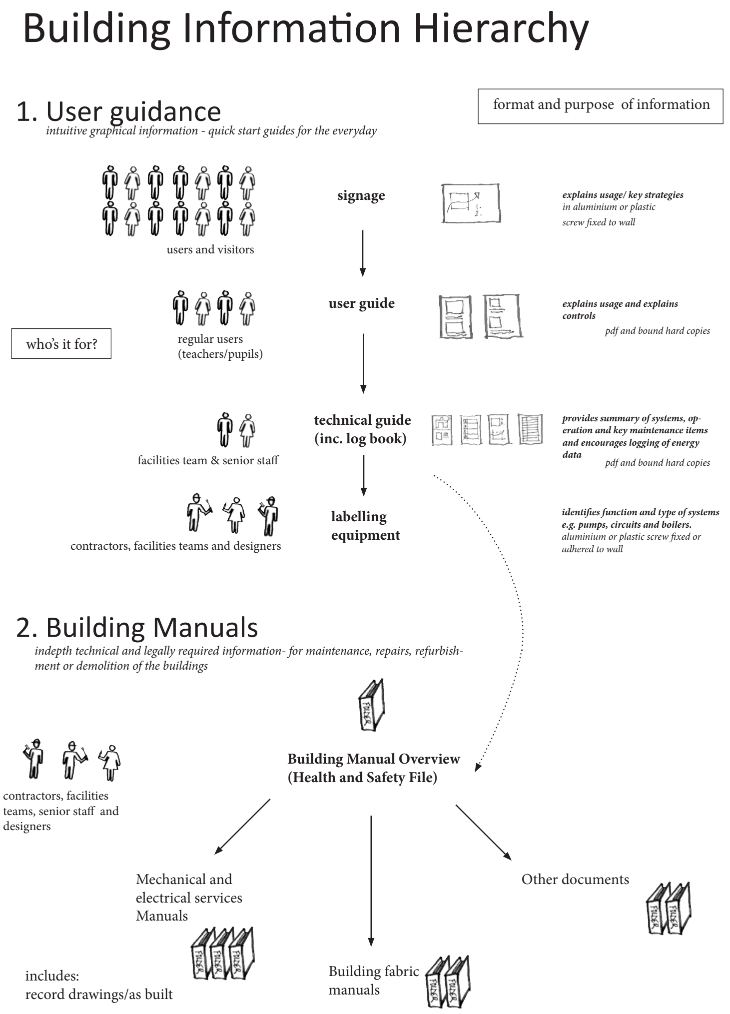


Fig.4.6.1- Building Information Hierarchy Diagram – used to explain to users and contractors the different type of information provided at Handover.

4.7 Operational and Maintenance Costs

At Bessemer Grange, the annual cost of maintenance including the cost of replacements and sub-contracts is higher than the annual cost of energy. See Fig.4.7.1. Given that budget figures also do not include the salaries of the facilities manager, then this difference is actually even greater. Therefore it is not surprising that in interviews with facilities managers and head teacher, it was clear that reducing energy consumption was not a priority - see section 6.1 of this report for more details.

Total School Annual Budget 2012/2013:
~£2,200,000
over 80% of costs are salaries.

• Energy Costs:
~£20k on Gas
~£20k on Electricity
~£5k on water

•Maintenance costs:
~ £20k (Boilers, lift, kitchen equipment etc)
~ £77k (Building maintenance inc skip hire)
~ £103k (Building maintenance inc fencing and landscaping)

NB:
1. Approximately £120k of the above figure were estimated to be spent on refurbishment works rather than everyday maintenance.
2. Indicative figures exclude staff salaries, cleaners and cleaning equipment

Fig.4.7.1 -Bessemer Grange break down of annual of costs

In fact, the facilities management were critical of the high cost of maintenance or replacement of some of the 'green' technologies such as the filter for the waterless urinals, replacement TRVs for radiators in the Old Building, low energy light fittings and the maintenance of the solar thermal collector. Furthermore, they were frustrated that the quality of the ironmongery was not as good as they had hoped for; meaning some elements had to be replaced earlier than anticipated.

Whist the maintenance costs at Bessemer are predominately related to the maintenance of the Old Building, the school put forward a clear message: *greater priority should be given to the consideration of maintenance costs in new buildings*. Based on this finding, Architype are now working more closely with the MEP engineers, Facilities Managers and maintenance contractors to provide a schedule of estimated maintenance costs on new projects at design stage. To highlight the importance of these costs, a summary of these costs is also included in Architype's internal key performance indicators for Soft Landings which are being developed to track the progress of projects using this framework. See Fig.4.7.2.

Example- Soft Landings KPI's

ARCHITYPE

Date:	21/2/13		Workstage	RIBA C
Rev:	A		Author	JA

Project	
Project number	7140
Project title	**School no.1**
Initial Budget £	3,500,000
Initial Budget £/m²	2,569.75
Initial Floor Area	1362.00
Total Occupancy	60 pupils, 30staff
New Build / Refurb	Refurbishment
Target Design Life	60yrs
Procurement Form	Traditional
Tender process	Single Stage
Contract Name	JCT
Sustainability ratin	BREEAM Very good
Schedule of servic	With project manager
Pitstops	See gateway sign-off date schedule

Aftercare	
Aftercare in Brief?	2yrs full SL
Soft Landings reserv	**£15000**
Manuals & Metering	
User guide	By ARC
Maintenance guide	By ARC/MEP/Hayes
H/S File	in NBS (Arc/CDMC)
OM Manuals	in NBS (MEP/Arc)
Log Book	in NBS (MEP/Arc)
Signage/Labels	Statuary by M/C- graphic by Hayes/Arc/MEP
Training	in NBS (Arc/MEP)
Commissioning	in NBS (Arc/MEP)
Metering Strategy	MEP with Arc comment
Soft Landings Champion	
Softlandings Champi	Catherine Harrington
Softlandings support	Jon Ackroyd
Client Champion	Joe Bloggs

Benchmark Setting	Design Stage
Energy survey	Confirm current consumption
	TM22
	BUS survey
Benchmark Testing	**Post Occupancy**
Residency	Yes- 6weeks . Led by Arc
Air tightness	No
Thermal Imaging	Yes by Arc
BUS	1no. after 18months
Interviews	Yes by ARC
Temperature & RH	Yes- MEP (scope TBC)
CO2	Yes- MEP (scope TBC)
TM22	Yes- MEP (scope TBC)
DEC	No
Meter Check	Yes as part of above
Acoustic testing	Yes for Part E

Operational energy & cost - Estimates

	kWh/m2/a	Area (m2)	Total kWh/m2	Cost per unit		
Gas	15	1,362.00	20430	0.03	612.9	
Electric	30	1,362.00	40860	0.17	6946.2	
Use						Annual cost estimate
Total	45 kWh/m2		61290		7,559.10	Total Energy (exc water etc)
					15,000.00	Maintenance Contracts
					22,559.10	Estimated Annual running costs* (Exc. cleaning)

Jon Ackroyd: Should be based on client energy supplier prices

Jon Ackroyd: To be completed by MEP engineer using CIBSE Guide F then updated using TM22/PHPP)

Jon Ackroyd: Cost based on costed maintenance plan with MEP and FM provider

*** These figure are estimates based on rules of thumb and information available. These do not provide any type of guarantee that this performance will be achieved. The purpose of Soft Landings is to test performance against prediction to improve the overall performance of buildings.**

Fig.4.7.2 - Architype's Key performance indicator sheet for Soft Landings - This document is used to Track the level of Soft Landings being used on a project and includes an estimate of maintenance costs.

5 Review of Design, Comfort and User Satisfaction

5.0 Chapter Introduction

This section sets out key findings regarding the design and environmental performance of the buildings excluding services. The first half of the chapter focuses on design whereas the second is focused on the environmental performance.

Evidence has been summarised from semi-structured interviews, forensic walkthroughs, the Building User Survey (Arup, 2010), observation on site and feedback from users as well as data for temperature, lighting, indoor air quality (VOCs) and CO_2 studies.

In the Building User Survey, 55 out of 76 staff responded, giving it a response rate of 72%. The methodologies and raw data for these studies can be found in the appendix. Refer to chapter 12 for details.

Fig.5.0.1 - The covered pergola to the Children's centre. This entrance provided an attractive and welcoming entrance to the building. Sheffield stands were fitted to allow visitors to secure buggies - however these were later considered insufficient and a separate store was retrofitted. See Fig.5.5.11.

5.1 Overall Satisfaction and Comfort

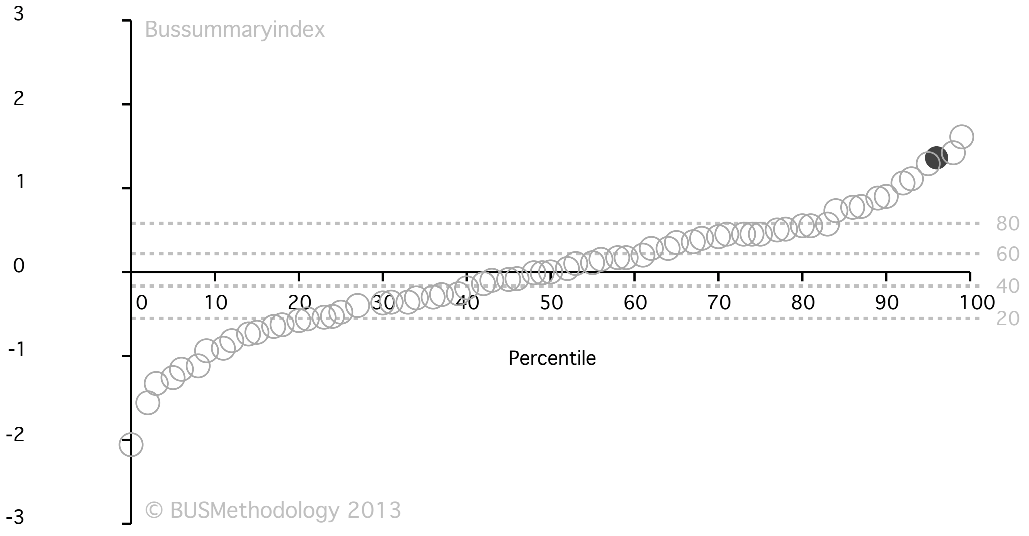
Both the New and the Old Building are very popular and perform extremely well in terms of the Building User Survey (BUS). See appendix N for raw data and methodology. The summary index score given for both comfort and overall performance lies in the top 20% of all non-domestic buildings surveyed by Arup. The New Building scores particularly highly and is rated in the 96th Percentile. See Fig.5.1.1.

The 2011 OFSTED inspection found that the school had reached a ‘good’ status, an improvement on ‘satisfactory’ in 2008. With a new permanent headteacher in place, the school appears to be on the up with an improved community perception, a significant rise in pupil numbers and the staff clearly believing that the Children’s Centre is a major asset. The School is now over-subscribed and is being expanded further. See chapter 9 for more details.

There was consensus amongst the school’s Senior Leadership Team that the New Building had been ‘integrated well’ with the Old Building and was a ‘great improvement on what had been there previously’. It was generally felt that the presence of the Children’s Centre ‘enhanced the profile of the school'- meaning the design met many of its original goals.

It was also acknowledged that thorough consultations had taken place at each stage of the project and that the scheme had been subject to budgetary constraints, which had led to the omission of certain desired features. Disappointments raised in interviews centred on: a desire for more space, overheating on the first floor and the feeling that the buidling’s designers had perhaps favoured eye-catching design over everyday pragmatism.

The New Building's careful design process with extensive consultation and input from users, as well as positive informal feedback from staff, meant that the high overall BUS score was expected. However, a similar result was not expected for the 1950s built Old Building that was previously in a poor state of repair.



Study mean: 1.39 | Study building percentile: 96 | Quintile: 5
Building code: 9062
Web content © BUSMethodology 2013

Fig.5.1.1 - BUS Summary Index of the overall performance of the New Building- showing that overall the building is extremely popular with results in the top 5% of recorded buildings.

As far as perceptions are concerned, Fig.5.1.2 and 5.1.3 confirm that users felt that both buildings performed very well across a variety of areas, with the New Building scoring above scale mid points and benchmarks in every category and the Old Building scoring above benchmarks in 9 out of 12 categories and inline with 3.

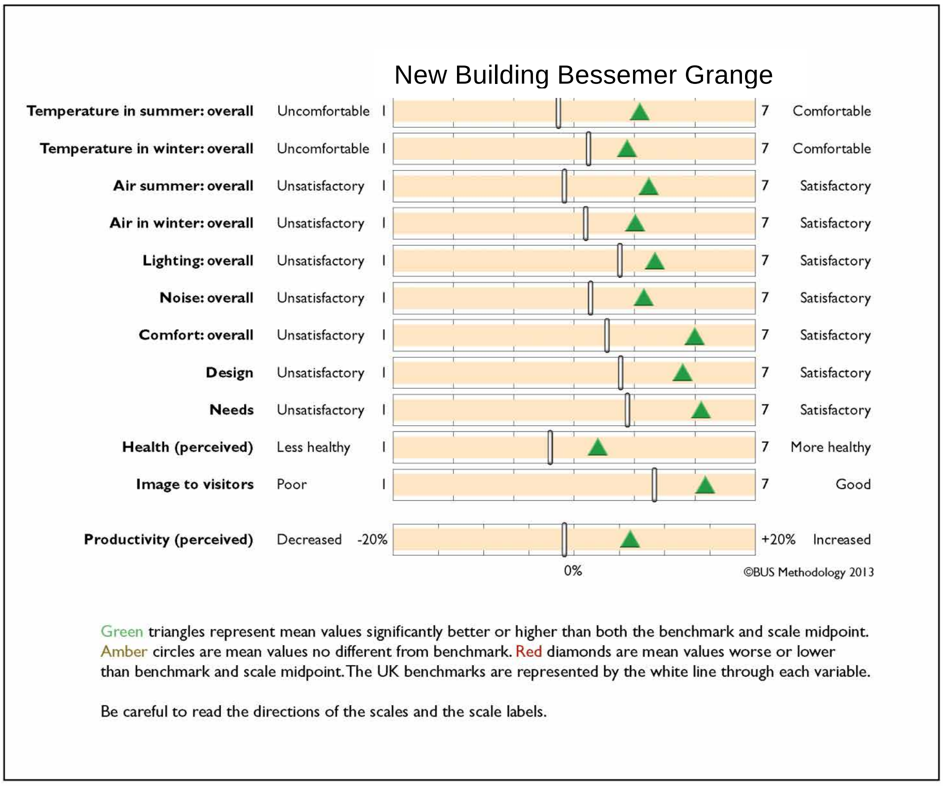


Fig. 5.1.2 - Summary of BUS Results for the New Building

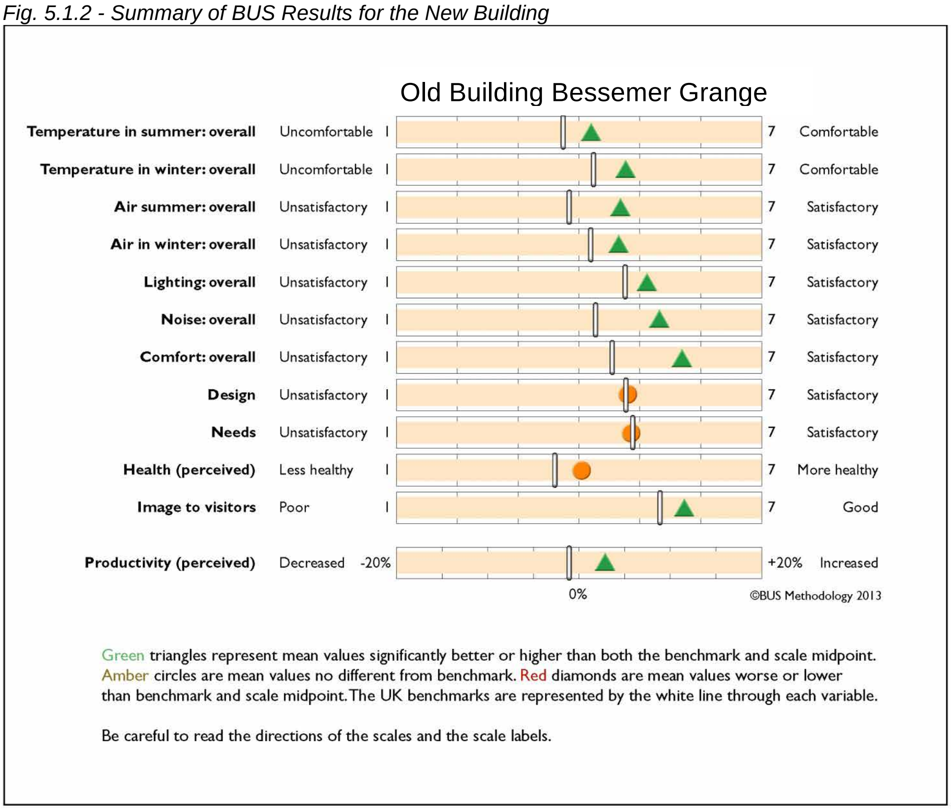


Fig. 5.1.3 - Summary of BUS Results for the Old Building

5.2 Forgiveness & Image

The almost unanimously positive result of the overall scores for the BUS survey however, may mask the true picture. The BUS survey incorporates a *'forgiveness'* score, calculated by dividing the *'Overall Comfort'* score by the mean of 6 other variables. At Bessemer, this score was very high for both buildings with values above 1. The score indicates that the overall positive image or impression of the buildings may override specific problems or issues. This correlates with feedback from interviews.

In particular, the BUS results showed that the New Building scored in the 75th Percentile when rated on its *'Image'* alone, with positive comments recorded such as *'...excellent learning environment'.* The Old Building scored lower for 'image' than the New Building. Nevertheless it scored higher than expected, clearly indicating the positive impact of recent and extensive refurbishments; *'[the building] has infinitely improved in the last 2 years.'*

Indeed, a more differentiated picture of the performance of the building was confirmed during interviews and comments in the BUS survey, which showed a range of problems with both the New and Old Building. See the following sub-sections.

5.3 Layout, Storage and Needs

Overall, the layout of both the Old and the New Buildings works well, however, there were a number of design issues that the client raised. See Fig.5.3.1 to 5.3.3. Interestingly, in discussion it became clear that the Old Building was particularly prized for it's *'Huge classroom[s], great storage, excellent outside area[s]'.* See Fig's 5.5.12 to 5.5.14. In essence, the pragmatic and generous design helped this older building meet the fundamental needs of the user. Its less favourable environmental conditions, see section 5.6, were accepted as it was an older building.

'Access to large outdoor space, natural light, free flow between reception classrooms' and *'Facility suitable for excellent learning environment'* were all comments recorded in the BUS survey, which highlighted the positive attributes of the New Building.

However, in interviews, staff expressed that the draft lobbies in the Early Years Centre were not generous enough and complaints were made about the ensuing congestion, especially as the lobbies also serve as cloakrooms. The headteacher felt that prioritising storage space, including coats, was important.

Some classrooms in the New Building have an unconventional shape due to the cranked form of the building which was generated from the need to conserve the mature Oak tree and the need to connect the New Building into the Old Building to the West of existing stair. However, user feedback has shown that traditional rectilinear rooms are preferred. It must be acknowledged that no single design will satisfy all. The new headteacher of Bessemer Grange preference was, for example, totally at odds with the former Head of Early Years who favoured a flowing, less conventional layout. However, arguably rectilinear shapes seem able to cater for a greater number of different activities in the school setting.

Some users complained about the lack of storage in the New Building. However, it is important to note that most of the original built-in storage was omitted during value engineering. Although the amount of storage complies with BB99 (DfES:2008) guidance, given the views of the teachers, it may be that this guidance needs some revision. See Fig's 5.5.10 and 5.5.11.

In spite of firm advice to the contrary from the design team, no dedicated reception area was provided for the Children's Centre housed on the first floor of the New Building, because the client insisted that a receptionist post could not be funded. This led to a less-than-satisfactory retrofitted reception which caused some irritation for users. See Fig.5.5.4. It also sticks out aesthetically as it is not in-keeping with the design standards of the rest of the building.

Also, as part of the refurbishment works within the Old Building, the reception area was relocated and enlarged. Nevertheless, it was still perceived as too small by users. See Fig.5.3.4 and 5.3.5. Users also reported overheating in this area to the facilities manager. The original natural ventilation strategy in this area failed to work for two reasons. Firstly, Building Control required automated dampers to prevent the spread of smoke in the event of a fire whereas the MEP engineers had only allowed for intumescent grilles. The cost of retro-fitting automated smoke dampers was seen as prohibitive by the client and therefore, grilles had to be sealed to prevent the spread of smoke: thus blocking the natural ventilation passage. Secondly, there was a higher than anticipated occupancy in the rooms which increased heat gains. Eventually, a small air conditioning system was provided for this area; a solution which worked well for comfort, but less well in terms of energy usage.

See appendix C for semi-structured interview, appendix M for copies of meeting notes and presentations and appendix P for a copy of the forensic walkthrough notes.

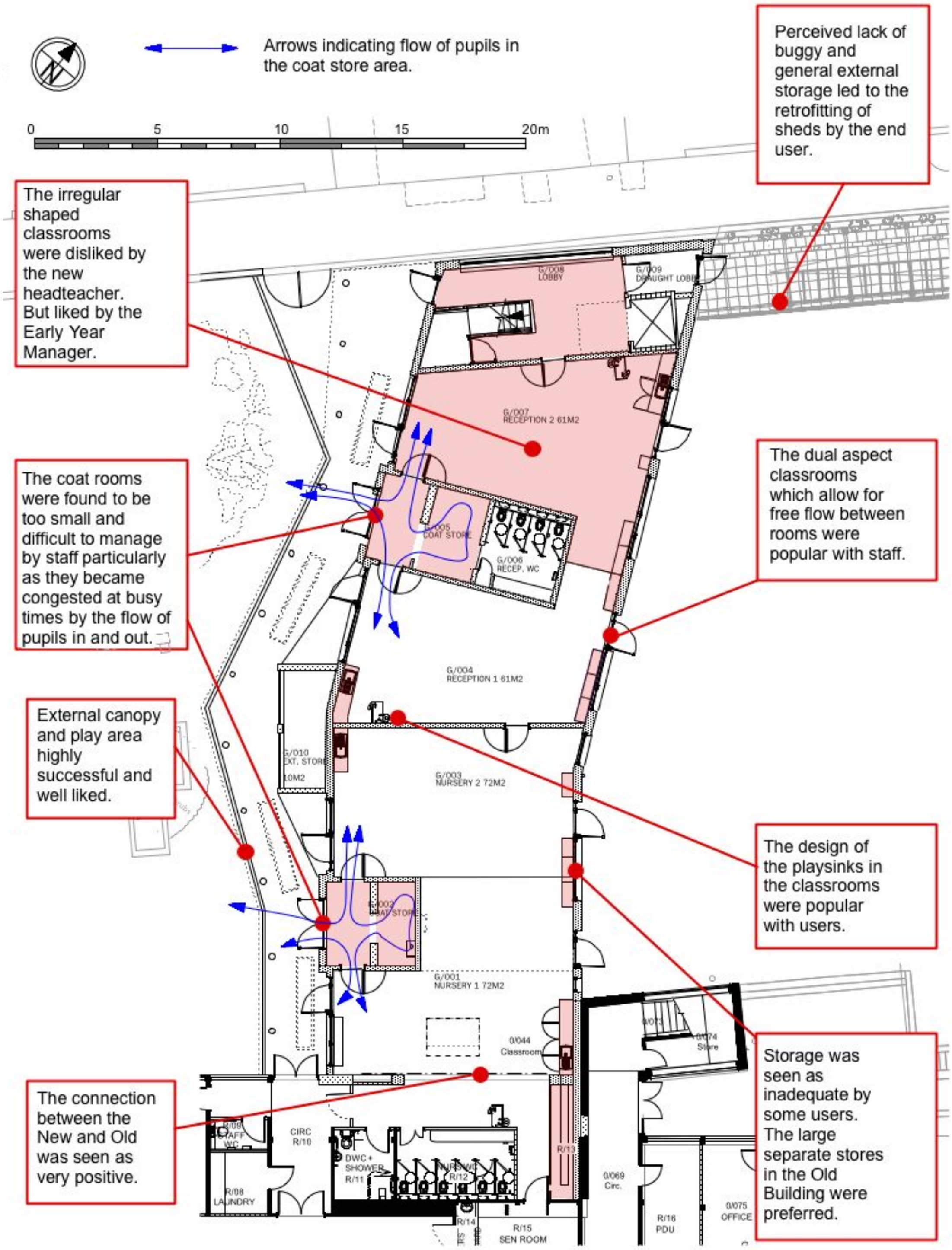


Fig. 5.3.1 - Ground Floor Plan of the New Building with commentary

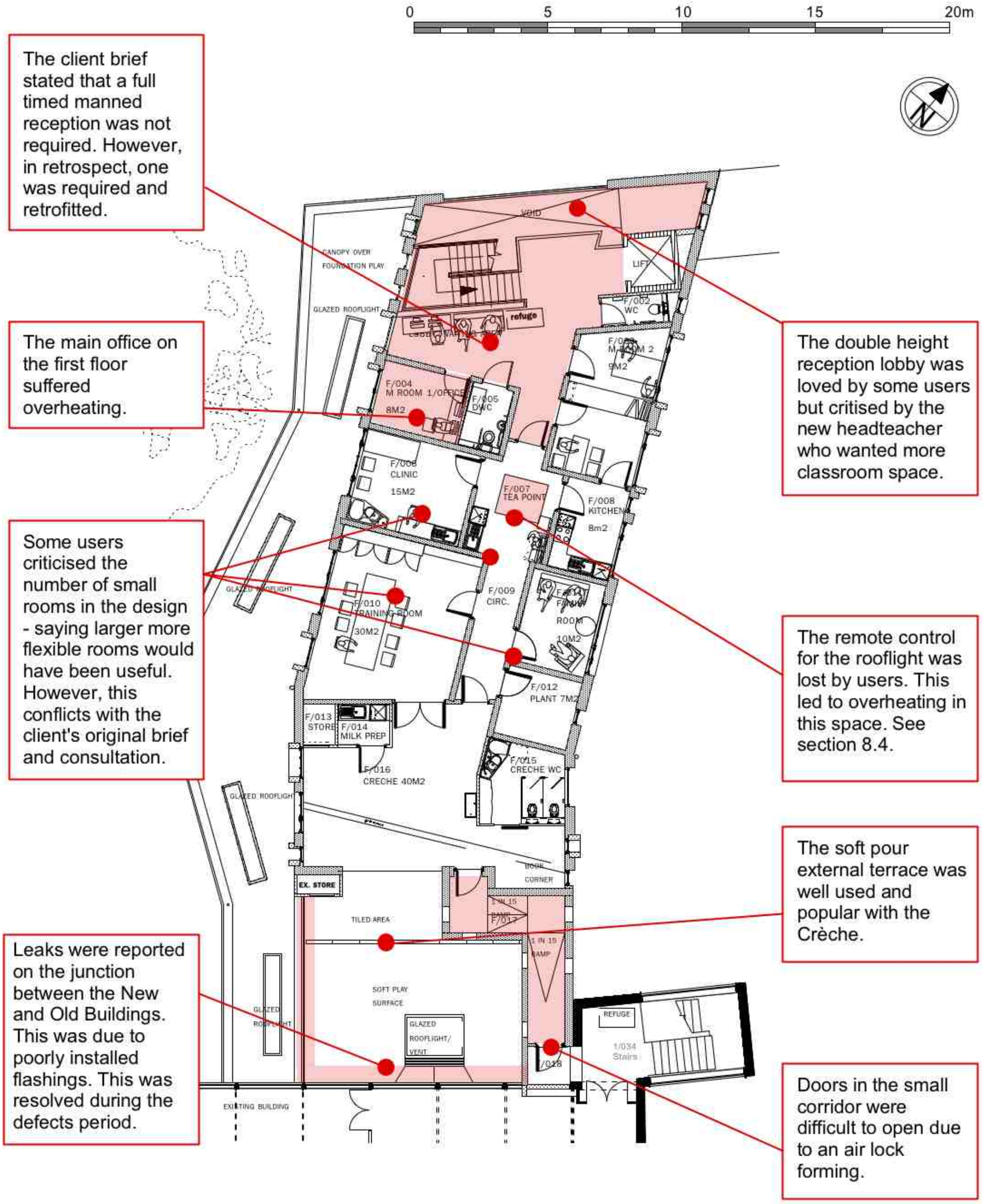


Fig. 5.3.2- First Floor Plan of the New Building with commentary.

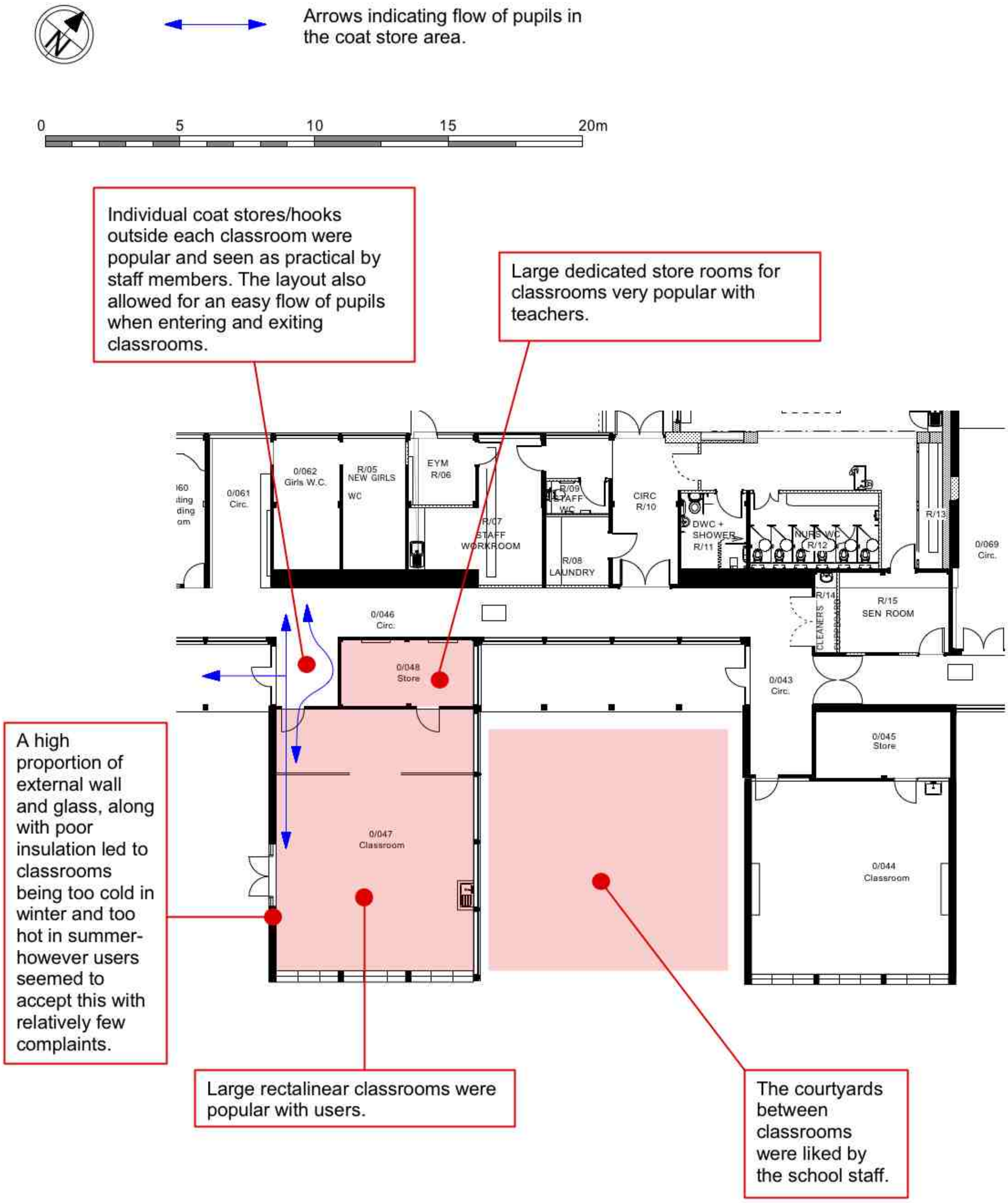


Fig. 5.3.3- Extract plan from the Ground Floor of the Old Building

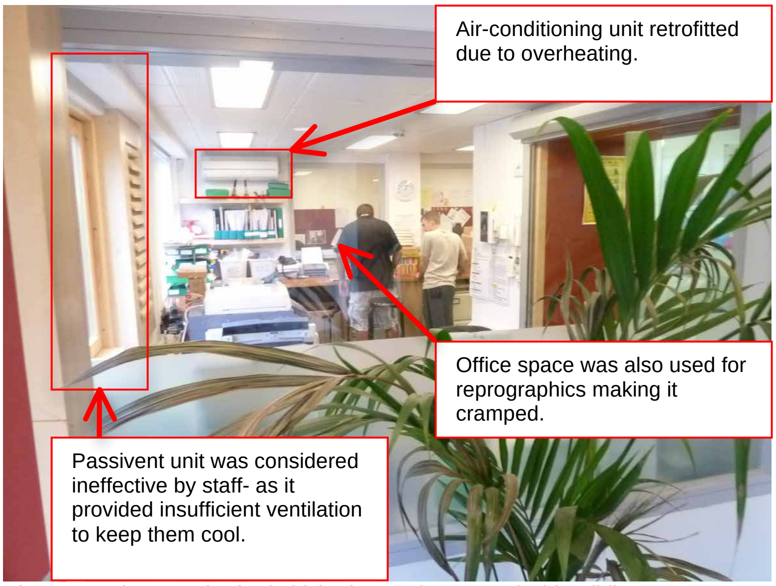


Fig. 5.3.4- Photograph of refurbished reception area of Old Building.

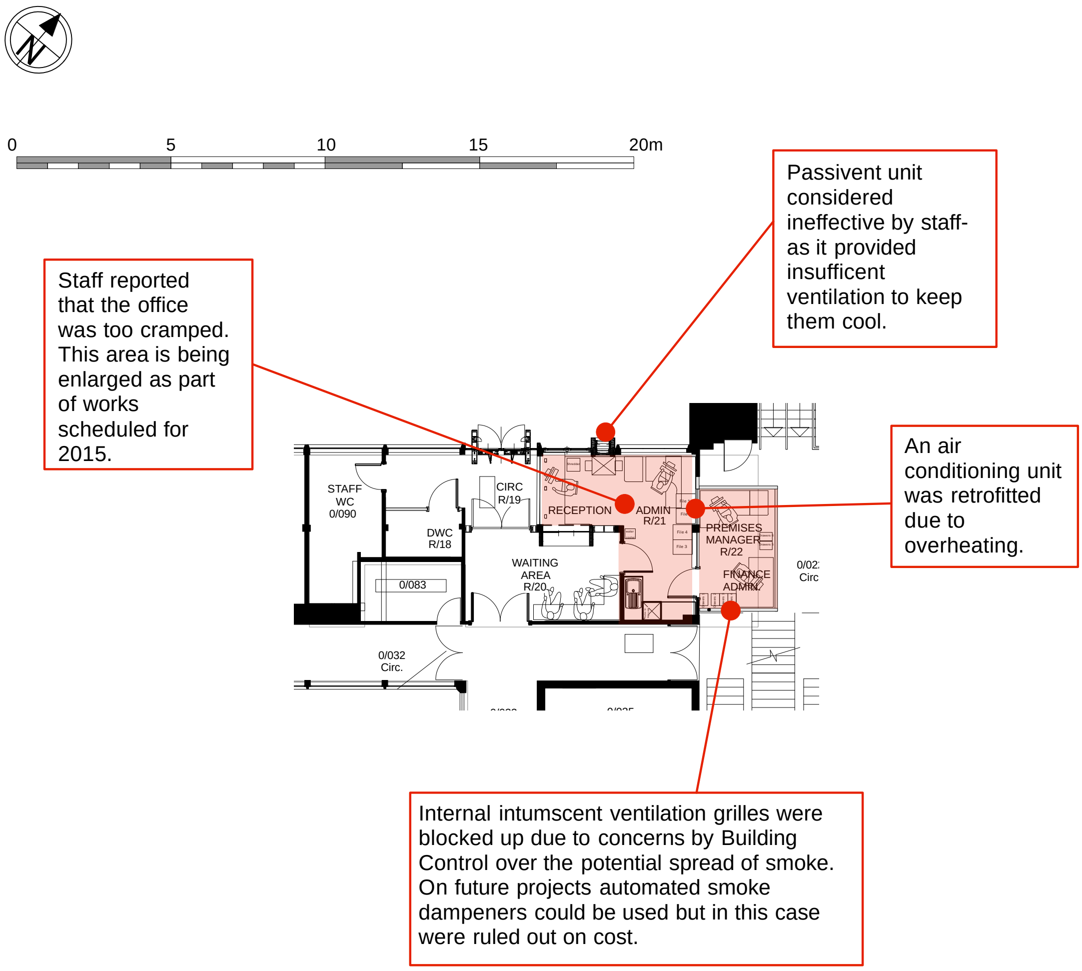


Fig. 5.3.5- Extract plan from the Ground Floor of the Old Building Reception area.

5.4 Health and Productivity

Non toxic finishes, paints and stains were used throughout the New Building and were generally popular with users. When the site was revisited in 2012-2013, the paint work appeared in very good condition with few marks or scuffs. This finding indicates that the Natural Building Technology (NBT) range used was lasting well – contrary to some fears originally raised at design stage by the Facilities Management Team.

In terms of 'health', the New Building scored more highly than the Old with users scoring it in the 90th percentile as compared with the 75th Percentile. An impression that improvement to health may be due to Non Toxic materials must be tempered by the following comment from one user *'Unfortunately children carry lots of germs, so definitely not more healthy.'*

With regard to productivity, the majority of users surveyed in the BUS survey of the Old Building stated that the building neither improved nor decreased productivity, with a small minority reporting a positive impact. In the New Building there was a big split; with the majority seeing a significant improvement in perceived productivity but a small minority seeing a reduction. The minority is perhaps explained by the overheating problem experienced in the first floor office. Please refer to section 5.6 and 8.4 and 8.5 for more details.

5.5 Materials & Construction

The New Building was constructed with a Cross Laminated Timber frame and clad in Thermowood timber boarding. The frame was quick to erect and cost effective according to the client's quantity surveyor. In some locations, the finish was poor and some manufacturing errors caused delays as the new panels had to be made to order in Austria. See Fig.5.5.5. Of interest here is the fact that no equivalent manufacturer could be sourced from the UK at the time.

Internally, the exposed timber frame was much liked but, on a walk through, the BPE team found that the coating had begun to turn a orange hue over time due to the fire protective paint used. See Fig.5.5.5. Architype are undertaking further research into finding an alternative product that does not have this problem.

The pallete of materials chosen, see Fig.5.5.2, was popular with users and was successful in expressing the building's construction materials.

Externally, the cladding experienced differential ageing due to the weather. The types of staining resulting from this was unpopular with some users. This was partially caused by water dripping down the façade, see Fig.5.5.8. It was caused by water running down the capping and catching in joints in the aluminium capping; a particular problem in driving rain. The contractor undertook remedial works to the joint to address this however, on future projects it is recommended that roof cappings should be given a fall of greater than 5 degrees towards the roof to ensure water migrates away from the façade. An overhang of greater than 40mm may also have assisted but, would also have impacted on the aesthetic appearance of the building. Painting or staining could mitigate general discolouring, however this in turn creates a maintenance burden. Clients should be made aware of these issues when timber is used for external cladding.

The reduced lifecycle carbon footprint of using these materials was calculated and results are given in chapter 7.

Fig.5.5.1- Photo of the ground floor reception classroom 2012. This was popular with staff for it's free flow layout and connectivity with the adjacent classroom. However most storage for these classrooms is located within freestanding units or beneath the sinks- which was criticised.

Fig.5.5.2- Photo of the Children Centre stair care 2012 – The palette of materials for the New Building included expressed cross laminated timber, natural lino cladding on walls, stainless steel and large windows for good natural light. The appearance of the building was highly prized by users.

Fig.5.5.3- Photo of the New Building's feature staircase – 2012. This dynamic entrance which expresses the materiality of the construction helped create the New Building's positive image. However the new headteacher criticised it saying some features such as recessed lighting were expensive to maintain and were not sufficiently robust.

Fig.5.5.4- A less than satisfactory reception area was retrofitted by the Children's Centre once funding was secured for a full time receptionist.

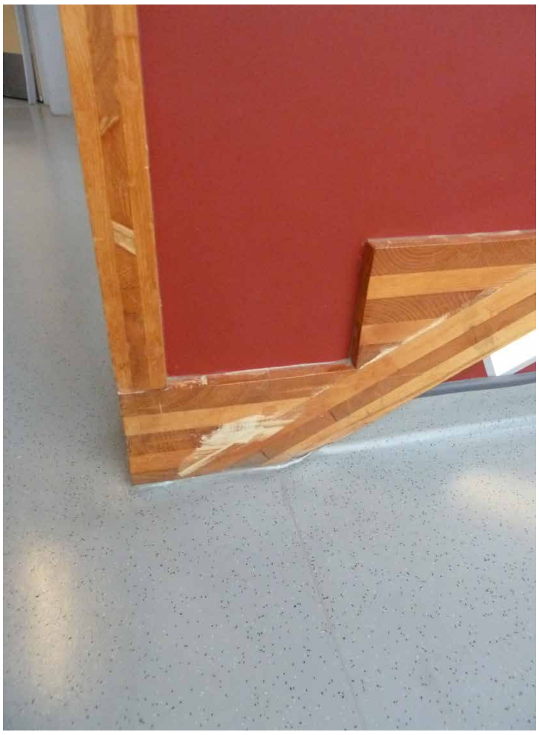


Fig.5.5.5- Defects in the manufacture of cross laminated timber were visible in some locations. The fire retardant coating caused the timber to yellow overtime, which was disliked by many.

Fig.5.5.6 - Photo of the wall in the ground floor lobby of the Children''s Centre. The design of signage was taken on by the client and not included in the main contract. This has led to a lot of unco-ordinated signs being fitted, which adds visual clutter to the spaces.

Fig.5.5.7 - Problems were experienced with external recessed lighting - with water leaking into fittings. These were replaced by the contractor but facilities staff complained future repairs would be expensive - they state a preference for wall mounted fittings with cheap replacement parts.

Fig.5.5.8 - Staining on the external cladding can be seen in vertical lines. This has been caused by water dripping from joints on the main capping. Remedial works were undertaken to improve this junction – however on future projects capping should have a greater fall toward the roof (away from the façade) and have a greater overhang to avoid this issue.

Fig.5.5.9 - Bespoke play sinks were fitted in the classrooms of the New Building. These were very popular with staff.

Fig.5.5.10 - Photo of ground floor nursery classroom in the New Building. The teachers fitted out the space with hanging and posters. More storage for this material was requested.

Fig.5.5.11 - A timber shed buggy store was retrofitted to the scheme by the end user as the provision for buggy storage provided was seen as insufficient.

Fig.5.5.12- Large rectilinear classrooms in the Old Building were popular with staff (2013) – despite being hot in the summer and cold in the winter

Fig.5.5.13- Photograph of large stores in the Old Building (2013). Teachers state that these allow them to use classrooms more flexibly.

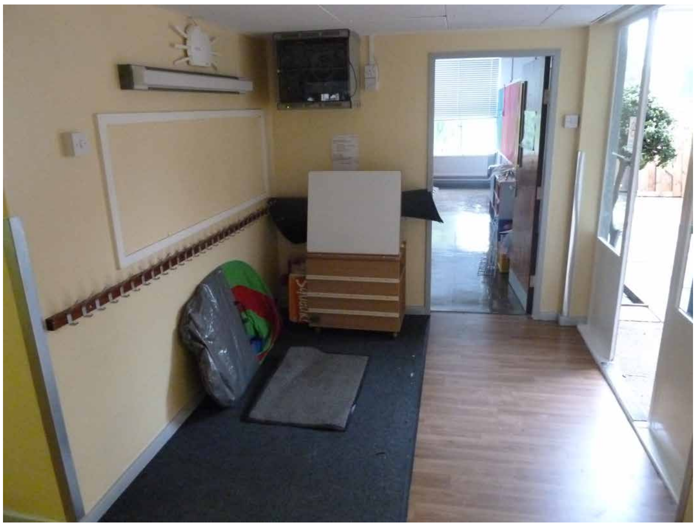


Fig.5.5.14- Individual coat areas outside classrooms that did not interrupt main circulation routes were popular with staff for being practical and robust. (2013)

Fig.5.5.15- Recessed radiators and large underground service ducts were other examples of the Old Building's pragmatic and integrated design. (2013)

5.6 Temperature

Temperature loggers (manufactured by Hobo) were installed in multiple locations in the Old and New Buildings for a period of over one year to provide an overview of the comfort conditions in the buildings. See Appendix F for locations of sensors and raw data, these were all newly purchased and pre-calibrated to give accuracy of ±0.53ºC. Temperature frequency plots are given for the New Building, Fig.5.6.1 and the Old Building respectively, Fig 5.6.2. Note that 'GF' indicates ground floor and 'FF' first floor;

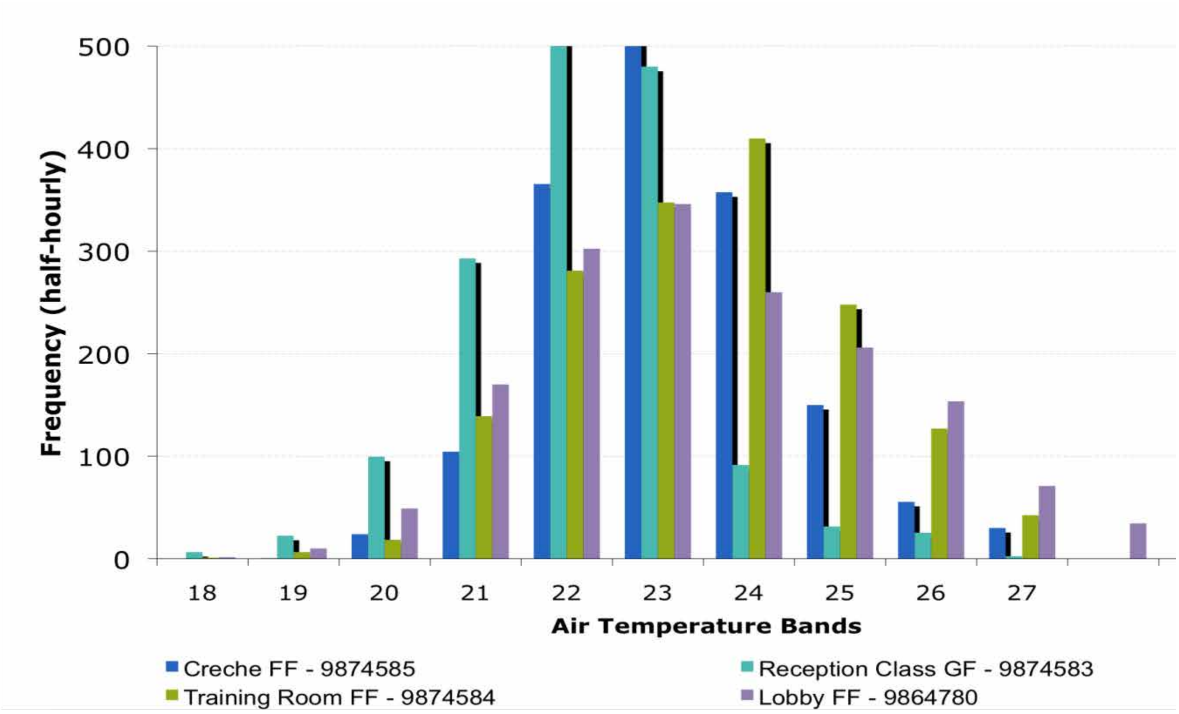


Fig 5.6.1 – Frequency of Temperatures Occurring over a year (every half hour) in Various Spaces in the New Building

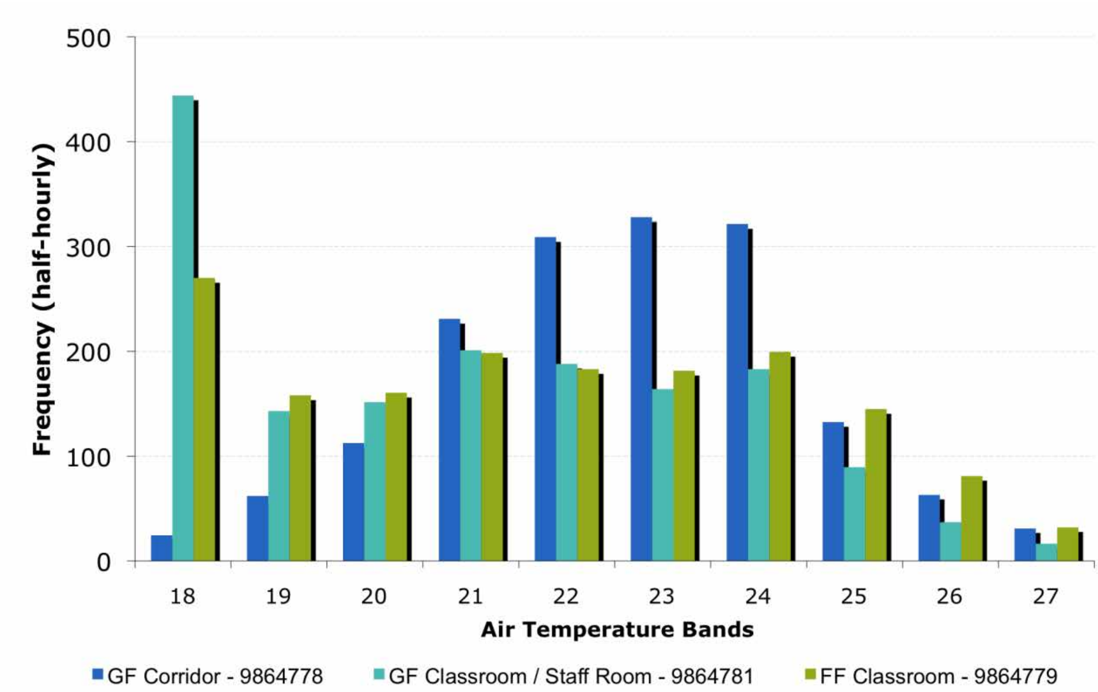


Fig 5.6.2– Frequency of Temperatures Occurring over a year (every half hour) in various Spaces in the Old building

The New Building's 'bell-shaped' distribution, see fig.5.6.1, suggests that control of temperature is reasonably good. Temperatures are predominantly in the comfortable 22-23°C range and rarely drop below 20°C - even overnight during cold weather. It does however show some propensity for over-heating, i.e. temperatures above 25°C: a typical characteristic of modern, well-insulated buildings with insufficient or malfunctioning ventilation.

The Old Building, Fig.5.6.2, has a much broader and more even range of temperatures across the whole spectrum during occupied conditions. It is relatively warm in the summer and gets too cold in winter. This finding was largely in line with expectations given the poor quality of the building's fabric and was not investigated further.

Minimal temperature differences were found between the monitored rooms on the ground and first floor in the Old Building. However, there was as much as a 2°C difference between the ground floor and first floor spaces in the New Building during summer days.

Overheating in the New Building

To understand overheating in the New Building in more detail, the BPE team subsequently compared the monitored indoor temperatures within the New Building spaces with the thermal modelling results obtained during the design stage. The monitored temperatures showed a higher percentage of overheating hours, although this was a proportionally small value compared with the total occupied hours.

Summer overheating Hours

Space	Hours with Temperature over **24°C**		Hours with Temperature over **26°C**	
	Predicted	Monitored	Predicted	Monitored
Crèche (FF)	83	230	12	50
Training Room (FF)	127	210	26	100
Reception Classroom (GF)	6	50	0	30

Predicted by thermal modelling

Monitored (by BPE team)

Fig 5.6.3 - Table comparing summer hours of overheating – predicted versus monitored

Based on these results and a complaint by the Children's Centre manager that there was overheating, further investigations were carried out and the data loggings were compared with the CIBSE Guide A (2006: 7th Edition) benchmarks. The benchmark contained therein set that in school spaces overheating criteria is defined as operative temperatures over 28°C for more than 1% of the annual occupied hours. Fig. 5.6.4 shows the results of the comparison:

Space	Crèche	Reception Classroom	Training Room
% hours over 28°C	1.01%	0.05%	0.21%

Fig 5.6.4 – Frequency of Overheating in Various Spaces in the Extension

The crèche overheating results comply with benchmarks set in BB87 (DfES, 2003) and BB101 (DfES, 2006) but fail those given in CIBSE Guide A (2006), although only by 0.01%; a figure less than the margin of error for the measurement and instrumentation (±0.53ºC). CIBSE notes that *'In normal operation, it may not be possible to meet these summer internal design criteria under all conditions without the provision of mechanical cooling, and it is necessary to analyse the risk of overheating and aim to minimise the length and severity of any discomfort.'* This suggests that robust modelling is needed when designing for naturally ventilated buildings, as some complaints that the space was too hot persisted, and so if this is the case certain areas of mechanical cooling may have been appropriate.

Further discussions pinpointed the source of these complaints to the office on the first floor of the New Building, which had not been monitored. This space was then monitored and was shown to overheat significantly due to the higher than anticipated occupancy, small amount of ventilation and solar gains. The problem of overheating was investigated further in this report and various actions were discussed and implemented to address overheating. Please refer to section 8.4 and 8.5 of this report for further details.

Perceptions of temperatures tell similar stories to the data. In the BUS survey, users rated the Old Building negatively and recorded comments such as *'Quite cold in the winter, quite warm in the summer...'* and *'Bit cold!'* reinforce this.

In the New Building, scores for air quality and temperature showed great disparity between different users. Whilst the majority seemed happy, a single user reporting being very uncomfortable, See Fig.5.6.5.
This response on the BUS when investigated, was linked to the Children's Centre Manager who worked in the first floor office. Again confirming the problem in this room with overheating.

In the Old Building levels of comfort are also affected by the phenomenon of 'heat creep'. See Section 6.6 for further details.

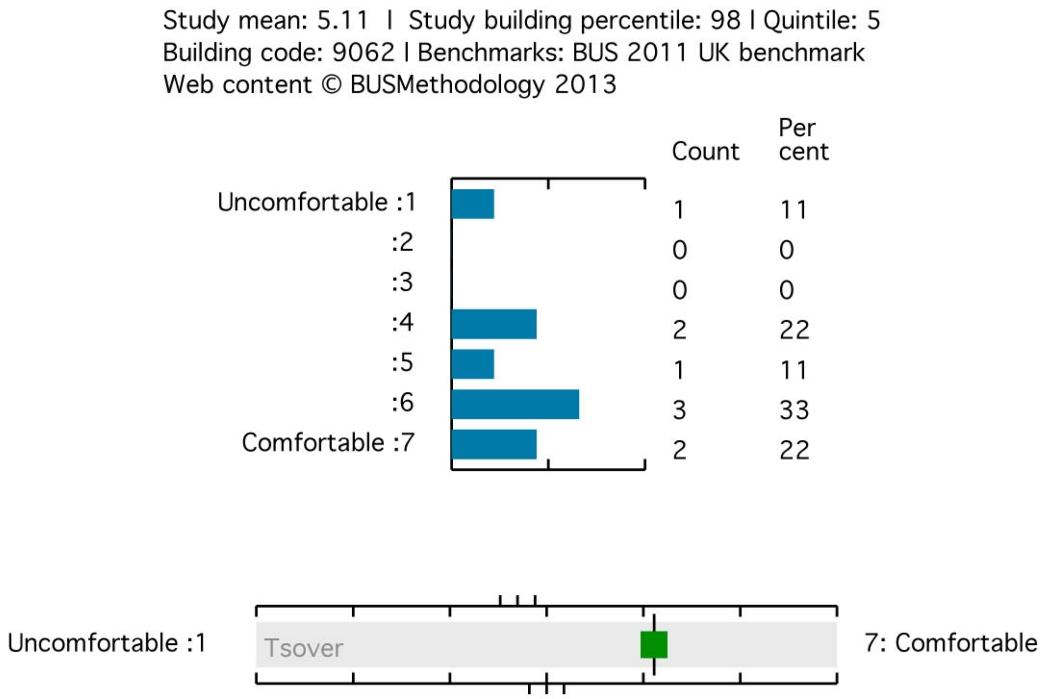


Fig.5.6.5 - BUS survey results for the New Building - Overall Temperature Summer

5.7 Indoor Air Quality

Limited monitoring of CO_2 and Volatile Organic Compound levels (VOCs) was carried out in the reception classroom in the New Building. This revealed that CO_2 levels could exceed DfES and CIBSE guidelines i.e. over 1500ppm. Levels of VOCs were within acceptable limits, although new research suggests that these guidelines themselves may need revision. For future design of naturally ventilated school buildings, further research and investigation is required to identify a simple and cost effective method of reducing CO_2 levels whilst avoiding creating complex systems.

The low VOC levels are likely due in part, to the use of natural wood finishes and paint, rubber flooring and the avoidance of products containing solvents, glues and plastics. The building also employs a 'breathing wall' construction. Also, most VOCs originate externally and the school is effectively in a cul-de-sac and not near busy roads.

Fig 5.7.1- Tongdy IAQ monitor used at Bessemer. The LCD display and alert sounders meant users disrupted this probe.

5.7.2. Hobo Temperature probe- These have no display, no requirement for power- meaning they were easy to place and were not disturbed by users.

Several attempts were undertaken to observe the Indoor Air Quality of the New Building, using the method for Monitoring CO_2 levels created for Architype by the Oxford Brookes KTP researcher. This method is based on the work of Mumovic on the evaluation of ventilation rates in schools. See appendix L for details of methodology and raw data. However, staff and/or pupils interrupted the Tongdy monitor, see Fig.5.7.1, by turning off the equipment when the CO_2 alert sounded and/or the data not being stored on the flash drive correctly. After several unsuccessful attempts, the BPE team were eventually successful in getting some limited data. In future, using a more discrete logger similar to the HOBO temperature probes, Fig.5.7.2, would be desirable to avoid attracting the attention of users who were distracted by the LCD display and the alarm sounding.

5.8 Day Lighting

Day lighting field surveys were carried out predominantly in the New Building. See Fig.8.5.1. Overall there was very good day lighting availability and the building was perceived as well-lit. Thoughtful features were appreciated such as the low-level windows, which brought natural light in at floor-level (where small children are seated or playing).

Ground floor spaces in the New Building showed a higher variation in the uniformity of day lighting levels than the first floor. In some locations the daylight factor (DF) was lower than 2%. For example niches; which strongly contrast with areas adjacent to windows, which are 20% or higher, as shown in Fig 5.8.2 and 5.8.4. However, visual comfort and glare control was available through the use of internal blinds. On the first floor, see Fig.5.8.3, the uniformity was much better. The difference can be explained by the installation of the canopy at ground floor which blocked a lot of light on the South-West side.

It was also worth noting that many walls in both buildings were covered with decorations, paintings and posters, lowering the overall room reflectance and occasionally partly obscuring windows. Bold colours such as blue on walls with low light reflectance value, reduced light levels in some areas. This further impacted on the uniformity of light in certain areas and should be taken into account by designers both in terms of day lighting and artificial lighting design for schools.

The problem of artificial lighting being switched on even with good daylight availability was observed in both the New and the Old Building. One possible explanation for this was the poor uniformity of light, leading staff to turn on lights to balance levels. This is discussed in more detail in section 8.1.

In the Old Building there were extensive glazed areas without adequate provision of blinds. This has resulted in complaints about glare which is particularly relevant in a teaching environment where the interactive white board plays a central role in lessons.

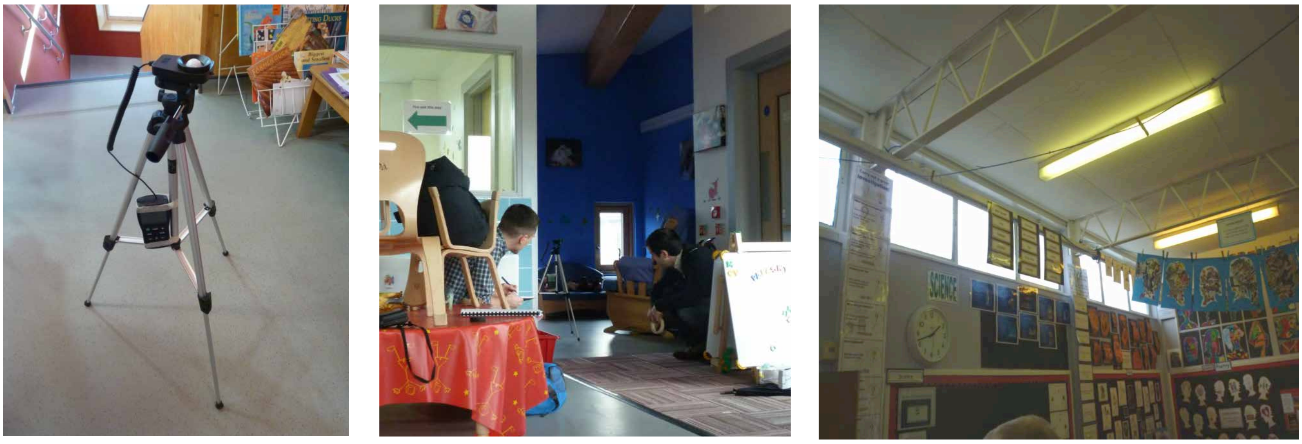


Fig 5.8.1 – (left and middle) Photos of the researchers undertaking the light survey using Lux Meters (far right) Old Building – artificial lighting being used to counteract contrasting levels between bright daylight windows and dark walls covered with drawings and posters

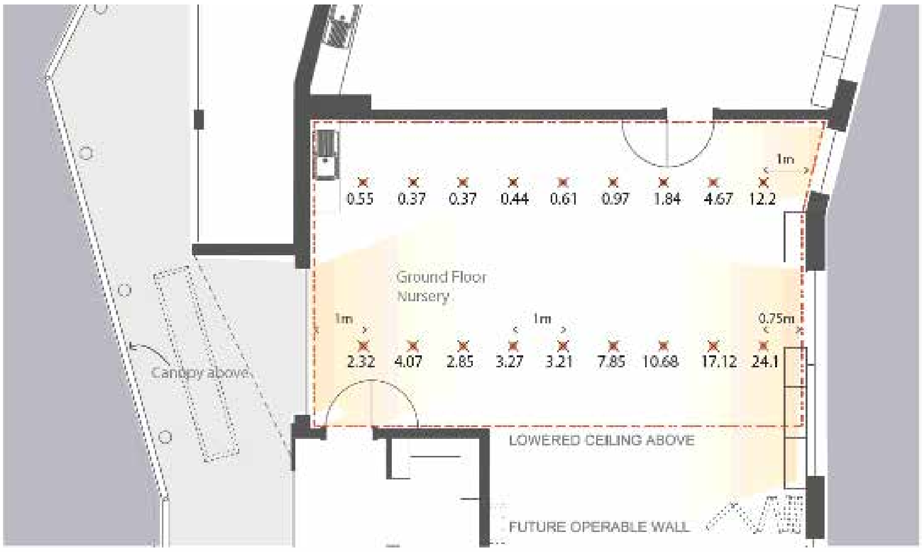


Fig 5.8.2 - Ground Floor Classroom Daylight Factor (%) mapped onto a plan of the room- showing a poor uniformity of daylight.

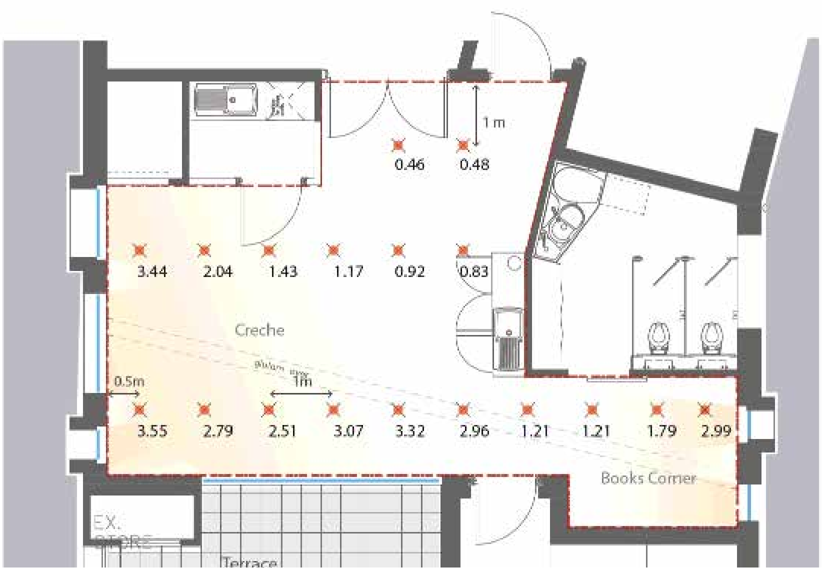


Fig 5.8.3 - First Floor Crèche Daylight Factor (%) mapped onto plan of room – showing a better level of uniformity than achieved on the ground floor.

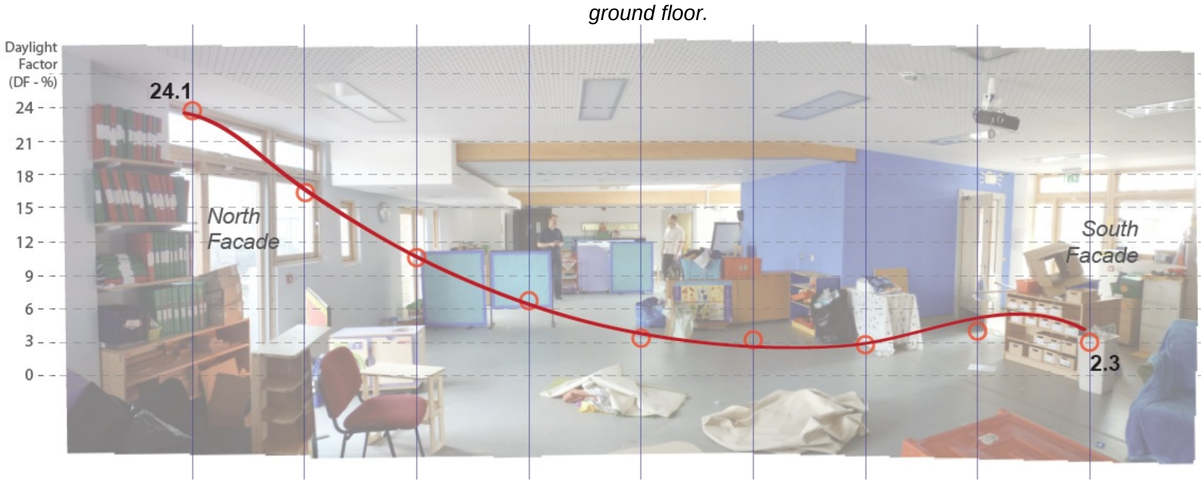


Fig.5.8.4 - New Building - Ground Floor Classroom Daylight Factor (%) mapped onto a photo - showing a poor uniformity of light.

5.9 Noise

A detailed survey of acoustics was not undertaken, however, overall BUS scores for noise in the Old Building and the New Building were very positive. Despite having poor insulation and single glazing, the Old Building scored much better than the New in terms of outside noise. This is most likely explained by the fact that the noisy early years play area is set away from the Old Buildings classrooms.

5.10 Facilities and Management

BUS scores showed that satisfaction with cleaning were rated highly in both buildings and that requests and concerns were addressed rapidly and efficiently. The Facilities Manager did highlight that the rubber floors were found to be difficult to clean at first as they required a different technique than the vinyl floor more typically found in schools. They agreed that once the correct cleaning process was used, this became easier however. it highlights the importance of easily accessible and clear literature for maintenance, as cleaning staff regularly change. Despite this, the facilities team stated that they preferred the use of vinyl flooring from a maintenance point of view and were less concerned with respect to the potential health issues associated with the use of a PVC product.

Overall on both surveys, users were asked to rate whether the facilities met their needs. The Old and New Buildings scored highly in the 90th and 92nd Percentile respectively. Only one respondent in the New Building rated it below average and three in the Old building rated it ‘poorly’. Overall this indicates that both buildings performed similarly in meeting the needs of their occupants.

Further details on maintenance are included in section 4.6 of this report.

5.11 Miscellaneous Issues

New coloured gates, see Fig.5.1.1, were highly popular as they helped identify the different entrances and were commonly refered to as ‘blue, green or red gate’. However, the slamming of the heavy ‘blue’ steel gates at the entrance of the New Building, was very disturbing and potentially dangerous. It was identified that the weight of the gate was too great for the powered closer installed by the sub contractor. Eventually, this was resolved in the defects period, by the contractor installing a new more powerful control arm. On future projects, particular care should be taken when specifying accessories for non-standard size items, such as doors or gates.

A number of other minor issues caused a disproportionate level of inconvenience and frustration. Conflicts between regulations and user needs, meant that fire alarms and door releases had to be wheelchair accessible at low level, Contrary to the safety needs of young children. Likewise heavy fire doors with mechanical closers were difficult for pupils to operate. Resolving such issues took a good deal of time.

Fig. 5.1.1- Sub-contractor installing new gate closer – after the original closer failed.

5.12 Fabric and Airtightness

A thermographic walkthrough was undertaken on both buildings to assess the effectiveness of the thermal envelope and identify areas of significant heat loss. This clearly showed that the New Building had significantly less heat loss than the Main School building. This was unsurprising given the much higher levels of insulation and high performance double-glazing. In addition, the air tightness test carried out in 2010 confirmed the efficient envelope of the New Building; it achieved 5.7 $m^3/(m^2.h)$ at 50 pa Permeability/leakage - a rate better than current building regulations.

Despite the overall satisfactory performance, there were some areas of concern with respect to heat loss in the New Building. One of the most interesting was the large Reglit glass window on the North façade. A thermal imaging camera was used to confirm the heat loss from the joints between the glass panels and from the window frame. Thermal images in Fig.5.12.1 show a difference of almost 3.5°C between the joints and the panels, and a difference of 5-8ºC between the edge and the rest of the construction. This constitutes a relatively high heat loss and may explain one user comment that the reception lobby could feel cold in the winter.

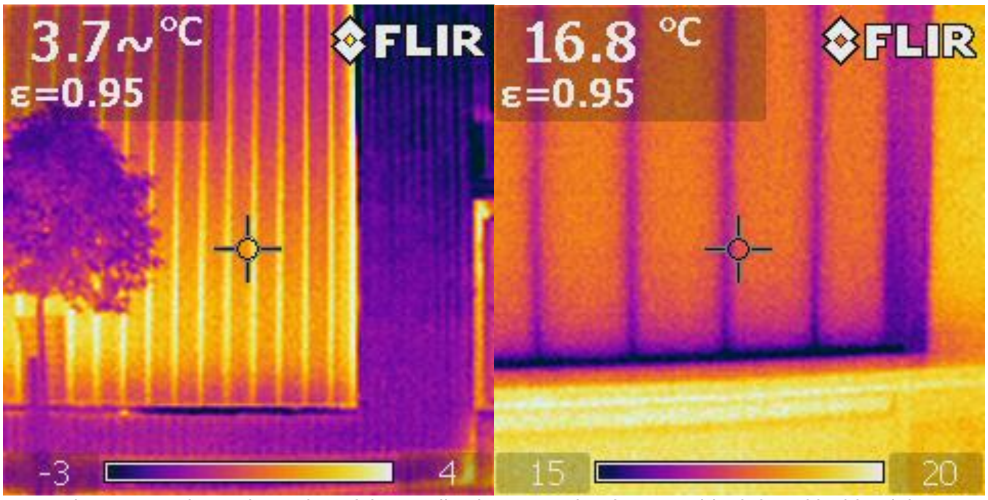


Fig 5.12.1 - Thermal Imaging of the Reglit Glass Façade - from outside, left and inside, right.

Interestingly, when the building's air tightness was retested as part of the BPE study in 2013, it only achieved a final score of 6.47 $m^3/(m^2.h)$ at 50 pa Permeability/leakage. See Fig.5.12.2 and 5.12.4. However, two extract ventilation units on the high level roof of the first floor adult & accessible WCs were unable to be accessed (due to the height) and these units were estimated to be leaking. Additionally, it was unclear whether the original test had sealed off the connection to the existing building or not. Therefore a direct comparison was difficult to make and the difference may not be as significant as it first seems.

Notwithstanding the above, there appears to be a drop in overall performance and air tightness. It is impossible to know whether this is a single deterioration or a continuous annual deterioration, as there is very limited information available. However, smoke pencil tests undertaken identified two areas of leakage:

1. **Doors and window movement:**
   With continuous and heavy usage of the timber composite windows and doors, it appears that doors were not sealing tightly, allowing air to escape through any gaps. If improved airtightness was required then windows with better seals would also be required. See Fig.5.12.5.

2. **The mastic seals:**
   The seals around openings did not appear to be continuous / meet in all places. These could have been damaged or may have deteriorated with age. Several such items that allowed air to escape were noted. See Fig.5.12.3. On new projects, Architype uses airtightness tape systems made by manufacturers such as SIGA or Proclima, which provide a suite of products to promote improved airtightness. The adhesive on these tapes is offered with guarantees of 60 years and when used correctly, can avoid such issues.

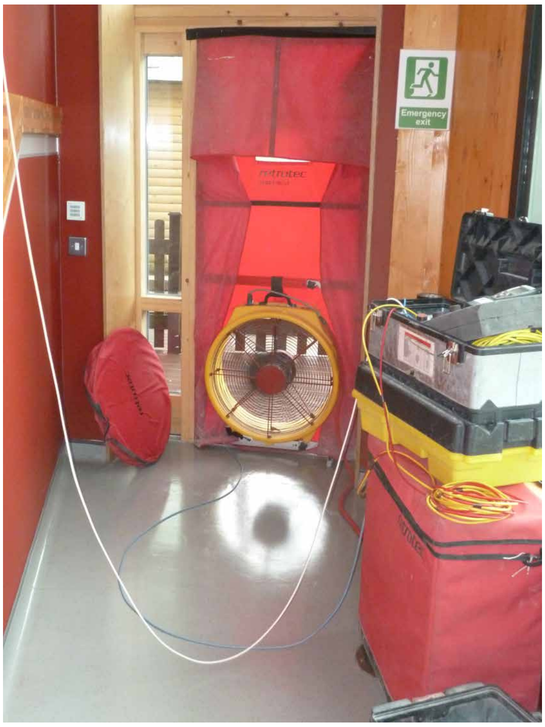


Fig.5.12.2- photo of the air pressure testing equipment installed.

BSRIA

DRAFT

AIR TIGHTNESS TESTING RESULTS

Stocking Lane, Hughenden Valley, High Wycombe, HP14 4ND, UK

t: +44 (0)1494 569800 w: www.chilterndynamics.co.uk

Air Tightness Testing and Measurement Association

Part L2B Air Permeability Test

Certificate No. Chilt/L090587-2

This document confirms that air tightness testing (in accordance with ATTMA TS1 issue 2, method B) was conducted by

Chiltern Dynamics

On the following building:

Bessemer Grange School, Dylways

London, SE5 8HP

on 24 July 2010

The building was a new school classroom block extension (timber frame with standard insulation) with an Envelope Area of 1238.14m².

The test was commissioned by Mr Tony Mistry of **Bryen & Langley Ltd** 48-60 Footscray Road, Eltham, London, SE9 2SU

Air Permeability Achieved	**5.69* $m^3/(h.m^2)$**
Target Air Permeability	5.00 $m^3/(h.m^2)$

*This result was achieved with some additional temporary sealing. A complete list of test conditions, equipment used, test data and the building description are given in full in the Test Report Chilt/L090587-2

Candice-Adele Henley, *Operations Co-ordinator*

Anthony Gunningham, *Test Engineer*

This document is confidential and remains the property of Chiltern International Fire Ltd

Enquiries about this certificate should be addressed to: The Secretary, ATTMA, c/o BINDT, 1 Spencer Parade, Northampton NN1 5AA Tel: +44(0) 1604 630 124, E-mail: attma@bindt.org

Fig. 5.12.4- Copies of the air pressure testing certificates.

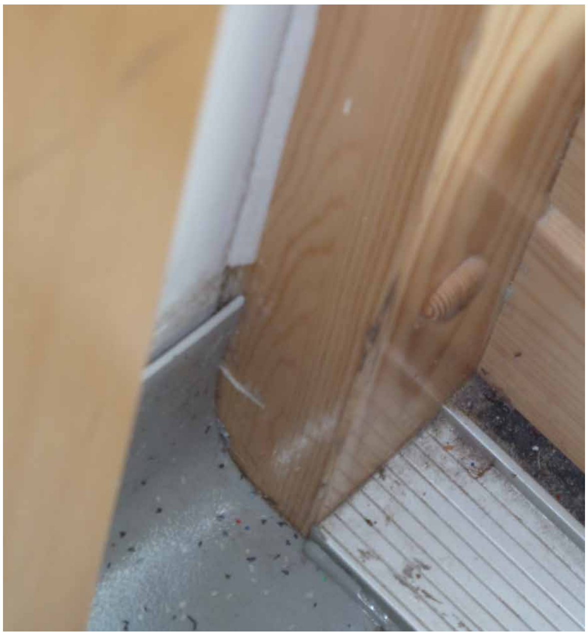


Fig. 5.12.3- Smoke tests showed junctions around doors where mastic has been used were area of weakness for airtightness.

Fig. 5.12.5- Smoke tests showed that the windows were a major source of air leakage.

6 Review of Energy and Water

6.0 Chapter Introduction

This chapter provides an overview of the operational energy and carbon performance of the New Building, Old Building and the whole Bessemer Grange site.

It draws from the CIBSE TM22 analysis carried out on the buildings, as well as the extensive metering and monitoring undertaken as described in section 6.3. See Appendix G for details of key assumptions and the TM22 excel data files. This information has also been uploaded on Carbon Buzz, a site that allows direct comparison of building performance to design targets.

Equally importantly, it also reflects the active engagement of the BPE team with the school management, the London Borough of Southwark and the teaching, administrative and maintenance staff throughout the duration of the study. This engagement was undertaken in order to understand and identify problems and to improve the environmental performance of the whole school as well as the comfort of users. It did not simply focus on energy use.

Several studies on specific technical issues raised in this chapter are discussed in more detail in chapter 8. Recommendations made to users and the clients based on findings in this chapter are contained within chapter 9.

6.1 Energy and Water - Key Findings

The following bullet points, charts and tables provide a summary of the key energy findings from the project:

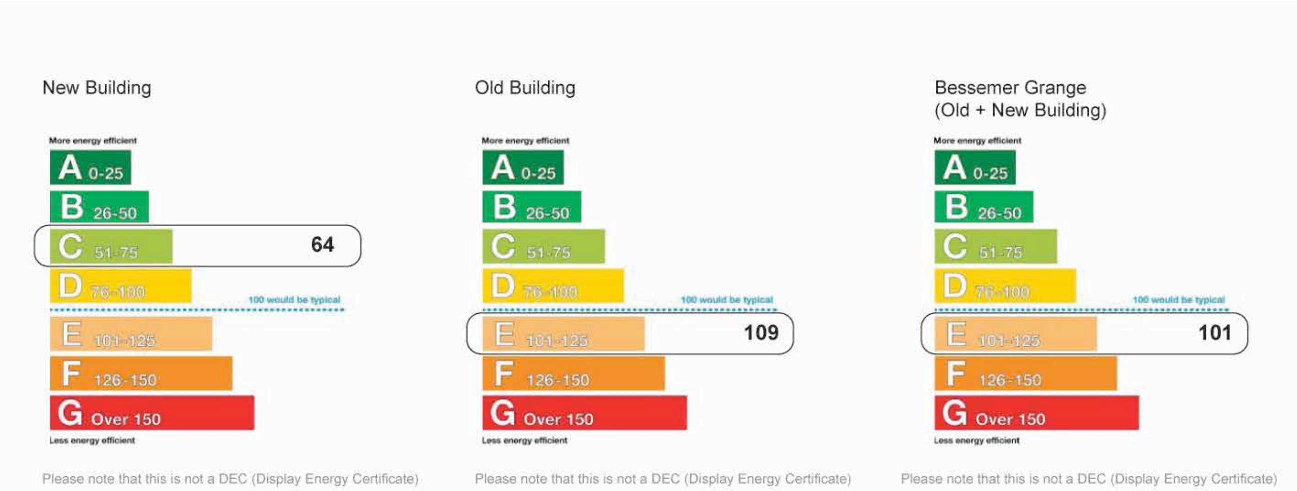


Fig.6.1.1– Unofficial DEC Ratings for the buildings - based on 2011/12 measurements from data readings logged on ***www.smeasure.co.uk****. The New Building's performance is negatively affected by the it's high electrical consumption. See Fig.6.1.2a and b.*

Please note that at the time of writing, Bessemer Grange had yet to undertake an official DEC evaluation, despite it being a legal requirement for all public buildings over 1000m2 (DFPNI: 2013)

Figures 6.6.2a to 6.6.2c. provide a summary of the energy performance of the building in comparison to benchmarks published by CIBSE, which are based on measurements from a large sample of real schools and nurseries.

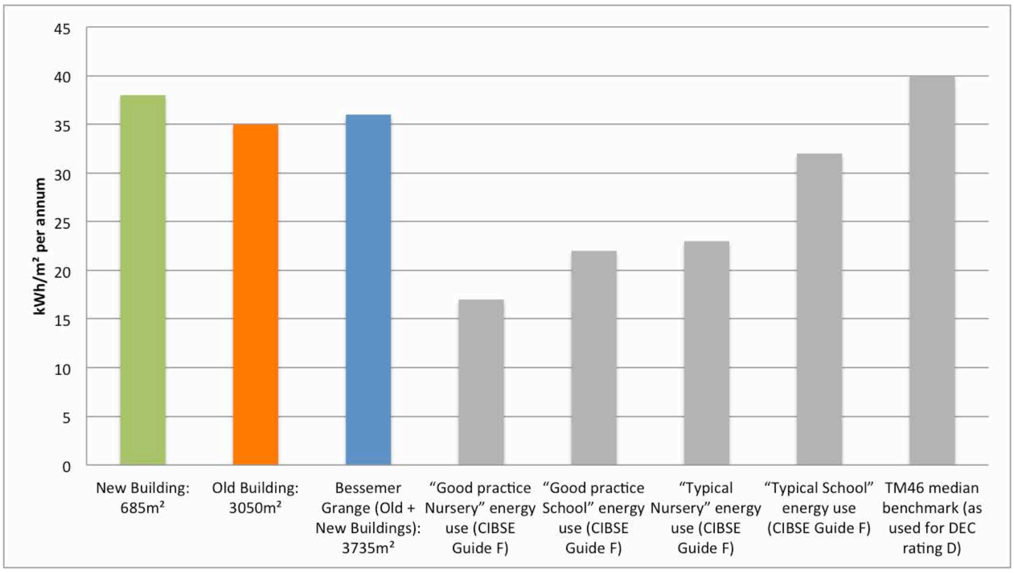


Fig.6.1.2a - Gas consumption 2011/2012 relative to CIBSE benchmarks – showing the New Building's excellence performance in comparison to benchmarks.

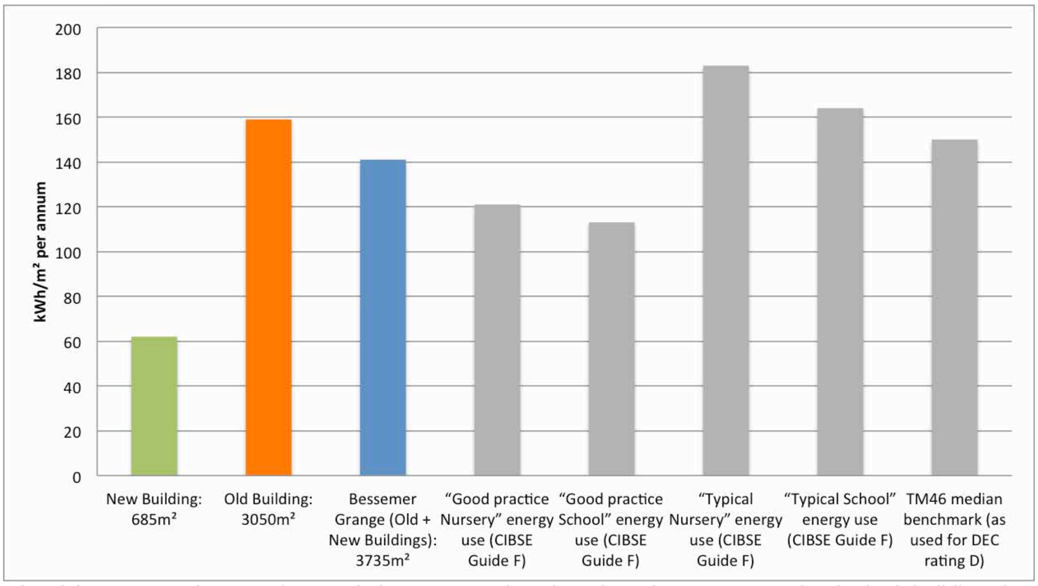


Fig.6.1.2b - Electricity consumption 2011/2012 relative to CIBSE benchmarks - shows consumption for both buildings is above typical benchmarks.

	New Building: 685m²	**Old Building:** 3050m²	**Bessemer Grange (Old + New Buildings):** 3735m²	'Good practice Nursery' energy use *(CIBSE Guide F)*	'Good practice School' energy use *(CIBSE Guide F)*	'Typical Nursery' energy use *(CIBSE Guide F)*	'Typical School' energy use (CIBSE Guide F)	'TM46 median benchmark (as used for DEC rating D)"
Electricity	38	35	36	17	22	23	32	40
Gas	62	159	141	121	113	183	164	150

Fig.6.1.2c - Gas and Electricity consumption table 2011/2012 relative to CIBSE benchmarks given in kWh/m^2 per annum.

	Lighting	Small power	Fans, pumps and controls	Cooking/Catering	Lifts	ICT equipment	Cooling
New Building	46%	24%	13%	9%	5%	2%	0%
Old Building	52%	10%	8%	9%	2%	1%	11%

F*ig.6.1.3 - Electrical energy usage breakdown taken from TM22 analysis- lighting dominates electrical consumption in both buildings.*

New Building:

The following bullet points summarise key energy findings from the New Building:

- The New Building performs well but not outstandingly in terms of operational carbon consumption. As shown in Fig.6.1.1, it would achieve an estimated 'C' display energy certificate (DEC) rating if assessed independently as a stand-alone building;

- Based on the CIBSE TM22 analysis, carbon emissions are ~33kgCO2/m2 per annum or 22.6 tonnes per year;

- Electricity consumption, ~38kWh/m2 per annum, see Fig.6.1.2b, is high even in comparison to 'typical' performance benchmarks. The higher carbon factor of electricity means that the elevated electricity consumption has a particularly adverse effect on the New Building's carbon consumption;

- Fig. 6.1.3 shows that electrical consumption is dominated by lighting. Further details are given in section 6.2.3;

- As shown in Fig.6.1.2a and 6.1.2c heating energy consumption, ~62kWh/m2 per annum, is relatively low, i.e. much better than empirical 'good practice' benchmarks published in CIBSE Guide F and CIBSE TM46 (110-150kWh/m2 per annum). See section 6.2.2 for more details;

- The design of the building features water efficient appliances, such as low flow WCs and percussion taps. These devices appear to have been highly effective and water consumption for the New Building was found to be c.1.3m^3/pupil per annum which is 50% better than the DCSF's (Department for Children, Schools and Families) 'good practice' benchmark of 2.7m^3/pupil per annum;

- The design of the under floor heating systems within the New Building functions reasonably well, although no local control is possible by users as room thermostats need to be reset manually by maintenance staff;

- Rather than installing a separate local gas-fired condensing boiler in the New Building, pipework was put in place to connect the New Building to the existing underground boiler room in the Old Building, which had ample spare capacity. See section 3.2. This made heating consumption higher than necessary. The separate boiler could have been accommodated and would have offered improved energy efficiency (higher boiler efficiency, reduced distribution losses and reduced pumping for distribution) and better local control (simplified metering, out of hours use and programming holidays);

- Attempts to re-programme the New Building controller (e.g. during holiday periods) failed, as the New Building and the Old Building's heating control panels were not linked correctly. See section 6.6 and chapter 9 for further details;

- The solar thermal direct hot water (DHW) system appears to be working (although it has required maintenance to fix problems with temperature sensors and so has been 'off-line' for periods), but there is no way for the school to assess the actual performance of the system (solar yield) as only limited parameters are recorded and there is no integrated heat meter (which would have added to the cost). Moreover, it runs the risk of the classic problem of being 'out of sight, out of mind' in the medium to long-term. See section 8.3 for further details;

- It was noted that only EPC/SBEM compliance energy modelling was undertaken during the detailed design of the building. This type of modelling does not include unregulated energy uses and therefore, does not provide useful benchmarks against which the school or the BPE team can compare actual performance data. The modelling that was undertaken was found to be completed using out-dated design information;

- The cost of carrying out an analysis to predict operational energy usage (which is quite involved, particularly in terms of establishing realistic usage profiles for the building) and installing additional metering could be seen as expensive for a small building in particular in relation to the actual annual energy costs as a proportion of the total annual spend of the school.

Old Building and the Whole Bessemer Grange Site:

The following bullet points summarise key energy findings for the Old Building and the overall site:

- The energy performance of the school as a whole is dominated by the Old Building which accounts for 80% of the overall floor area;

- The whole site as well as the Old Building on its own, would achieve an estimated 'E' display energy certificate (DEC) rating. However, for the overall, both heating (~141kWh/m2 per annum) and electricity consumption (~36kWh/m2 per annum) are in-line with 'typical' practice empirical benchmarks for schools and nurseries published in CIBSE Guide F and CIBSE TM46;

- Based on the CIBSE TM22 analysis, carbon emissions are ~50kgCO2/m2 per annum for the Old Building and 175 tonnes per year for the school as a whole;

- The Old Building is typical of school buildings of its time and is generally poorly insulated and leaky (poor air tightness) and has large areas of single glazing and an inefficient heating system (including, for example, old belt-driven pumps);

- The re-design of the heating systems as part of the New Building works has led to the problem referred to by users as 'heat creep'. Heat emanated from radiators within certain parts of the Old Building during spring and summer months when the space heating system was nominally switched off – causing discomfort and wasting energy. See section 8.2 for more details;

- While the school maintenance team are actively involved in the operation of the building and have developed a good understanding of the systems, there is a lack labelling of equipment and no log book in place meaning information may be lost if staff move on;

- Maintenance of the heating and renewable systems is sub-contracted out;

- Sub-metering within the building is limited, but following the BPE study the bursar now reads gas and electricity meters on a monthly basis;

- The annual operational running cost of the school was estimated to be ~£37,500 based on analysis of bills and this matches the ~£40,000 figure set-aside in the school's financial plans (annual budget, see section 4.7 for more details). The overall operating cost of the school is ~£2,200,000, so energy costs represent less than 2% of this. Staff salaries, including costs of supply teachers, dominate this operating cost;

- Electricity and gas prices are kept competitive as the London Borough of Southwark provides the school, with its energy services via the LASER Energy Buying Group - which represents local authorities and public bodies;

6.2 TM22 Analysis

6.2.1 Overview of TM22 Analysis

This sub-section presents the results from the CIBSE TM22 analysis together with information on real-life patterns of energy use within the building, drawn from the extensive post-occupancy monitoring conducted as part of this BPE study.

The limited sub-metering within Bessemer Grange School has made the use of TM22 particularly vital for the project in order to gain a good understanding of the breakdown of energy by end-use.

In-line with the approach taken throughout this report, the results for the New Building and the Old Building are presented side-by-side to allow comparison.

Fig.6.2.1 - Photograph of a portable plugin meter used to help the BPE team calculate electrical loads for electrical equipment as part of the TM22 analysis.

6.2.2 TM22 Simple Assessment of Energy Use

New Building

BUILDING ENERGY SUMMARY

Energy, carbon and cost summary	Units	Electricity	Fuels	Thermal
Non renewable fuel or electricity supplied to site	kWh/annum	26,109	42,390	0
Separable energy uses	kWh/annum	0	0	0
Renewable energy used on site	kWh/annum	0	0	2,500
Renewable energy exported	kWh/annum	0	0	0
Output from CHP used in building	kWh/annum	0		0
Exported CHP	kWh/annum	0		0

Unit values	Energy supplied (kWh/m² GIA)		Carbon dioxide emissions (kg CO_2/m² GIA)		
Type	Fuel/thermal	Electricity	Fuel/thermal2	Electricity3	TOTAL
Supplied	61.9	38.1	12.0	21.0	33.0
Exported CHP	0.0		0.0		
Raw TM46	150.0	40.0	29.1	22.0	51.1
CIBSE Guide F (Good Practice)	113.0	22.0	21.9	12.1	34.0
Benchmark from DEC	150.0	40.0	29.1	22.0	51.1

Fig. 6.2.2.1 – New Building - Energy summary.
***Note:** 'Supplied'=New Building.*

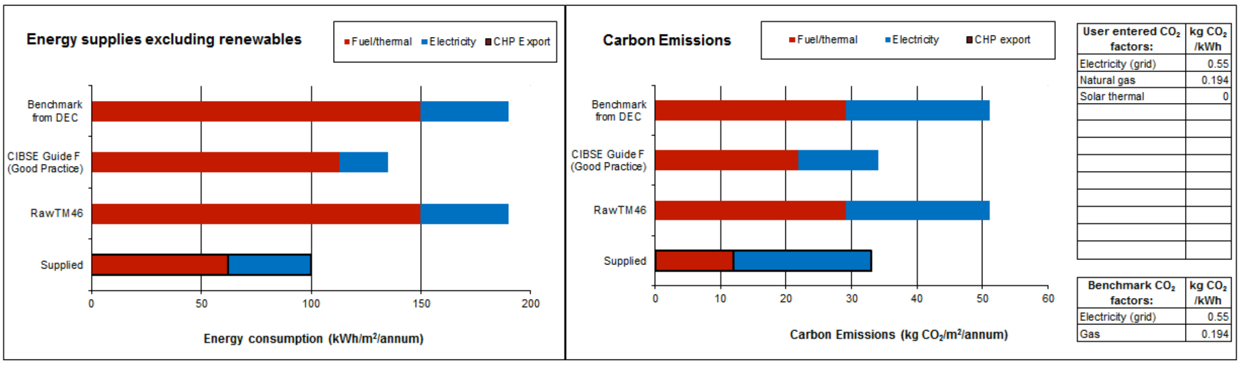


Fig. 6.2.2.2 – New Building – actual energy use compared with benchmark.
***Note:** 'Supplied'= New Building.*

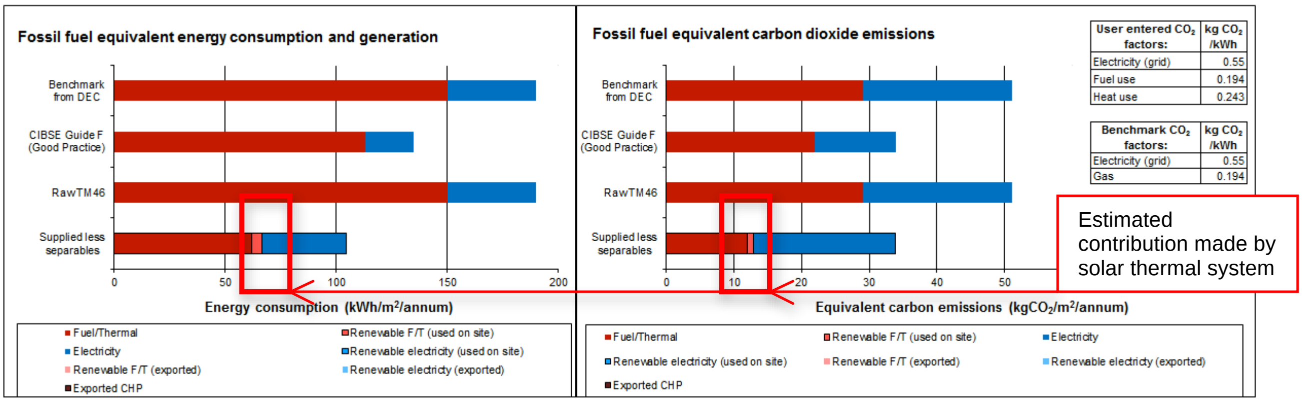


Fig. 6.2.2.3– New Building – indicates the small impact of solar thermal systems under 'supplied less separable' category.
***Note:** 'Supplied'= New Building.*

Fig's 6.2.2.1 and 6.2.2.2 on the previous page shows that the heating energy consumption in the New Building is ~62kWh/m^2 per annum which is much better than empirical 'good practice' benchmarks from CIBSE Guide F (2012) and CIBSE TM46 (2008) (110-150 kWh/m^2 per annum). This reflects good design and construction of the building envelope, including good air tightness and thermal insulation and minimisation of thermal bridging. See section 5.12 for more details. This figure is particularly good given that the heating system is comparatively inefficient; see section 6.6 for more details.

Electricity consumption in the New Building ~ 38kWh/m^2 per annum is high even in comparison to 'typical' performance benchmarks; further details of this elevated consumption are discussed in the following section.

The limited impact of the solar thermal system is identified in Fig.6.2.2.3, which is the only separable identified, and shows it supplied less than 10% of the overall energy consumption for the New Building. However, this had to be calculated on the basis of an estimate, as there was not sufficient metering in place, see section 8 for further details.

Old Building

BUILDING ENERGY SUMMARY

Energy, carbon and cost summary	Units	Electricity	Fuels	Thermal
Non renewable fuel or electricity supplied to site	kWh/annum	107,890	484,088	0
Separable energy uses	kWh/annum	0	0	0
Renewable energy used on site	kWh/annum	0	0	0
Renewable energy exported	kWh/annum	0	0	0
Output from CHP used in building	kWh/annum	0		0
Exported CHP	kWh/annum	0		0

Unit values	Energy supplied (kWh/m² GIA)		Carbon dioxide emissions (kg CO_2/m² GIA)		
Type	Fuel/thermal	Electricity	Fuel/thermal2	Electricity3	TOTAL
Supplied	158.7	35.4	30.8	19.5	50.2
Exported CHP	0.0		0.0		
Raw TM46	150.0	40.0	29.1	22.0	51.1
User Specified	113.0	22.0	21.9	12.1	34.0
Benchmark from DEC	150.0	40.0	29.1	22.0	51.1

Fig. 6.2.2.4 – Old Building - energy summary.
Note- *'Supplied'=Old Building. 'User specified' = CIBSE Guide F 'Good Practice'.*

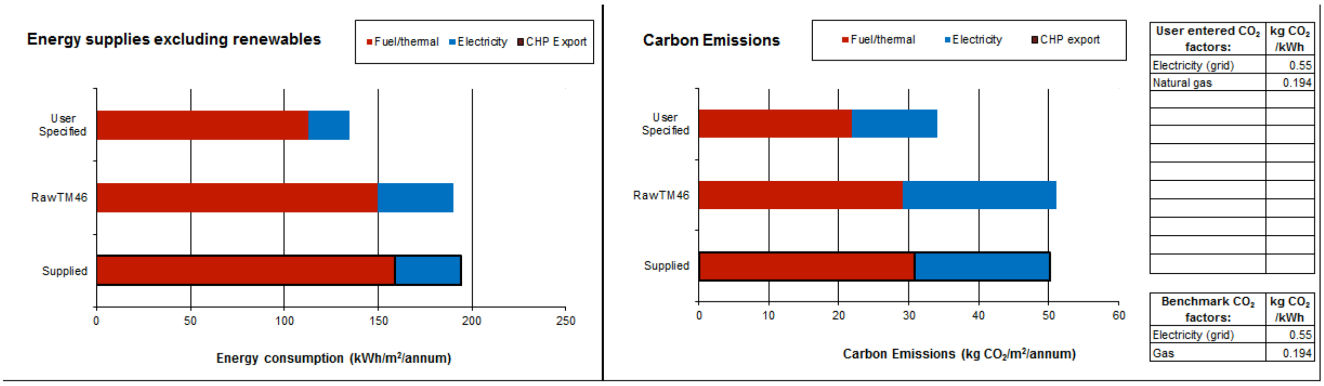


Fig. 6.2.2.5 – Old Building – actual energy use compared with benchmarks.
Note- *'Supplied'=Old Building. 'User specified' = CIBSE Guide F 'Good Practice'.*

Figures 6.2.2.4 and 6.2.2.5 show that in the Old Building, gas consumption of ~159kWh/m^2 per annum is slightly higher than 'typical' practice benchmarks for schools and nurseries taken from CIBSE Guide F (2012) and CIBSE TM46 (2008), which range from ~110-150 kWh/m^2 per annum. The annual electricity consumption ~35kWh/m^2 per annum is in-line with 'typical' practice according to these published benchmarks, which range from c.20-40 kWh/m^2 per annum.

6.2.3 TM22 Detailed Assessment of Energy Use

New Building

The tables and graphs 6.2.3.1 to 6.2.3.3 provide an indication of the detailed breakdown of energy use within the New Building in 2011/2012 (in particular electricity). Limited sub-metering made calculations difficult to verify.

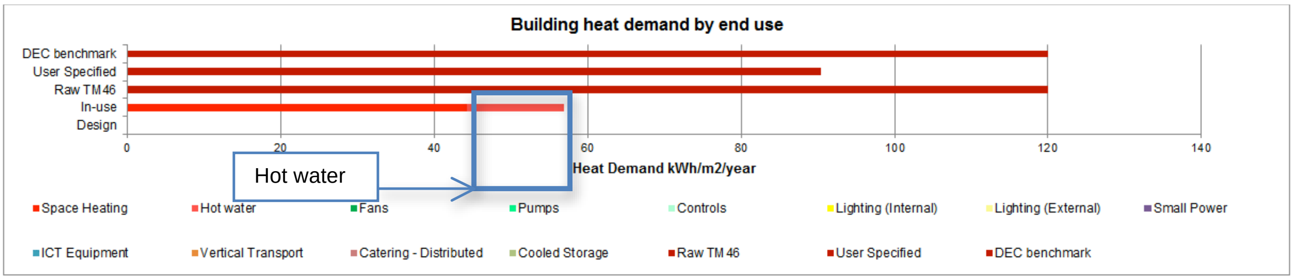


Fig. 6.2.3.1 – New Building – heat demand by end use.

***Note**- 'In-use'=New Building. 'User specified' = CIBSE Guide F 'Good Practice'.*

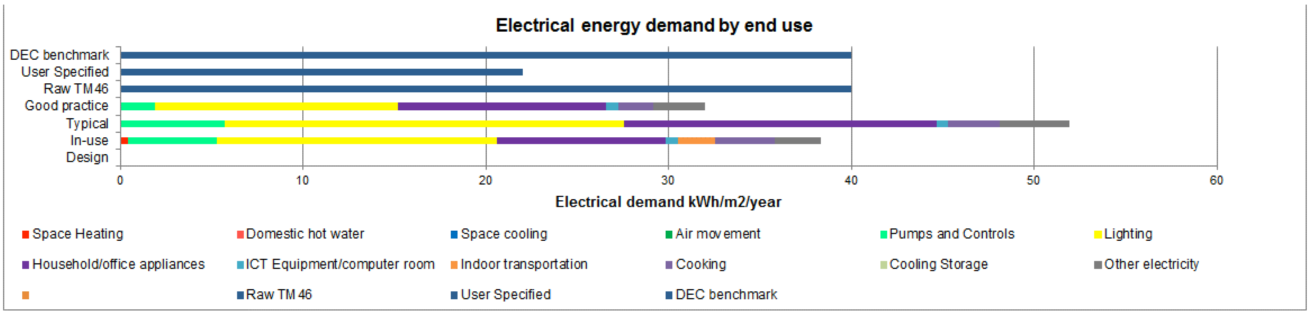


Fig. 6.2.3.2– New Building – electrical demand by end use.

***Note**- 'In-use'=New Building. 'User specified' = CIBSE Guide F 'Good Practice'.*

ENERGY DEMAND (kWh/m²/year)

		Heat demand (kWh/m2/year)		Electricity demand (kWh/m2/year)		Additional metrics for electricity demand				
System	Description	Design (kWh/m2/year)	In-Use (kWh/m2/year)	Design electricity (kWh/m2/year)	In-use electricity (kWh/m2/year)	In-use electricity (kWh/year)	In-use % of total	In-Use Full load W/m2	System hours/year	Utilisation
Space Heating		0.0	44.2	0.0	0.4	279	1.1%	4.4	93	1.1%
Hot water		0.0	12.6	0.0	0.0	0	0.0%	0.0	0	0.0%
Fans		0.0	0.0	0.0	0.0	26	0.1%	0.2	231	2.6%
Pumps		0.0	0.0	0.0	3.6	2,460	9.4%	0.9	3,967	45.3%
Controls		0.0	0.0	0.0	1.3	876	3.3%	0.1	8,760	100.0%
Lighting (Internal)		0.0	0.0	0.0	15.3	10,458	39.8%	10.1	1,507	17.2%
Lighting (External)		0.0	0.0	0.0	2.5	1,715	6.5%	0.5	4,712	53.8%
Small Power		0.0	0.0	0.0	9.3	6,361	24.2%	21.5	433	4.9%
Vertical Transport		0.0	0.0	0.0	2.0	1,398	5.3%	1.3	1,625	18.6%
Catering - Distributed		0.0	0.0	0.0	3.3	2,250	8.6%	9.4	349	4.0%
Total		0.0	56.9	0.0	38.3	26,259	100%	48.5		
Metered building energy use		0.0	56.9	38.1	38.1	26,109				
Variance TM22 versus metered total		0.0	0.0	-38.1	0.2	151				
Variance TM22 versus metered total		#DIV/0!	0%	#DIV/0!	1%	1%				

Fig. 6.2.3.3 – New Building - Heat and Electrical demand and utilisation by end-use.

Old Building

Figures 6.2.3.4 to 6.2.3.6 provide an indication of the detailed breakdown of energy use within the Old Building (in particular electricity) in 2011/2012. Limited sub-metering made calculations difficult to verify.

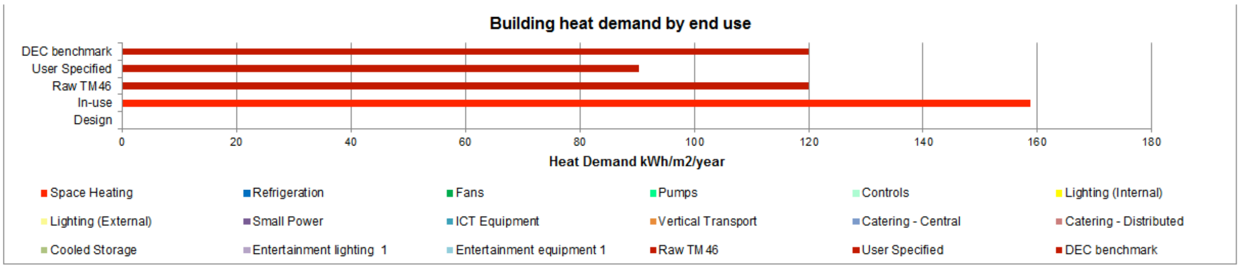


Fig. 6.2.3.4 – Old Building – Heat demand by end use. The limited sub-meter did not allow for a split between hot water and heating demand so output shows combined output.

***Note**: 'In-use'=Old Building. 'User specified' = CIBSE Guide F 'Good Practice'.*

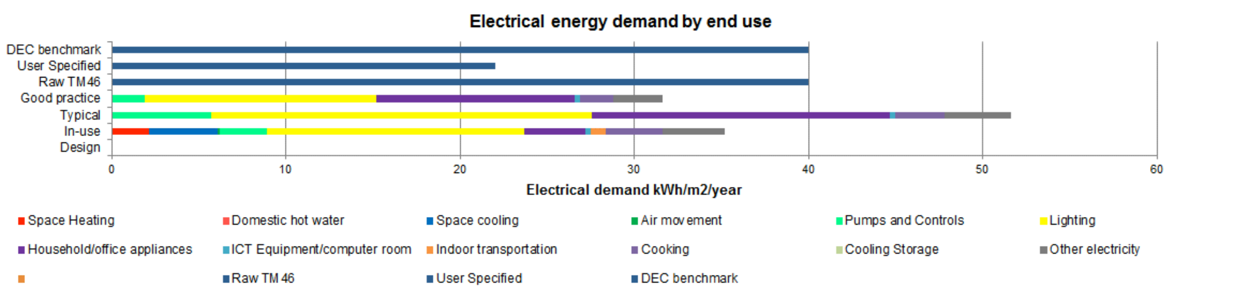


Fig. 6.2.3.5 – Old Building – Electrical demand by end use. .

***Note**: 'In-use'= Old Building. 'User specified' = CIBSE Guide F 'Good Practice'.*

ENERGY DEMAND (kWh/m^2/year)

		Heat demand (kWh/m2/year)		Electricity demand (kWh/m2/year)		Additional metrics for electricity demand				
System	Description	Design (kWh/m2/year)	In-Use (kWh/m2/year)	Design electricity (kWh/m2/year)	In-use electricity (kWh/m2/year)	In-use electricity (kWh/year)	In-use % of total	In-Use Full load W/m2	System hours/year	Utilisation
Space Heating		0.0	158.7	0.0	2.2	6,599	6.2%	8.9	244	2.8%
Refrigeration		0.0	0.0	0.0	3.9	11,976	11.2%	3.5	1,134	12.9%
Fans		0.0	0.0	0.0	0.1	313	0.3%	0.9	109	1.2%
Pumps		0.0	0.0	0.0	2.3	6,938	6.5%	0.3	6,671	76.2%
Controls		0.0	0.0	0.0	0.4	1,314	1.2%	0.0	8,760	100.0%
Lighting (Internal)		0.0	0.0	0.0	14.8	45,110	42.1%	10.4	1,421	16.2%
Lighting (External)		0.0	0.0	0.0	3.5	10,603	9.9%	0.9	4,056	46.3%
Small Power		0.0	0.0	0.0	3.5	10,765	10.0%	12.1	291	3.3%
ICT Equipment		0.0	0.0	0.0	0.3	911	0.8%	0.5	573	6.5%
Vertical Transport		0.0	0.0	0.0	0.8	2,519	2.3%	0.3	2,665	30.4%
Catering - Central		0.0	0.0	0.0	2.5	7,549	7.0%	15.9	156	1.8%
Catering - Distributed		0.0	0.0	0.0	0.8	2,408	2.2%	3.8	206	2.3%
User 1	Entertainment lighting 1	0.0	0.0	0.0	0.1	272	0.3%	3.1	29	0.3%
User 2	Entertainment equipment 1	0.0	0.0	0.0	0.0	0	0.0%	0.3	181	2.1%
Total		**0.0**	**158.7**	**0.0**	**35.2**	**107,277**	**100%**	**60.9**		
Metered building energy use		0.0	136.5	35.4	35.4	107,890				
Variance TM22 versus metered total		0.0	22.2	-35.4	-0.2	-613				
Variance TM22 versus metered total		#DIV/0!	14%	#DIV/0!	0%	-1%				

Fig. 6.2.3.6 – Old Building – Heat and Electrical demand and utilisation by end-use . The limited sub-meter did not allow for a split between hot water and heating demand so output shows combined output.

The breakdown of electricity demand in the New and Old Buildings differs somewhat, but is in both cases dominated by lighting.

For the New Building, see Fig. 6.2.3.3, the split was as follows: lighting (~46% of which 6.5% is external lighting); small power (~24%); fans pumps and controls (~13%); cooking (~9%); lifts (~5%) and ICT equipment (2%).

For the Old Building, see Fig 6.2.3.6, which houses the school kitchen/canteen, the TM22 analysis indicated the following breakdown in terms of major end uses: lighting (~52% of which 10% is external lighting); small power (~10%); lifts (~2%); fans pumps and controls (~8%), catering (~9%) and refrigeration (11%);

Some factors may justify higher consumption in the New Building relative to the Old Building, which houses the main school kitchen/canteen and ICT suite. Being modern, the New Building has a higher specification of equipment, is much more compact with less circulation and ancillary spaces, and thus has a higher density of equipment. This assumption is demonstrated in Fig.6.2.3.7, which shows the gas energy consumption when expressed per person (i.e. pupil and staff members) is five times greater in the Old Building in comparison to the New Building. The electricity consumption per person is almost double. Further discussion on use of 'per pupil or person' consumption is discussed in chapter 10.

Further studies[1] were undertaken with respect to lighting to identify some of the reasons for the elevated consumption. These showed that there was an over specification of fittings in classrooms and the feature lighting in the entrance hall had no daylight dimming and there was no economical use of lighting; the zoning for example, was not fully exploited by users. See section 8.1 of this report for more details.

Additionally, in assessing energy used for vertical transportation, additional studies[2] indicated that the single lift could be responsible for more than 10% of the New Building's annual electricity consumption. Analysis showed that most of the energy used is due to the standby mode of the lifts (>98%). Due to the limited occupancy of the New Building on the first floor, and the secure connection back to the main school, the lift is not used frequently, and is left in standby mode for most of the time during which the systems associated with the lifts are continuously running in the background. The analysis finally found that the lift is actually responsible for around 5% of annual electricity use within the New Building.

The high percentage of consumption associated with catering, cooking and refrigeration identified in both Buildings (~9%) highlights the importance of operating equipment efficiently, including switching off where possible when not in use, and ensuring future procurement of energy efficient equipment and appliances as part of replacement cycles, whether minor replacements of faulty appliances or major refits of school canteen.

	New Building	Old Building (exc. bulge classes)
Number of Users (persons)	160	380
Floor Area (m^2)	685	3050
Total Electricity (kWh per annum)	26,030	106,750
Total Gas (kWh per annum)	42,470	484,950
Electricity per person (kWh/m^2 per annum)	163	281
Gas per person (kWh/m^2 per annum)	265	1276

Fig. 6.2.3.7 – 2011/2012 Energy consumption per person in kWh/m^2 per annum - Clearly showing the relative efficiency of the New Building in comparison with the Old Building.

[1] Lux levels readings were taken in spaces to assess whether they were overlit with artificial lighting. Calculations were then undertaken to esimate the energy consumption of the light fittings in the spaces in comparison to benchmarks to assess whether the spaces were overlit. Refer to Section 8.1 for further details.
[2] The manufacturer's website provided a special online tool to allow the calculate energy consumption and relative use from standby mode.

6.3 Review of Consumption Profiles and Base Loads

In order to understand patterns of energy use, substantial monitoring using temporary portable equipment was undertaken at Bessemer Grange. Comparisons with readings from permanent meters were also made wherever possible.

Long-term monitoring was used to:

- Analyse energy use profiles on daily, monthly, seasonal and annual basis and analyse energy signatures for the building;
- Assess maximum and minimum demand levels;
- Explore the impact of operational improvements carried out during the BPE study, such as reprogramming of controls;
- Fully understand the origins and reasons for the phenomenon of 'Heat Creep' - implicated in overheating.

To study electricity, a power meter was fitted to the mains electricity supply by an electrician. See Fig.6.3.1. Key results from these studies are contained in sub-section 6.5 below.

In addition to the power meter, plug-in kWh meters were also deployed on ICT equipment and white goods to assist in understanding their usage as part of the CIBSE TM22 studies discussed above in section 6.3.1.

To study heating energy consumption, a non-invasive ultrasonic clamp-on heat meter was fitted to the space heating circuits to the New and Old Buildings and also to the domestic hot water circuit serving the New Building, as discussed in sub-section 6.5. See Fig.6.3.2.

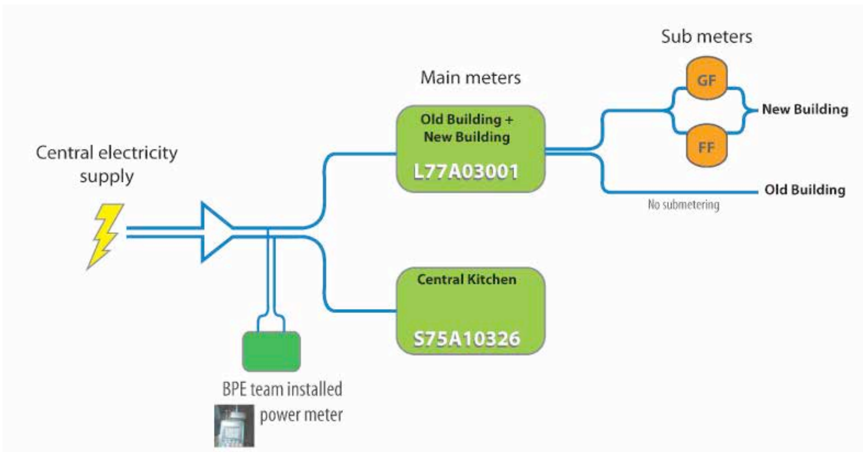


Fig. 6.3.1 – Installation of power meter as part of the two-year energy performance monitoring by the BPE team (safe installation and removal has to be carried out by a qualified electrician, limiting the flexibility in terms of moving the meter around the building).

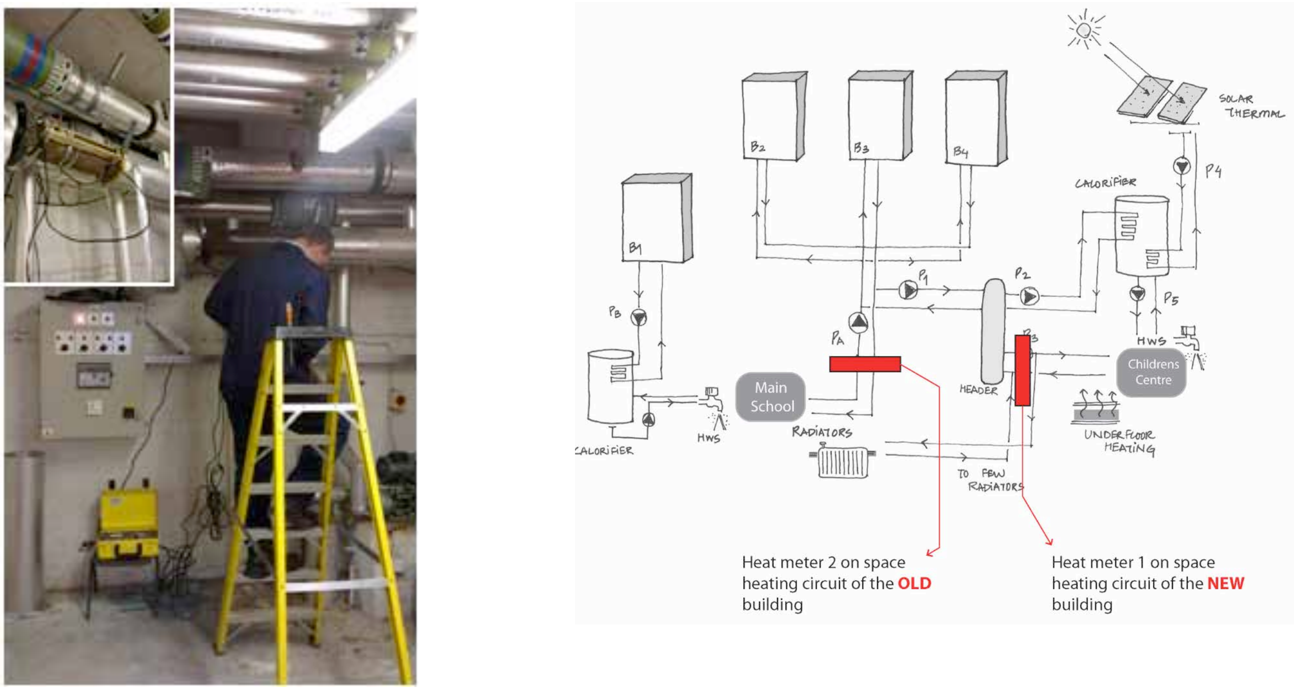


Fig. 6.3.2 – Installation of ultrasonic 'clamp-on' heat meters as part of two-year energy performance monitoring. Following temporary removal of a small section of pipework insulation, the meter is clamped to the outside of a straight section of bare pipe to measure flow rate, with temperature probes on flow and return pipes.

A series of problems were experienced with the clamp-on heat meters due to a faulty data logger module (i.e. a manufacturing defect). This required substantial correspondence with the equipment suppliers and testing and many additional site visits to finally resolve. This resulted in loss of data due to intermittent monitoring during the first year of the project. The equipment supplier subsequently agreed to loan a second heat meter free of charge to the BPE team during the second year of monitoring.

6.4 Electrical Consumption Profiles

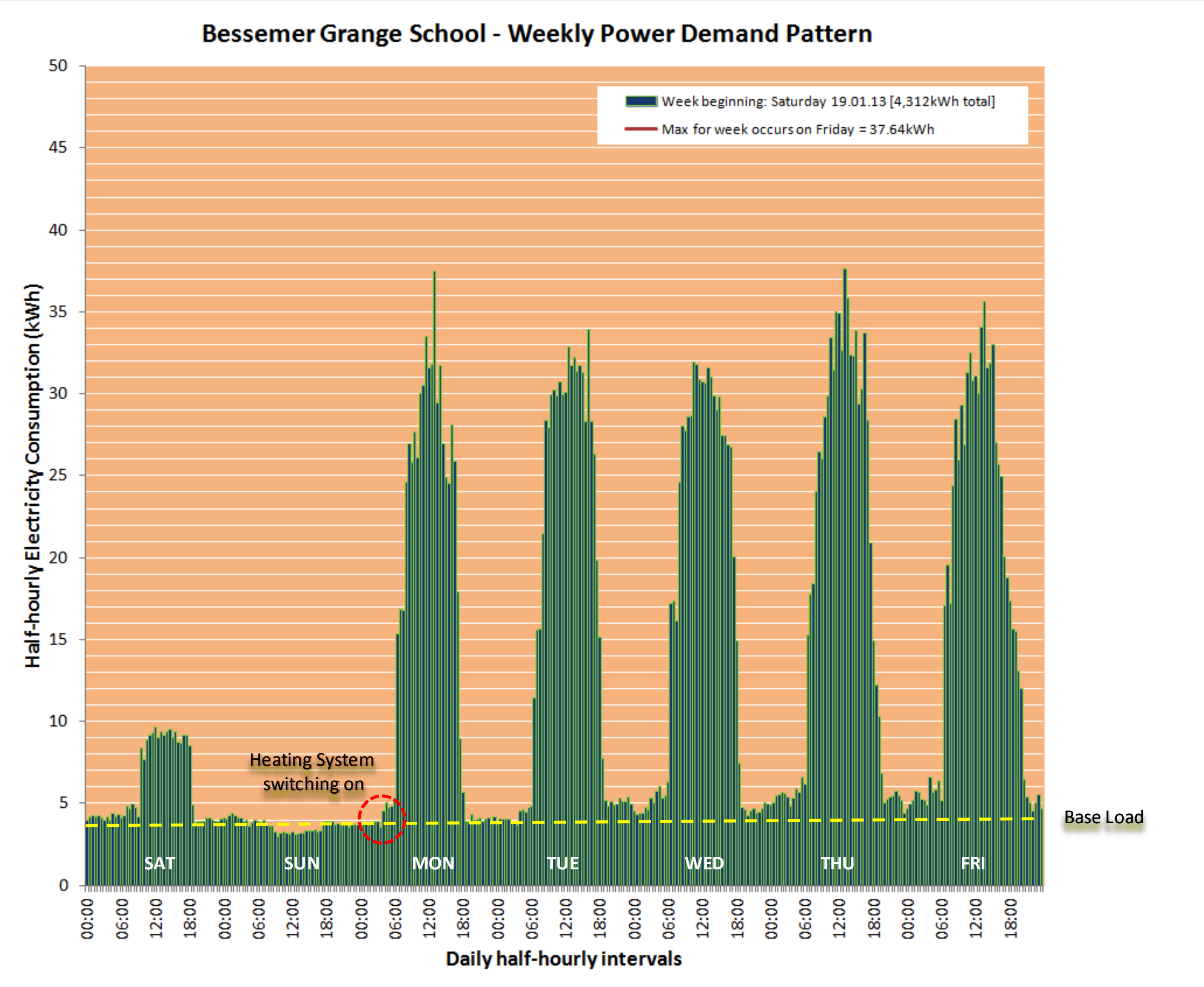


Fig. 6.4.1 – Bessemer Grange School (Overall) - Half-hourly electricity consumption profile for a cold winter week (peak consumption).

To gain an overall picture of energy consumption, data was generally recorded at 10-minute intervals and integrated to give half-hourly readings. It was also cross-checked against readings from the main electricity meters.

Analysis of the half-hourly data showed no distinct changes across the 2-year period of the BPE study with repeating patterns according to season, i.e. higher consumption in winter months (with spikes depending on the timing of cold weather snaps) where demand for lighting and heating (i.e. pumping) is greatest and reduced to a minimum during summer as would be expected. The graphs also show the reduction in demand during holiday weeks throughout the year.

Key findings from the long-term monitoring:

- Analysis of weekly consumption shows a regular pattern. There were spikes on weekdays from 6am to 6pm - peaking from noon to early afternoon - when school meals are being prepared and served, and then again in late afternoon as daylight fades and lighting is switched on. Demand reduced to a much lower ‘base’ level overnight. One noticeable change, identified on Fig.6.4.1, is that during the winter period, demand starts increasing from 3 to 4am as the heating system switches on prior to the early morning arrival of the cleaners. As can be expected, at weekends, a significant reduction in demand can be observed.

- The peak electrical demand for the overall building recorded during the monitoring period was 80.5kW during the cold snap in January 2013. This equates to around ~21.5W/m2 based on the overall floor area (3,725m^2). Design guidelines (CIBSE Part K – Electricity in Buildings) suggest allowing for a minimum design load of ~30W/m2 for school buildings for lighting and small power alone to which must be added allowances for lifts, mechanical ventilation and air-conditioning equipment when estimating capacity and selecting equipment. The peak loads observed are therefore relatively low and well below expected capacity;

- Maximum daily electricity consumption is around 4,500kWh on a peak winter day (~1.2kWh/m2/day based on floor area) with minimum daily consumption ~1,000kWh (~0.3kWh/m2/day) during the summer holidays. Consumption during the summer holidays is roughly one-fifth of peak winter demand;

- Base electrical loads (i.e. the minimum level of demand which the building does not drop below) are ~10-12kW in winter (equating to 5-6kWh in any half-hour period) and ~6kW in summer. In winter, there is additional use of lighting (internal and external) and the space heating system (all boilers and pumps) are operational. The CIBSE TM22 studies indicate that the base load is made up of a wide range of end consumers including lighting, small power equipment (including computers, printers and photocopiers), security and alarms, building services plant and also lifts);

- The base loads in the school as a whole, as illustrated on Fig. 6.4.1, account for 40% of total consumption during term times, and over 80% during holiday periods;

- Consumption during the core school opening hours of 08:00 to 16:00 equates to about 50% of annual consumption, so roughly 50% of the electricity is consumed during the core hours and 50% out of hours/overnight. Although not untypical, this represents a large amount of energy wastage. Further studies into the reduction of base load consumption would merit further investigation outside this study.

6.5 Gas Consumption Profiles (Heating and Hot water)

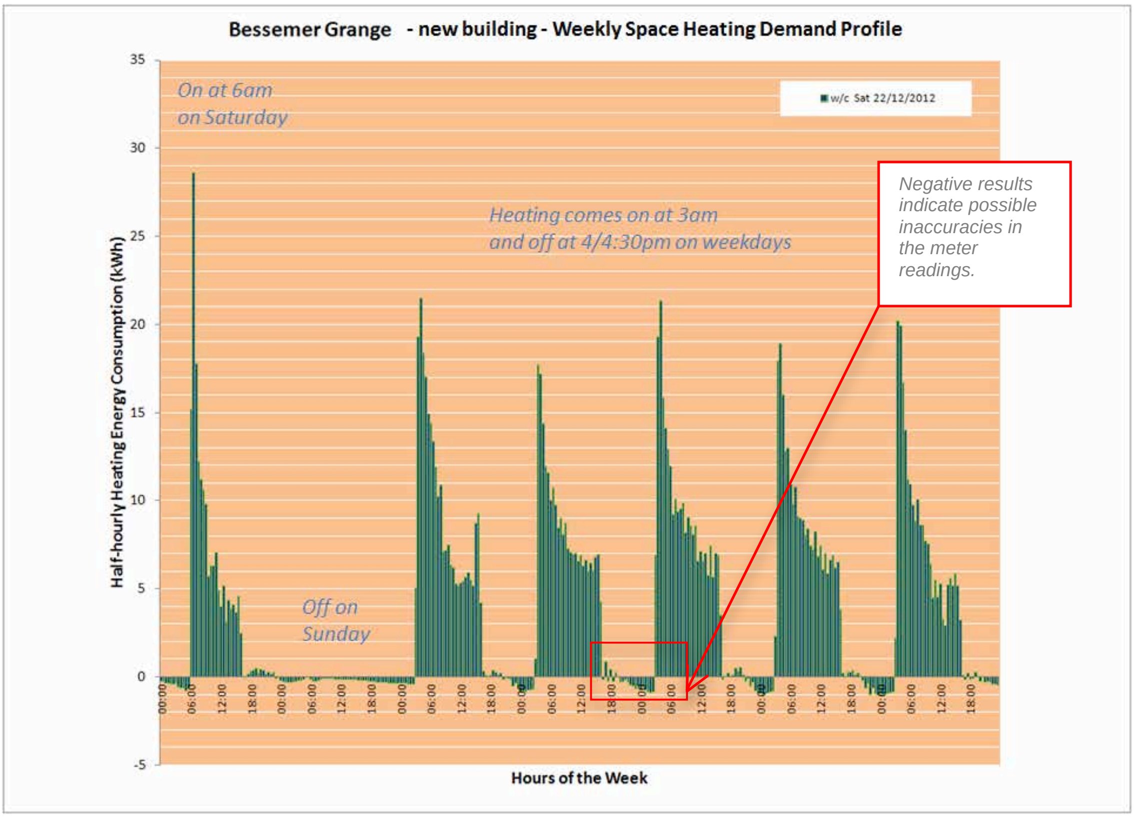


Fig. 6.5.1 – Weekly heating energy consumption profiles for the New Building (Christmas 2012).

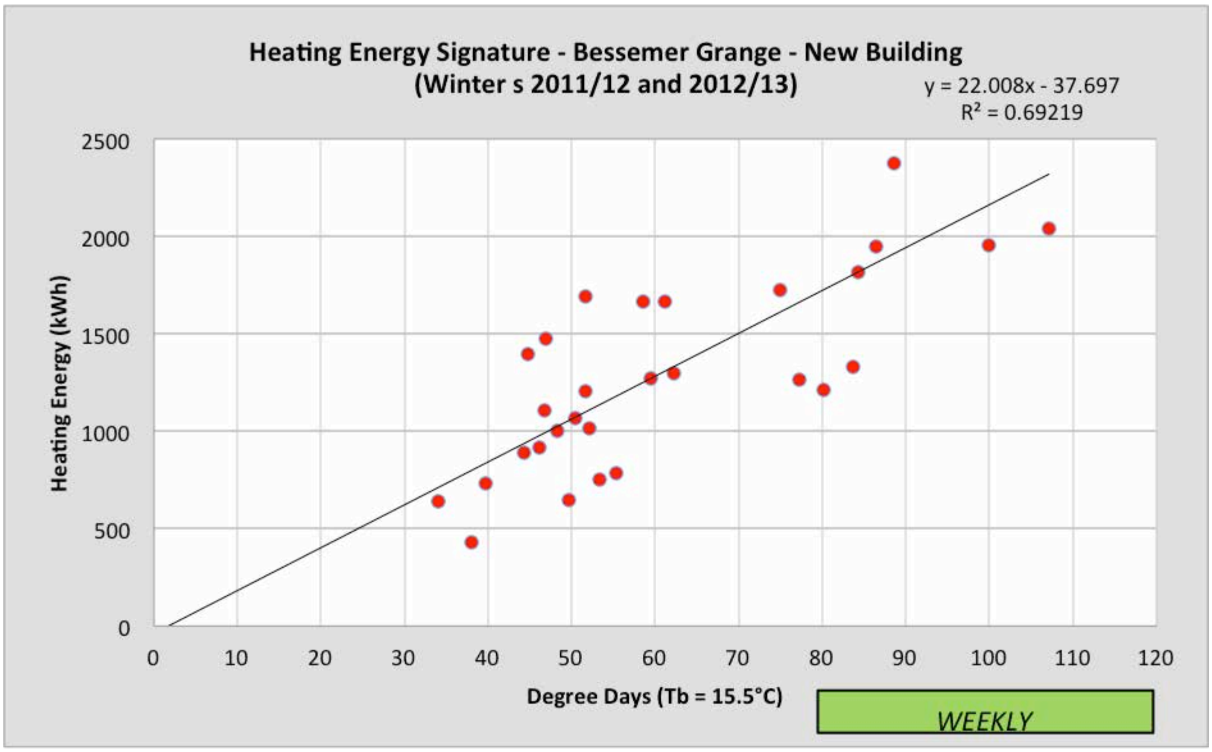


Fig. 6.5.2 – Heating energy signature for the New Building using weekly data obtained over two winters
Note: *there was no significant difference between the two winters.*

Both heat meters were used to get an indication of the pattern of heating demand and the quality of control in the Old and New Buildings.

The meter readings were also correlated with gas meter readings. The monitoring revealed the following:

- Across two winters, the New Building showed very regular patterns of heating energy demand throughout each heating season, see Fig.6.5.1;

- In contrast, winter monitoring of the Old Building showed very erratic patterns, with the heating switching on and off throughout the day. Peak heating demand was frequently observed at around 3:30am on weekdays, when the heating system would initiate. This either suggests very poor control (note that the circulation pump to the space heating is an old constant speed belt-driven pump in contrast to the new variable speed pumps supplying the New Building) and/or a problem with the heat meter installation (by Solenvis) which was difficult to install on the old heating pipe (even though the quality parameters of the heat meter suggested that this was ok);

- The heating energy signatures for New Building is shown in Fig 6.5.2 based on weekly cumulative heating consumption data. It can be seen that the New Building is relatively well controlled but there is some scatter of data[3] (R^2 value = 0.69) particularly on milder days (lower heating degree day levels) indicating improved control is possible. For the Old Building, there was very significant scatter due to the erratic measurements mentioned above and no clear trend emerges (as described above);

- The heating in the New Building comes on at 3.30 although it is not scheduled to come on until 5.30am and switches off just after school finishes at 4:30. The early start is determined by the optimum start function on the controller, which automatically determines the 'most efficient' time to engage the heating systems. However, the early start is somewhat surprising given that the New Building is well insulated and there is no excessive thermal mass. It probably reflects in part, the fact that the Old Building requires

[3] An R^2 value of 1 shows that the building is perfectly controlled in response to changes in weather (and there would be no scatter of points), while a value of 0 indicates that consumption is not related to the weather at all. The closer to 1 the energy signature of a given building is, the better the level of control.

a longer pre-heat period and that the New Building has underfloor heating systems (rather than traditional radiators and convectors) and so takes longer to heat up;

- Generally, the monitoring showed the space heating to the New Building coming on every Saturday (even though it is not programmed to), but off on Sundays;

- Various attempts were made to improve the New building's performance through fine-tuning and optimising of the system. However, these attempts were not successful due to various issues including problems with the linkage between the New and Old control panel. See section 6.6 for further details;

- A temperature sensor on the ground floor feeds information to the control panel of the New Building's heating system. The sensor had initially been set to 19°C, then raised to 27°C due to complaints of under-heating in other rooms. In effect, this meant that the heating would not switch off as the set-point could not be achieved and so could have led to over-heating and energy wastage. When the contractor was called back in it was set to 21°C. Note that individual rooms do have their own thermostats but these have to be manually set by maintenance staff, so there is effectively no local control for users. This suggests that the commissioning process should have formally allowed for monitoring of space temperatures through different seasons and fine-tuning of the system during the twelve month defects period following practical completion;

- There were a number of problems identified with the solar thermal system. See section 8.3 for more details.

- ‘Heat Creep’ was coined by the school staff and refers to the issue of the Old Building being heated in part, even during spring and summer when it should normally be off. This caused some discomfort and wasted energy. See section 8.2 for more details.

6.6 Improvement Potential

A wide range of actions was undertaken as part of the BPE study to improve the comfort and performance of both Buildings. See chapter 9 for an overview of recommendations given to the users and client.

Electrical consumption

As part of the TM22 analysis, the BPE team identified an improvement target of approximately 15% for electricity consumption reduction in both the New and Old Building. This was to be accomplished via changes in behaviour in use of lighting (i.e. switching off lights) and through a reduction in the number of hours external lights were left on. See Fig.6.6.1.

To achieve this, the BPE team held ‘energy scavenger hunts’ to engage pupils' interest in identifying wasted energy and to inspire them to turn lights off. These one off events worked well with pupils and some staff members however, they did not appear to have a long-term impact. Other more strategic proposals to develop a clear environmental policy for the school was met with little appetite, as limited resources were focused on the everyday demands of teaching.

External lighting was also significant and important in terms of safety of users. Revised programming of time-clocks (according to season/daylight hours) was discussed to reduce hours of operation of the external lighting by approximately 20%. However, the school did not want to change their hours of lighting and the changes were not implemented. In future, it was recommended that when upgraded, they would use low energy or LED fittings.

When data for 2012-2013 was compared with 2011-2012, it was clear that 15% savings had not been achieved and consumption remained similar to the previous year.

Further studies were also conducted to identify other causes for the elevated lighting consumption. See Section 8.1. Longer-term options for reducing electrical consumption via capital investment were discussed with the school see sections 9.1 and 9.2 for details.

Gas consumption

Given that the New Building consumes only ~10% of energy used by the Old Building due to its smaller sizes and relatively good performance, the greatest opportunities for the reduction in energy consumption come from upgrading the Old Building’s poor fabric. This is discussed in more detail section 9.1 to 9.2 and chapter 10.

However in the shorter term, the BPE team used TM22 analysis to identify a potential 15% improvement through operational savings in terms of gas consumption for both buildings. This was based on ‘achievable’ savings by combining optimised usage heating controls and resolving the ‘heat creep’ issue. See Section 8.2 for more details.

Whilst the client agreed in principle to undertake changes to resolve ‘heat creep’ in reality, the work still has not yet been undertaken due to delays in procurement. Therefore no energy savings were achieved by this measure.

In terms of improvements in heating controls the BPE team worked with the school facilities managers and the third-party responsible for maintenance of the heating system, Barrier Air Conditioning Ltd, to try to improve the operation during winter 2012/13 based on the evidence of monitoring from the preceding winter 2011/12.

The heating controller to the New Building was reprogrammed by school maintenance staff with support from the BPE team, with the aim of preventing heating of the New Building on Saturdays (unless staff were present in which case the heating would be boosted by maintenance staff) and during holidays. However, subsequent monitoring over Christmas 2012 shows that this failed to work. See Fig.6.5.1.

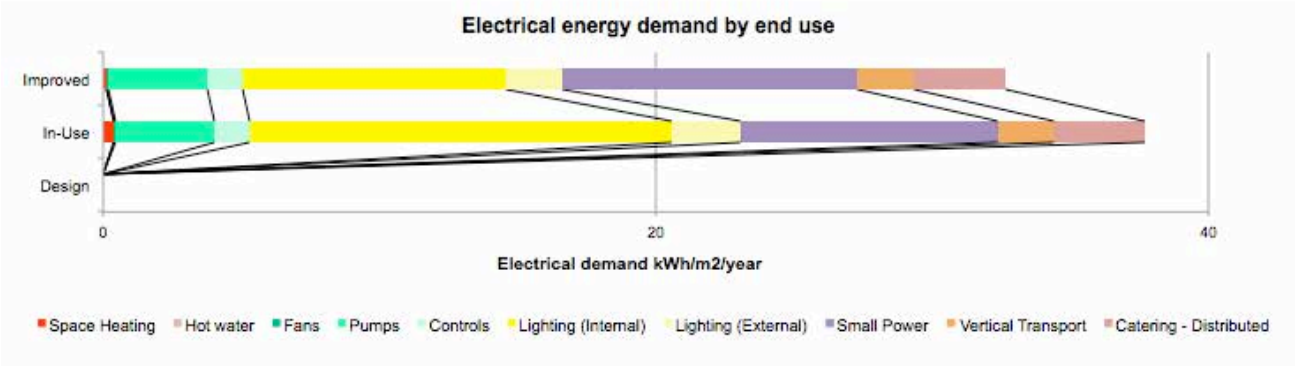
It also found that neither Barrier Air Condition Ltd nor the School had knowledge of how the controller for the Old Building's boilers worked or the password needed to access it. This knowledge had been 'lost' at some point either when the boiler plant had been installed or, due to changes in the facilities staff. Therefore, the original manufacturers of the system were contacted by the BPE team and invited to site. They were able to assist in setting the controls for the Old Building, however, it was found that the linkage between the New Building controller and Old School's boiler controls panel and pump sets did not function correctly. This explained the problems in setting the calendar controls over the Christmas period. The manufacturer determined that the problem was caused due to incorrect design or installation of controls as part of the New Building works.

These problems were raised with the MEP engineer, sub-contractor and the client as part of a series of meetings regarding the issues associated with 'Heat Creep'. See Section 8.2. In these meetings it was agreed that the installation of a separate boiler and control panel in the New Building would go ahead and would resolve the problems with the controls. However, in the short term it meant that no improvements in heating consumption were achieved.

ENERGY USE (kWh/m²/year)

Click to refresh graphs

		Design		In-use		Improved	
System	Description	Fuel/Thermal demand (kWh/m²/year)	Electricity (kWh/m²/year)	Fuel/Thermal demand (kWh/m²/year)	Electricity (kWh/m²/year)	Fuel/Thermal demand (kWh/m²/year)	Electricity (kWh/m²/year)
Space Heating		0.0	0.0	44.2	0.4	37.6	0.1
Hot water		0.0	0.0	12.6	0.0	11.3	0.0
Fans		0.0	0.0	0.0	0.0	0.0	0.0
Pumps		0.0	0.0	0.0	3.6	0.0	3.6
Controls		0.0	0.0	0.0	1.3	0.0	1.3
Lighting (Internal)		0.0	0.0	0.0	15.3	0.0	9.5
Lighting (External)		0.0	0.0	0.0	2.5	0.0	2.0
Small Power		0.0	0.0	0.0	9.3	0.0	10.7
Vertical Transport		0.0	0.0	0.0	2.0	0.0	2.0
Catering - Distributed		0.0	0.0	0.0	3.3	0.0	3.3
Total		0.0	0.0	56.9	38.3	48.9	32.6
Total predicted saving (kWh/m²/year)						8.0	5.7
Total predicted saving (%)						14%	15%



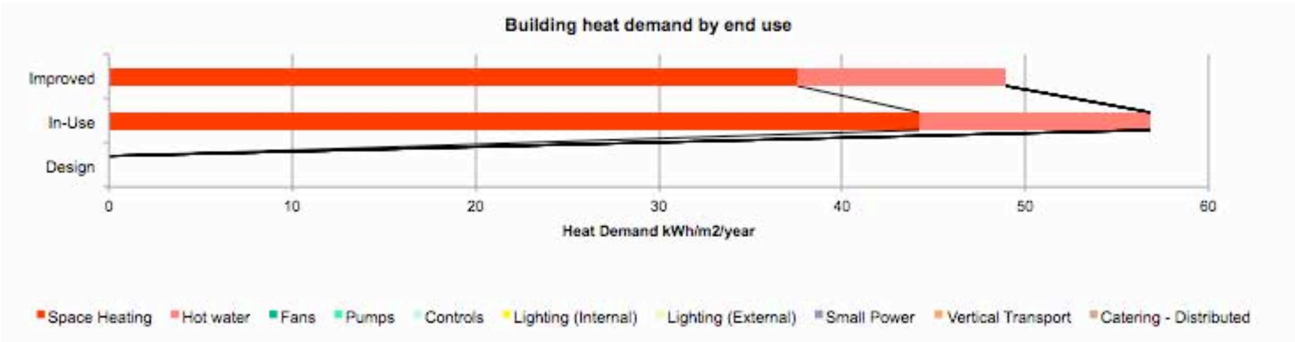


Fig.6.6.1 - Extract from TM22 analysis showing estimated improvements in energy consumption - in reality these were not realised.

7 Review of Whole Life Carbon

7.0 Chapter Introduction

This chapter provides background information on whole life carbon (sometimes referred to as Life Cycle Carbon), embodied and sequestered carbon of buildings, including a discussion on methodologies for calculating them. It then presents the results for the New Building at Bessemer Grange and compares these against current benchmarks in order to provide an overview of the New Building's performance. This investigation has been undertaken as part of the BPE study in order to assess whether the use of natural materials was successful in reducing the carbon footprint of the building. This is a relatively new field of research with few case studies published and therefore this study also provides an opportunity to expand the existing knowledge base.

7.1 Background to Whole Life, Embodied and Sequestered Carbon

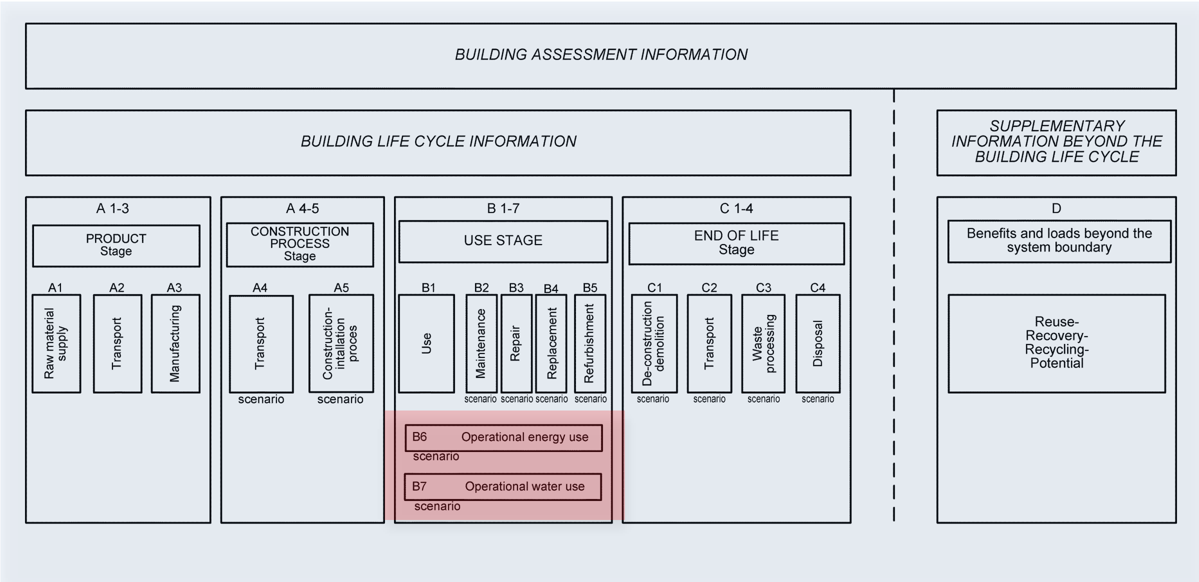
Buildings in operation and construction account for almost 47% (HM Government: 2010) of the UK's carbon emissions and represent a significant proportion of the Government's target to reduce emissions in 2050 by 80%. Significant efforts have been made to analyse energy consumption in use, however, limited effort has been placed on reducing the embodied emissions in order to minimise the carbon impact of the construction process. This is due to a perceived danger of losing focus on operational emissions, which are believed to represent the largest part of the industry's carbon footprint. *'A disproportionate focus on embodied carbon and its role in the total life cycle analysis of a building threatens to distract the property industry from the potential financial impacts of poorly-performing buildings to 2030 and beyond. For landlords and developers, it is also important to highlight that operational carbon in existing buildings is a far greater driver of yields.'* (Low Carbon Work Place Ltd, 2011:p.8).

So why is whole life carbon important? Even using current standards, embodied carbon is a major contributor to carbon emissions. Dr.Craig Jones suggests: '*constructing a new UK house is equivalent to over 20 years' operational carbon emissions, so it's pretty significant*' (Jones, 2013). However, over the next ten years with UK Building Regulations and other environmental standards improving the fabric of new and existing buildings, along with the gradual decarbonisation of the grid, the proportion of carbon emissions from operational consumption will likely decrease significantly in relative comparison to embodied carbon emissions. Crucially, embodied carbon emissions used in construction and production processes are consumed in the present, whereas theoretical operational energy savings may never be realised. Simple changes at the early stages of a buildings' design can have a major impact on the total embodied carbon emissions being released into the atmosphere, with some designers suggesting savings of 10-20% can easily be accommodated with little cost implications. Considered together, these points make a focus on embodied carbon increasingly important; especially where a tipping point in CO_2 levels in the atmosphere is concerned.

Defining Whole Life Carbon and Embodied Carbon

Where operational energy use and carbon emissions are relatively straightforward to quantify and measure (meters and bills), standardised methodologies for the calculation of embodied carbon have only recently been agreed. Confusion over boundary conditions, assessment methods and data sets, has often led to embodied carbon figures being difficult to compare and analyse in a robust and competent manner. However, the recent Europe-wide publications in connection with Life Cycle Analysis (LCA) seek to address this, including BS EN 15978:2011 – *Sustainability of Construction Works, PAS 2050: 2011 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services*, along with open databases such as the University of Bath's *Inventory of Carbon & Energy (ICE)* by Hammond and Jones, and the increasing availability of manufacturers' EPD data allow standard comparisons of whole life and embodied carbon.

BS EN 15978:2011 defines whole life carbon (Life Cycle Carbon) as all the processes involved in the production, construction, operations and demolition of buildings. See stages A to D shown in Diagram 7.1.1. Embodied carbon refers to all stages A to D but excludes operational energy and water.



Whole life carbon includes all stages. Embodied carbon includes all stages except stages B6 and B7.

Operational stages - B6 & B7

Fig 7.1.1 - BS EN 15978:2011 Modular display of the different stages of a building assessment- highlighted for clarification.

7.1.2 provides a diagram representing these stages in the example of steel a building;

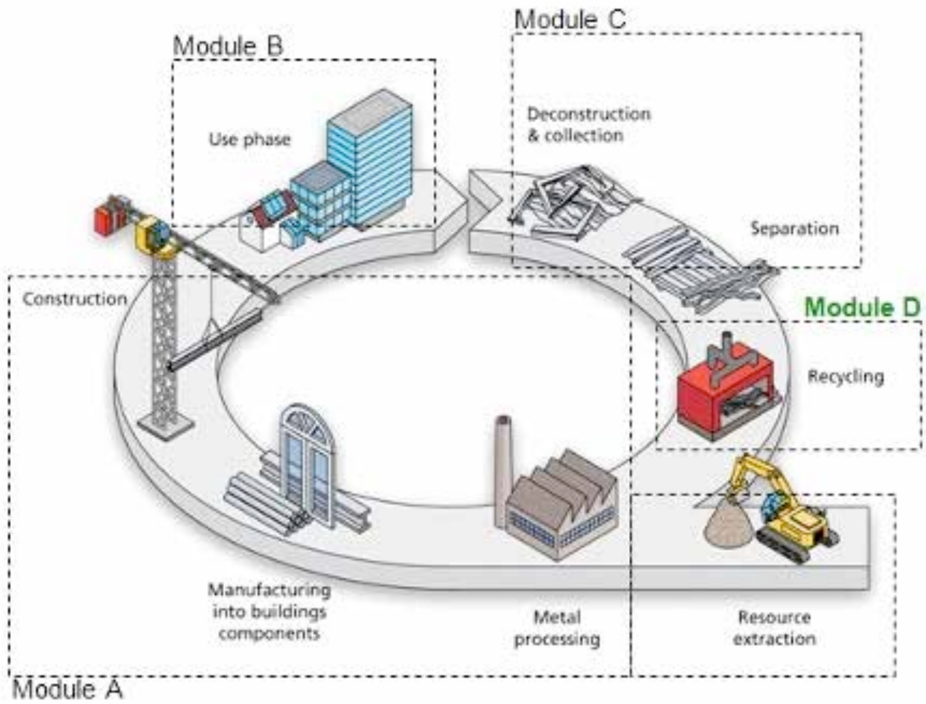


Fig 7.1.2 –Stages/Modules of Steel Construction, Constructalia, The Steel Construction Website

What is Carbon Sequestration or Carbon Storage?

Carbon sequestration describes the long-term storage of carbon dioxide (or other forms of carbon) with the aim of mitigating or deferring global warming and avoiding dangerous climate change. It has been proposed as a way to slow the atmospheric and marine accumulation of greenhouse gases, which are released by burning fossil fuels. BS EN 15978:2011 *& PAS 2050* provides guidance on how to calculate the carbon that is sequestrated in products, and how these are to be recorded as Stage D benefits. For the purposes of clarity this can only be accounted for in whole life assessments and should not be used in partial embodied carbon [cradle to gate] calculations. This is therefore calculated separately see section 7.4.

7.2 Embodied Carbon - Bessemer Grange New Building

To see how the New Building compares to other similar buildings, the BPE team calculated the embodied carbon at Bessemer Grange, to the BS EN 15978:2011 over a period of 100 years (see Appendix K3). These results were then compared against benchmarks. Generally there are few benchmarks in this area, most of which are only for Cradle to Gate i.e. Product Stage [A1-3] and therefore we have highlighted the New Building Cradle to Gate emissions to allow comparison. It is worth noting that the UK Green Building Council (UK GBC) are proposing to develop more accurate benchmarks for the all stages of embodied carbon in 2014/15. The current available benchmarks are from *'Environmental Performance Indicators for Sustainable Construction*' from M4i in 2002 (These have been uplifted into Carbon equivalent figures, CO_2e), and Atkins' *Embodied Carbon Benchmarking* values (which have been assumed to be Cradle to Gate), also shown below. It should be noted that these figures do not include FF&E and services, which is also the case in Architype's analysis of Bessemer Grange New Building.

Building Type	**M4i (2004: p.17) Benchmark Scores [$kgCO_2/m^2$], Cradle to Gate [A1-3]**				
	Best	**25%**	**50%**	**75%**	**Worst**
Education	500	640	857	975	1000
Modified with CO_2e uplift[1]	**530**	**678**	**908**	**1033**	**1060**

Embodied Carbon Benchmarking (Atkins, 2012:p.9) Cradle to Gate [A1-3]
Primary School / Kindergarten / Nursery:**690 $kgCO_2e/m^2$** [range ~500-1000]

Bessemer Grange New Building **Cradle to Gate [A1-3]. 491 $kgCO_2e/m^2$**

The results show that the New Building at Bessemer Grange calculated at 491 $kgCO_2e/m^2$ performs extremely well - even better than the M4i 'Best' benchmark range of 530-678 $kgCO_2e/m^2$ and the Atkins best of 500-1000$kgC0_2e/m^2$. This is primarily due to the high percentage of natural materials and products used in the building that are inherently low in embodied carbon, together with the limited use of cement based products.

[1] Hammond and Jones ICE 2.0, Op. cit, suggest that an uplift figure of 6% is needed for modifying CO_2 figures to CO2e to take into account the relative effect of other gases such as methane etc.

If we look in more detail and assess those materials / components which are contributing most to the embodied carbon, we see that Steico woodfibre insulation, Fermacell plasterboard, KLH cross laminated timber, cement screed and reinforced concrete are the main contributors each contributing over 20,000 kg.CO_2e as shown in Fig 7.2.1 right.

What is interesting is if we then look at the volumes of these materials in the project, against the percentage of embodied carbon emissions, it clearly demonstrates how good timber based materials are in relation to their cement based counterparts.

1. 44m^3 Concrete RC [19.9%]
2. 44m^3 Cement Screed [18.7%]
3. 22m^3 Fermacell Plasterboard [8.3%]
4. 103m^3 Steico wood fibre insulation [7.5%]
5. 213m^3 Cross Laminated Timber [13.7%]

If concrete or steel had been used in the superstructure, clearly it would make the total Embodied Carbon significantly higher.

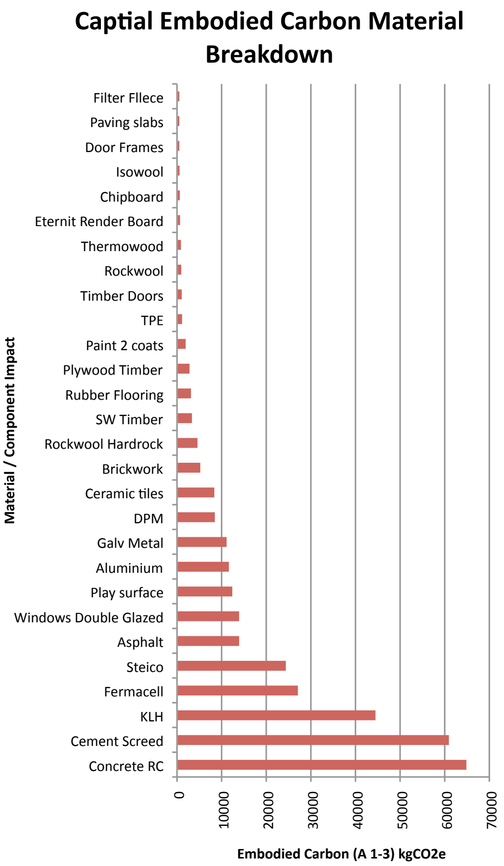


Fig 7.2.1 - Material / Component Embodied Carbon Emissions – New Building (Stages A1-3) over 100yrs

7.3 Whole Life Carbon – Bessemer Grange New Building

To review the Whole Life Carbon footprint of Bessemer Grange New Building the operational carbon, see chapter 6, was added to the embodied carbon emissions. When incorporating these, the results showed that over a one hundred year period, operational carbon represented 31% of the total emissions, whereas embodied carbon represented 69%. When compared against benchmarks this shows that the New Building at Bessemer Grange is following the expected 'near future' scenario for construction projects, where embodied carbon becomes a more significant factor than outweighing the operational carbon over the building's whole life – despite the fact that the New Building has a relatively small embodied carbon footprint.

The RICS research paper Redefining Carbon (Sturgis Associates, 2010) gives a range of building types, which have varying splits of operational and embodied carbon. See Fig.7.3.1. The RICS's predictions show that as regulations increase, lower operational energy carbon emissions result. These will become relatively small in comparison to embodied carbon.

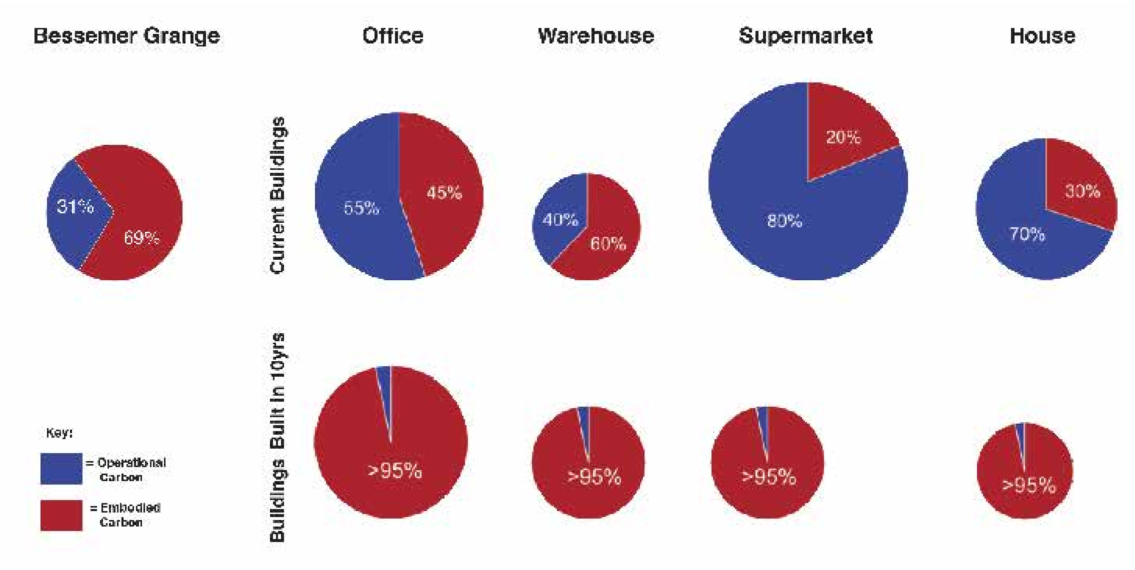


Fig.7.3.1 – Whole Life Carbon footprints pie chart showing the split between operational and embodied carbon. The results for the New Building at Bessemer Grange are compared with examples provided by the RICS for current buildings and future buildings.

Break Down of Whole Life Carbon

To better explain the result, the BPE team have broken down the emissions using categories defined by the RICS in the New Rules of Measurement. As shown in Fig.7.3.2 there are three main factors, that dominate carbon emissions in the New Building; substructure, superstructure and completed buildings (i.e. operational carbon), each accounting for over a quarter of the total (assuming replacement cycles are incorporated into the relevant categories). Please note that FFE and services were not modelled to provide parity with the available benchmarks, and current recommendations on calculating embodied carbon. The results from this limited case study, suggest that prioritising research into embodied emissions that arise from superstructure & substructure as well as operational emissions, are the best ways to minimise carbon emissions.

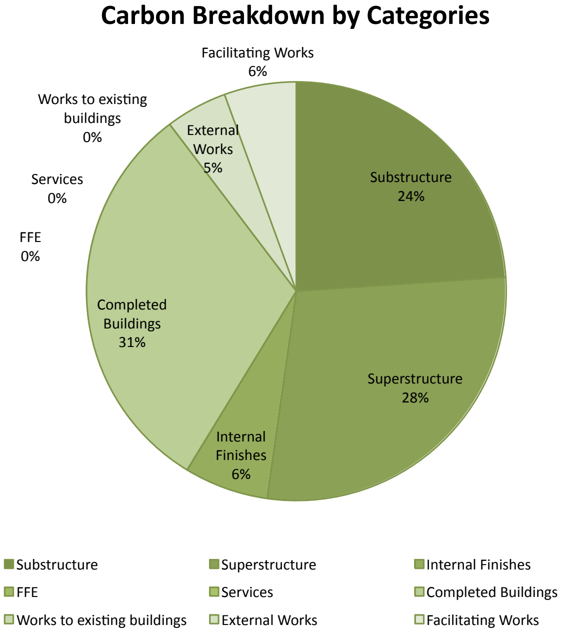


Fig 7.3.2 - Bessemer Grange New Building Whole Life Carbon Emissions pie chart - Based on RCIS New Rules of Measurement

7.4 Sequestration – Bessemer Grange New Building

The amount of carbon that is sequestered or stored by the New Building has been calculated using the PAS 2050 methodology in order to assess the impact on further reducing carbon emissions.

Results, see Fig.7.4.1, show that the building stores 362 $kgCO_2e/m^2$ within its timber structure and a further 6 $kgCO_2e/m^2$ is absorbed by the concrete elements over a one hundred year lifecycle. Sequestration therefore can be shown to effectively reduce the overall impact of the building by upon 7.5% over the embodied carbon emissions. The detailed calculations for both of these are shown in Appendix K2, with a full list of independent verified data sources. However, when accounting for carbon benefits, the whole lifecycle needs to be considered, and what happens at the 'end of life' with timber has always been an uncertainty. The figures show that even if 100% of the timber decomposes in landfill (worst case option as methane is released) this would still give rise to a ten times carbon benefit compared to concrete (per volume). If 100% of the timber is reused, this benefit doubles to a twenty times.

	Carbon Storage $kgCO_2e/m^2$	Carbon Absorption over 100yrs $kgCO_2e/m^2$	100% Organic Decomposition [worst case] $kgCO_2e/m^2$	Sum Net removal $kgCO_2e/m^2$	Material Used m^3	Effectiveness of removing Carbon per unit volume
Timber	-362	n/a	187	-175	262.7	-0.666
Concrete	n/a	-6	n/a	-6	88.2	-0.068

Fig 7.4.1 – Bessemer Grange results for Carbon Sequestration over a 100year lifecycle

7.5 Whole Life Carbon – The Importance of Grid Carbon Factors

The whole life cycle carbon footprint analysis - including for carbon sequestration - was based on the methodology set out in Appendix K1. Two lifecycle assessments were carried out, one assuming the current UK grid factors are maintained, the other assuming the grid is decarbonised (as currently targeted by the UK government). The analysis also shows - in the lighter shades of each of the bar graphs - the impact of carbon discounting / time-weighting on future emissions. This follows a methodology set out in PAS 2050 that modifies these impacts to show that relative impacts of future emissions are less significant than current ones:

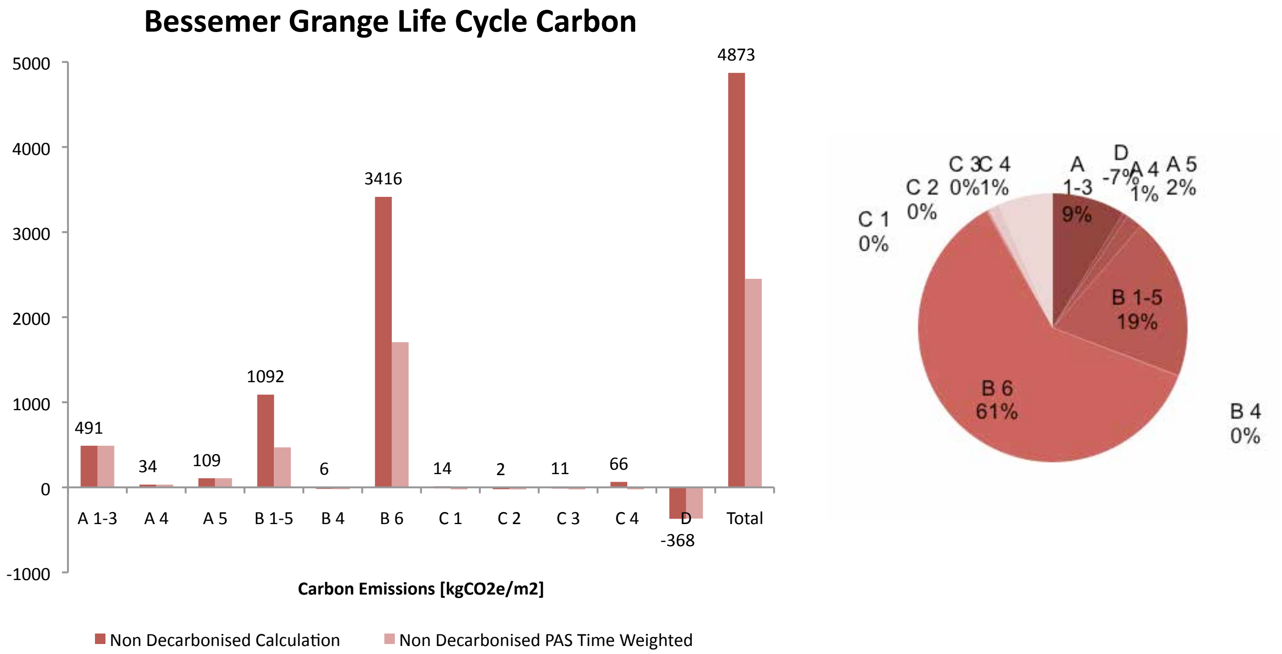


Fig 7.5.1 - Bessemer Grange Whole Life Cycle Carbon Footprint over time bar graph & pie-chart - using current UK carbon factors

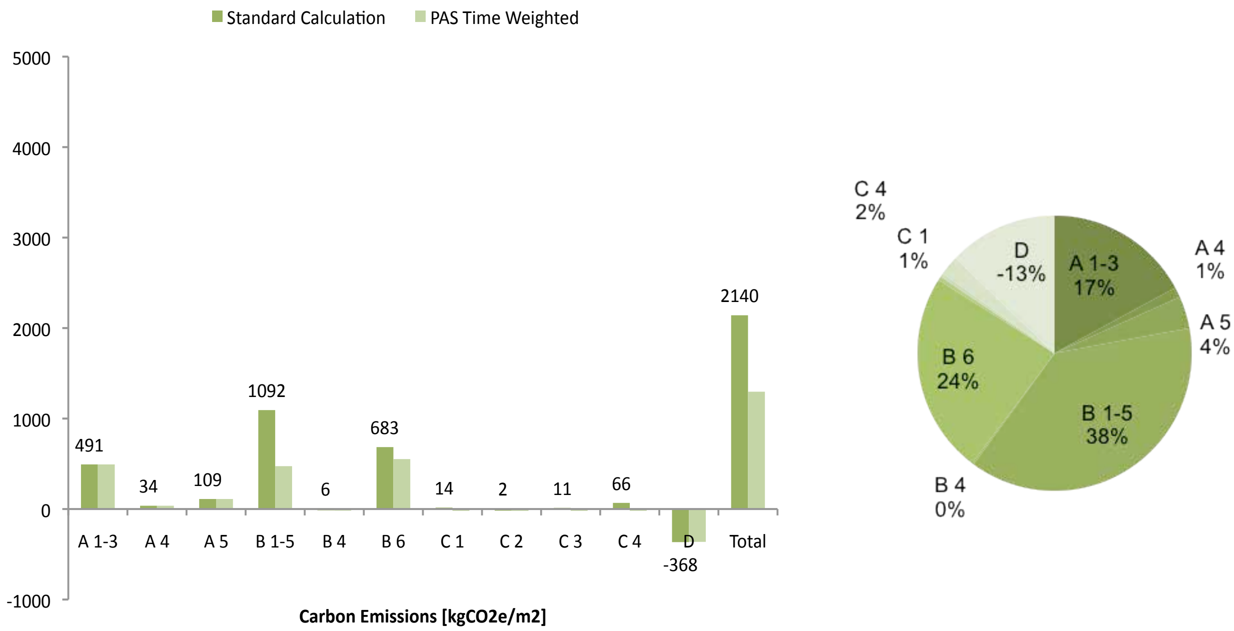


Fig 7.5.2 - Bessemer Grange Whole Life Cycle Carbon Footprint over time bar graph and pie-chart- using future carbon factors based on a decarbonised grid

The results show that the current UK fuel mix means that operational carbon emissions are five times higher than the decarbonised grid. Current lifecycle standards focus on the use of assumptions based on current practice and assumed emissions. Often the government's legal obligations require changes to the grid mix and are not considered by whole life cycle carbon analysis. It could be argued that this overemphasises the impact of operational energy efficiency savings and actively discourages society from addressing and changing measures that affect carbon released in the present. The government should give clearer guidance on the anticipated grid carbon intensity over a longer time period so that whole life cycle carbon footprints can be assessed in a more robust and consistent manner.

Undertaking this full analysis is useful in highlighting both the relative weights of the various lifestyle stages, but also to examine areas where improvements could be made. More research and validation is needed in this new area of study. In fact, the authors of this study - Architype and Chapman BDSP - are part of a group of companies developing a tool to assist with this work called 'Rapiere', which was developed through another TSB funded research project. This project is looking at developing an online tool for designers and developers to rapidly assess the embodied carbon, operational carbon and operational costs of different projects or ideas, to allow for comparison. See Fig.7.5.3. For further details refer to **www.projectrapier.com**

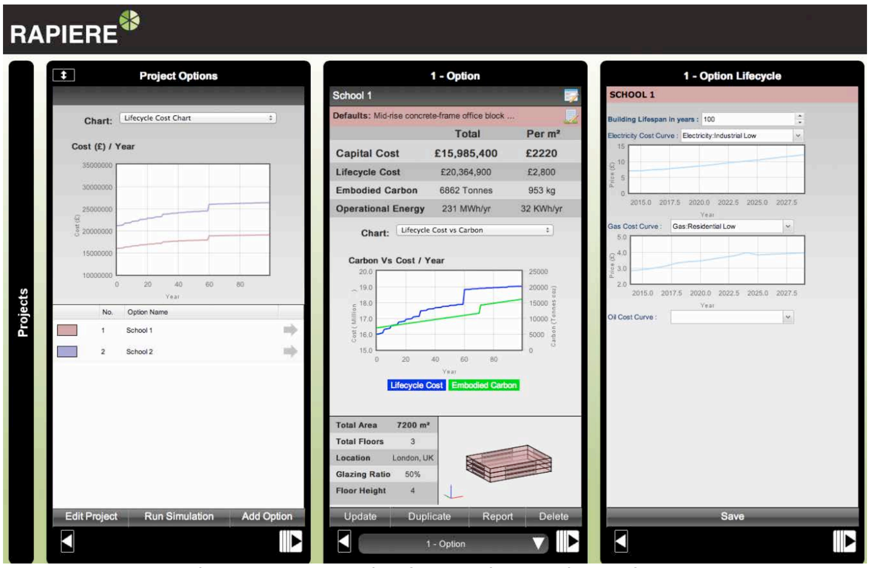


Fig.7.5.3 - Screen shot from Project Rapiere software

8 Technical issues

8.0 Chapter Introduction

This chapter provides some of the further detail on specific issues, which were felt to be interesting or noteworthy. In particular, it looks at the over consumption of energy by artificial lighting, the wastage of energy from ‘heat creep’, problems with the solar thermal panel and difficulties with ventilation and overheating on the first floor of the New Building.

8.1 Artificial Lighting - ‘What’s causing the overconsumption?’

In chapter 6 of this report it can be seen that electricity consumption is high in both buildings and lighting represents almost 50% of usage. This might be expected in the Old Building, which has inefficient fittings, however, the New Building should in theory be more efficient. The over consumption of electricity is particularly environmentally damaging because of the significantly higher carbon factor of electricity in comparison to gas.

Asymmetry of Daylight and Management

As highlighted in section 5.8, the asymmetry of day lighting in the Old Building and on the ground floor of the New Building may contribute to teachers leaving lights on in order to balance lighting levels in the rooms. There was little evidence that teachers used the divided banks of lights, see section 3.5, to reduce consumption. Instead, they tended to leave lights on all the time and wait for the facilities manager to turn them off at the end of the day. Better signage, labelling and policies toward turning lights off could help reduce consumption further. However, given a teacher’s other priorities this is unlikely to work alone. There is little doubt that the use of daylight dimming sensors in each fitting could have helped reduce electricity consumption. This would have allowed the balancing of dark niches without the need for turning on all the lights. On future projects the difficult balance between solar shading, daylight levels, daylight uniformity and control of artificial light merits further investigation.

Lighting Levels

During walk through investigations it was noted that there appeared to be a higher number of light fittings specified than necessary. Therefore the BPE team measured light levels on overcast day in the crèche. With artificial lights on, it was found that no area had a Lux level of less than 600 Lux, double the 300 Lux recommended standard (Society for Light and Lighting, 2006) for nurseries and play areas.

To investigate this further, a simplified calculation for the lighting loads was therefore carried out in the crèche. It was based on information from the lighting schedules and equipment surveys. See Fig.8.1.1. This showed a lighting load for that room of 16 W/m^2, in comparison to 8-9W/m^2 recommended for a typical classroom. It would appear therefore, there has been an overdesign of lighting in this room. The project team were questioned on why this occurred and the only answer that was forthcoming was the possibility that the lighting manufacturer, who had assisted the MEP engineer in providing lighting layouts, may have over specified the number of fittings required. On future projects, careful reality checking of lighting designs might help to drive down electrical consumption.

Type A	Light fixture wattage (2x28W lamps)	56	W
	Number of fixtures	11	
Type B	Light fixture wattage (29W lamps)	29	W
	Number of fixtures	2	
	Total wattage	674	W
	Area of the room (about)	42	m²
	Lighting Load / unit area	**16.05**	W/m²

Fig 8.1.1- Calculation of Typical Lighting Load in the Extension

Elsewhere on the BPE team's walkthrough, it was also noted that the entrance lobby of the Children's Centre, see Fig. 8.1.2, included a large number of fittings. This incorporated a feature lighting configuration on the main staircase and up lighting of the timber structure. This was a deliberate move by the designers to create a bold and welcoming entrance, an aspiration that appears to have been successful, see section 5. However the feature light only included one switch, meaning it was rarely turned off. Furthermore, as it was liked users often did not want to turn this feature light off. Avoiding a reliance on lighting features to create design features might have helped reduce electrical consumption. Alternatively, linking these lights to daylight dimming control would have at least ensured the lights only came on when required.

Fig 8.1.2 – Photo of feature lighting and ceiling lights turned on in the Children Centre's despite good daylight levels.

8.2 Wastage of Gas – 'Heat Creep'

As identified in chapter 6, the re-design of the heating systems as part of the New Building works has led to the problem referred to by users as 'heat creep'. Heat emanated from radiators within certain parts of the Old Building during spring and summer months when the space heating system was nominally switched off – causing discomfort and wasting energy.

Investigations revealed this problem was caused by a valve that was omitted during installation when the Old Building's system when modified to supply the New Building. This meant that whilst the pump P_A , see Fig.8.2.1, supplying heating to the Old School was switched off in the summer, the absence of the valve in the position circled in Fig.8.2.2 meant that heat flowed into the Old Building's radiators when top up hot water was required to assist the solar thermal collector in the New Building.

This meant that when the New Building required top up hot water, water had to circulate over 60m each way through the Old School building to reach the calorifier in the New Building. See Fig.3.1.1. In theory, as the New Building had a low hot water demand the solar thermal panel might be able to meet much of that demand. However, due to a requirement for Legionella prevention, the system had an automated twice-daily top up function programmed into the controller, in order to heat the solar thermal cylinder up to 60℃. Therefore, hot water was circulated around the system regardless of demand by the users.

To assess the distribution losses in the heating circuit from the main boiler room to the New Building, the BPE team performed some primary calculations to quantify the distribution losses. See Fig.8.2.1. The material specifications for the pipes and insulation were taken from the Operation and Maintenance (O&M) manuals.

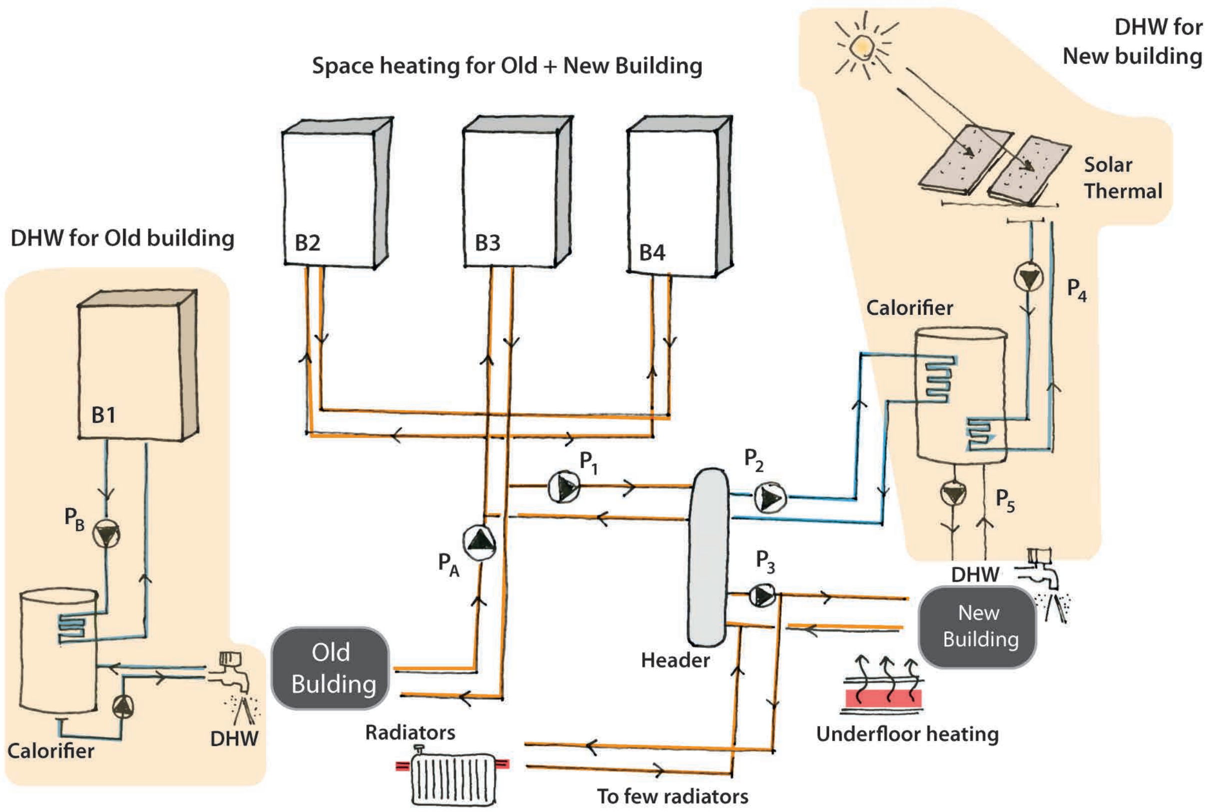


Fig.8.2.1- Simplified diagram showing the configuration of the heating and hot water system - demonstrating it's complexity.

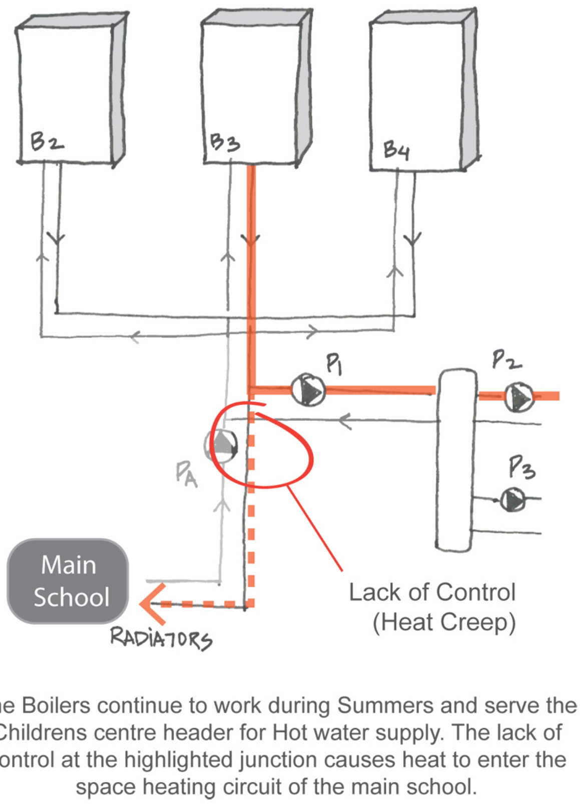


Fig.8.2.2 – An enlarged version of diagram 8.2.1 showing the location of the missing valve, which caused 'heat creep'.

Distance:	60	m		
Pipe internal Diameter:	32	mm		
Insulation lambda:	0.04	W/mK		
Insulation thickness:	25	mm		
Heat emission (from CIBSE Guide C table 3.26)	0.29	W/mK		
	FLOW		RETURN	
Ambient air temp	20	C	20	C
Pipe temperature	80	C	70	C
ΔT (Temp. Difference)	60	K	50	K
Heat Losses	1044	W	870	W
Total heat losses	1914	W		
Heating energy loss				
Running hours	2210	h/year		
Heating energy	**4229.94**	**kWh/year**		

Fig 8.2.3 - Simplified Distribution Loss Calculations.

Calculations showed that from a 60m run of pipe with an ambient temperature of about 20ºC and a flow of 80ºC and return of 70ºC, instantaneous heat losses were calculated to be approximately 1900W. With a total of about 2200 hours of operation over the year, total heat losses would be approximately 4230 kWh/year. From the basic TM22 calculations based on meter readings, the above value represents about 10% of the total energy supplied for heating in the New Building is wasted in distribution losses.

Architype were naturally concerned to find out why the system was installed without the valve, which plays a crucial role. Therefore, the whole process from design to delivery was re-examined.

Investigations found that the client had originally required that the two buildings have separate heating controls. However, the sub-contractors questioned the efficacy of the MEP design, stating that the tendered design did not include for separation. The MEP designer reviewed this and undertook a redesign with the specialist sub-contractor. The installer provided a quote for ~£10,000 to make the separation possible. This was agreed, the work was carried out, and the heating controls for the New Building became separated from the Old Building. Unfortunately, the design missed the above-mentioned valve therefore creating the unintended consequence of 'Heat Creep'. When this problem surfaced, disagreements arose between the MEP designers and specialist sub-contractor as to who was to blame.

To resolve these disagreements and the residual issue, Architype and the client arranged a series of round table discussions between the sub-contractor, contractor and consultants. The client did not want to pursue either party to pay for the problem and instead, wanted a solution to be put forward. Three options were presented and two priced. The client chose to proceed with fully separating the systems, by installing a local boiler in the New Building's plant room at a cost of ~£11,000, although at the time of writing, these works had not been undertaken. See chapter 9 for more details.

8.3 Solar Thermal - Difficulties Logging Data and Displaying Yields

In spite of the difficulties in disaggregating energy consumption, monitoring conducted by the BPE team uncovered strong evidence that the solar thermal system was not working. These difficulties included technical problems surrounding the data logging. After convoluted consultations with the manufacturer Viessmann, it emerged there were incompatibilities in how the decimals places are represented in English and German, making the data indecipherable. The German system uses commas instead of points to define the decimal point and semi-colons to separate values in comma separated value files. Unfortunately, even after the logging problem was spotted and adjustments to interpretation made, recorded data showed that the system was not working correctly.

Consequently, the BPE team sent the raw logging data to Viessmann for analysis. Viessmann confirmed in January 2012 that the Solar Yield Logging was not correctly set-up during commissioning. They also suspected that the connections from the solar collector temperature sensor and the solar cylinder temperature sensor to the control panel needed to be swapped over. The installers, Solar Green, were called back to site in February 2012 and stated that the system and the loggings had been rectified.

During further site visits in December 2012, the BPE team interacted with Barrier Air Conditioning and the school's maintenance contractors and it was found that system was faulty due to a waterlogged thermostat sensor attached to the solar thermal panel. This caused the circulation pumps and the whole system to stop functioning. The BPE team liaised with the school and Barrier Air Conditioning to take action to repair the issue.

After considerable effort the BPE team got to the point where the data was being correctly logged by the solar thermal system. Unfortunately, on further investigation, the team found that the sensors were not located in positions that allowed the controls to accurately calculate the solar yield. This meant that output provided by the control panel was simplistic and unrealistically high. See for details Fig.8.3.1.

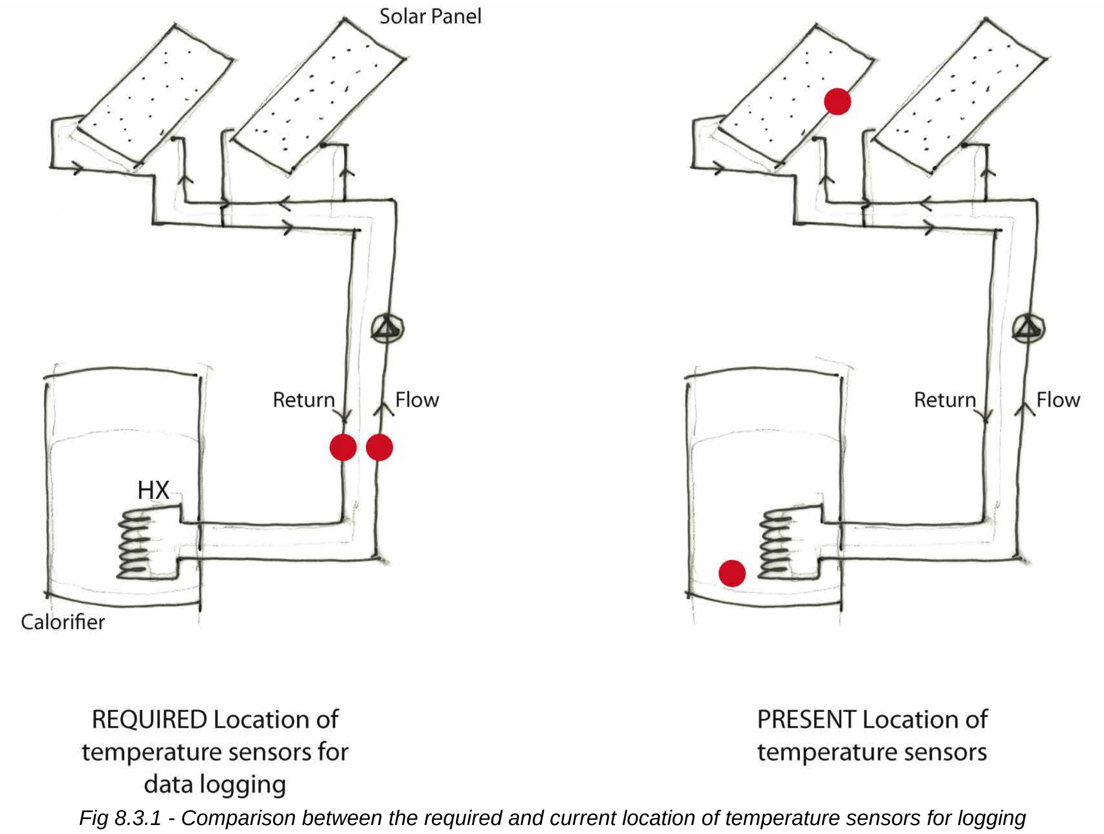


Fig 8.3.1 - Comparison between the required and current location of temperature sensors for logging heat output from the solar thermal system

To accurately log the useful yield, the flow rate and the difference between the flow and return temperatures would need to be measured, as shown in Fig.8.3.1. To achieve this, an extra heat meter or an extra set of sensors would be required. A further issue that was raised by the school was the cost of maintenance. The school has added the maintenance of the solar hot water system to their existing heating maintenance contract at a cost of approximately £500 per annum. The school felt that this cost might outweigh the potential benefit of the system.

On future projects, the BPE team would recommend requiring that the sensors mentioned above along with a graphical display for users and maintainers, are included as a minimum part of any such system. Maintenance costs should also be factored in to any paybacks calculated. Fine tuning and returning commissioning visits should be included within the contract. Whilst these considerations would undoubtedly make the system more expensive and increase the any pay-back time, they appear essential if systems such as this are to be operated and maintained effectively.

8.4 Ventilation Controls – Difficulties Operating Windows and Rooflights

Monitoring of temperature, reported in chapter 5.6, has shown that the New Building performs reasonably well overall in terms of temperature, but that space on first floor level on the west façade can overheat. Investigations have shown this happens because of a combination of factors: inadequate external solar protection, single-side ventilation and particularly difficulties in operating windows and vents.

Windows:

Generally, the designed natural ventilation did not fully function because the windows had several problems. See Fig.8.4.1. The main opening elements of windows were controlled by handles and were restricted to 100mm to prevent children from falling out. This significantly reduced the available ventilation. Also, handles were on key controls as had been requested by the previous facilities manager. This meant that each time a member of staff wished to open a window they had to insert a key. This was onerous but functioned in classrooms, which were regularly occupied, because the teachers had keys. In the Children's Centre (on the first floor), where occupancy is variable, users had to ask the reception staff for keys. In reality, this does not happen and as a result some rooms become too warm.

To address this, the BPE team liaised with the window manufacturer Rational who suggested that plastic plugs could be used to disable the window locks, as shown in the Fig.8.4.4. Unfortunately, this solution only worked in side-hung windows and did not work for some of the larger windows. Further discussion with the manufacturers confirmed that non-locking handles could be provided for approx. £15 each (excluding VAT, delivery and instillation). This option was put forward to the school but was not undertaken at the time of writing. In retrospect simple handles with no key locks should have been used.

The majority of windows also have an operable upper pane, which is controlled via an automated actuator as the handles are well above the 1400mm recommended (UK Government, 2006, Building Regulations: Part M1-4.30) height to allow disabled users operate window controls. The model of actuator installed had a handle to open the windows for maintenance. Many users were not aware that the actuator control switch on the wall operated the window and instead, intuitively reached up and opened the window with the maintenance handle. See Fig.8.4.2. This unfortunately disengaged the motor of the actuator and required resetting. This has created a maintenance burden for the facilities staff and is clearly unsatisfactory. In retrospect, avoiding the need for actuators by lowering the window heights, or by finding an alternative more intuitive actuator product without this handle, would have been a better approach.

Actuators were also problematic in the main lobby area of the New Building. See section 4.3. In addition to the absence of guidance on how to open the windows, the actuators themselves developed intermittent faults. As the wiring was concealed, the problem was difficult to diagnose. The actuator manufacturer blamed the electrical sub-contractors, suggesting the problem related to faulty wiring. The sub-contractor claimed there was a fault with the product or the control panel. Although the problem was fixed the school has reported that problems have recurred outside the defects period. Perhaps actuators are not ideal in the school environment where more robust, simple and intuitively graspable controls are desirable. If actuators are required, then particular attention should be paid to ensuring that the controls are clearly labelled and that wiring is easily accessed. On future projects, Architype are now looking to use mechanical controls such as Teleflex openers where appropriate, as they appear to provide a more robust solution.

In rooms, which had openable doors, overheating proved less of a problem. This solution was precluded for safety reasons in rooms on the first floor of the New Building. On other Architype projects, fully openable ventilation grille panels are now being specified in response to this problem. These panels, see Fig.5.1.9, allow rapid ventilation to be provided quickly, simply and securely with the added benefit that they can be left open at night. This type of manually controlled ventilation could have wider application where the openable area of window is limited due to restrictors.

Fig.8.4.1 - New Building - first floor office window- a fairly typical arrangement of windows.

Fig 8.4.2 - Signage produced by the user to stop people incorrectly using the automatic window handle.

Fig 8.4.3 - Openable ventilation Louvre used on another Architype project to provide a large area of ventilation whilst not compromising safety from falling.

Fig 8.4.4 - Cap fitted to window handle to disengage locks.

Fig 8.4.5 - Photographs showing the window handles with caps successfully installed. This system only worked with the side-hung windows.

Roof lights and First Floor Ventilation:

As discussed in section 4.3 and as shown on Fig.5.3.2, the remote control for the roof light on the first floor of the New Building was lost. This meant the natural ventilation strategy on the first floor did not function as effectively as it might have. See Fig.8.4.6. The BPE team therefore provided details for replacement remote controls including wall-mounting kit to the facilities managers. Where automated controls are required, Architype now look to mount controls fixed to walls or preferably a clearly labelled switch control. On other projects, Architype also use ventilation transfer grilles above doors. This facilitates warm air being drawn out of the building via the 'stack effect'. This approach could have worked well here, see Fig.8.4.6, although the design would have needed to ensure that the transfer grilles were acoustically attenuated and were fitted with smoke dampers if required. See Fig.5.3.5 in chapter 5.

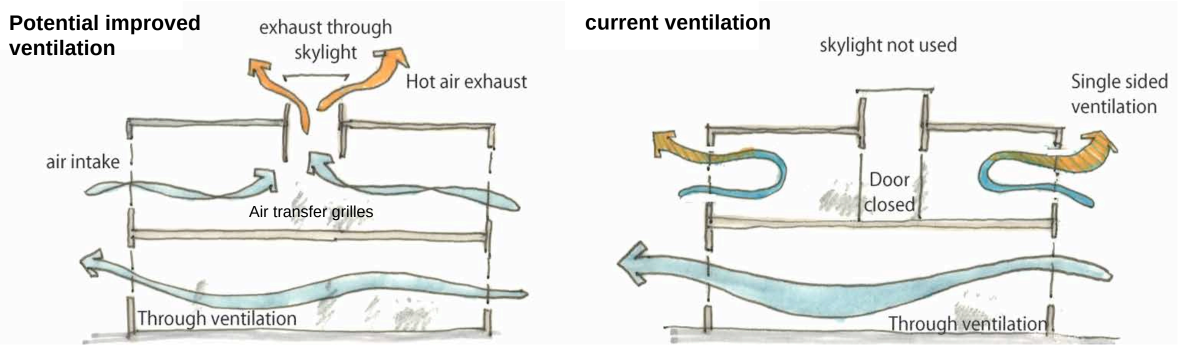


Fig 8.4.6 – Sketches showing ventilation strategies for different floors of the new building (left-hand image shows an improved option, the right-had image shows the building as operated).

8.5 Overheating - First Floor Office

As discussed in section 5.5, overheating in the small office was identified by staff as a particular problem. The BPE team therefore moved one of the temperature sensors into the office and monitored it from June 2012 onwards to study it closer.

The office, which is a small room approx. 8m^2 located, includes desk space and facilities for approximately two people to work. See Fig.5.3.2. It has a large South-West facing window. See Fig.8.4.1, which is manually operable and shaded both by a 400mm reveal and the Bessemer Oak directly in front. Fig.8.5.1 below shows the resulting temperatures that are clearly higher than intended and uncomfortable in the height of summer.

The red line on Fig 8.5.1 shows that difference between the internal and external temperature is well above the recommended 5ºC maximum found in BB101. In summer, this figure averaged between 2.5-12ºC as indicated by the yellow band. This contrasts strongly with design models, which predicted that the room would only have; 64h above 24ºC, 13hour above 26ºC, 1hour above 28ºC and no hours above 30ºC. Thus, either the model (program or data entry) was substantially flawed, or the room was not being used in the correct manner, resulting in significant overheating.

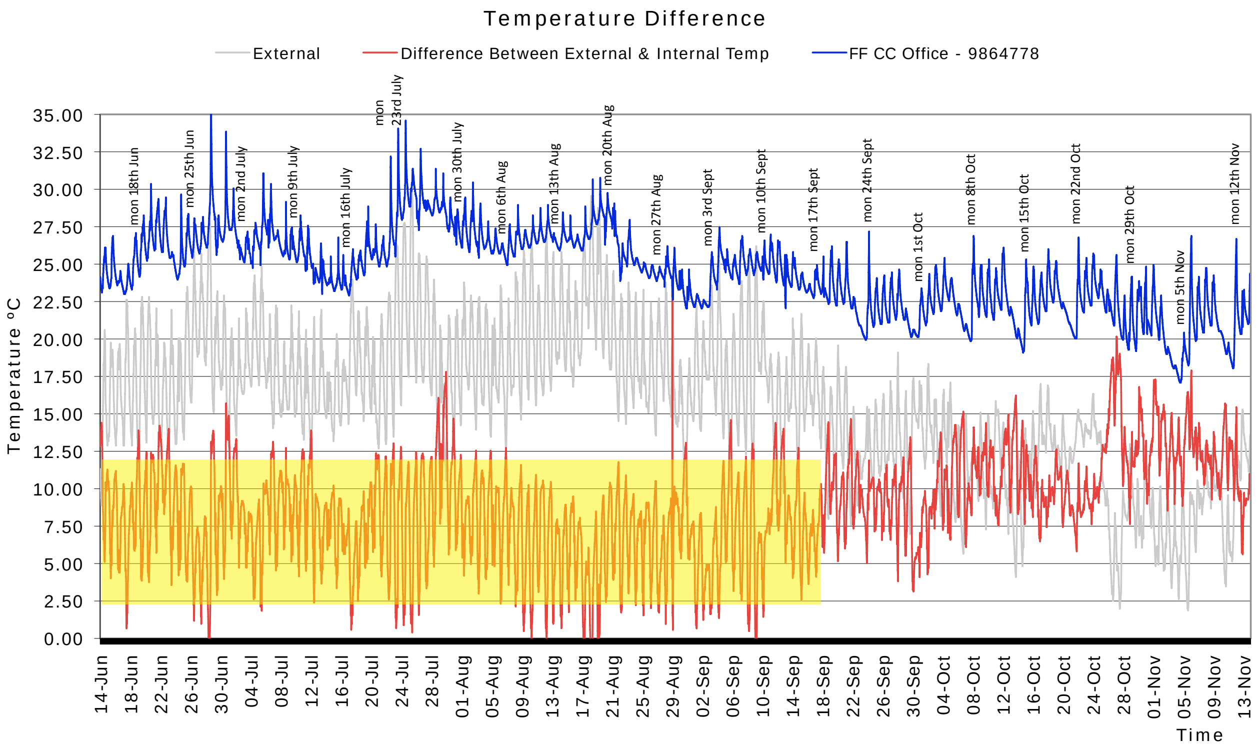


Fig 8.5.1 - Graph of summer & autumn 2013 temperatures in the New Office & externally - The yellow area indicates the average temperature difference between the two temperatures.

To better understand the causes of the overheating, the BPE team calculated the breakdown of internal heat gains from the all the equipment, lighting, people and solar gains. See Fig.8.5.2. From these calculations it was found that the heat gains averaged over the day came to 38 W/m^2. The CIBSE AM 10 (2011) 'Natural ventilation in non-domestic buildings', provides a rule of thumb of between 30-40W/m^2 as the maximum average heat load that natural ventilation can meet. As such, the room appears to struggle to remove heat using natural ventilation alone. A key reason for this may relate to the fact this space appears to have been modelled as a meeting room, and so would not have been in permanent use and would not have had the equipment heat gains which combined, are ~62% of the heat gains.

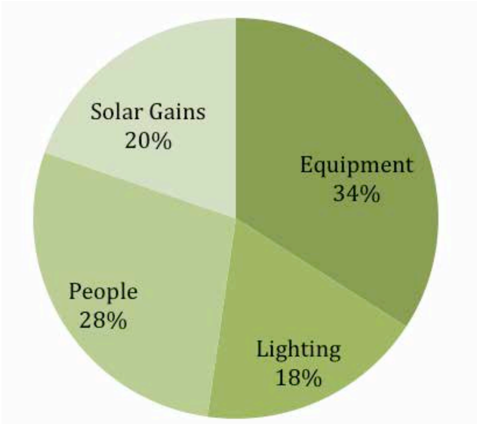


Fig 8.5.2 - Current fraction of heat gains in Children's Centre Office

The BPE team liaised with the school as to the options for assisting a reduction of the gains in this space. Various options including fitting blinds, a brise soliel and ventilation units were looked at. After discussion, it was felt that that testing a cost effective approach of fitting window film and blinds in order to reduce solar gain in the room, would be a valuable experiment for a simple retrofit option. It was hoped this would reduce the heat gains to a moderate level. In addition, the school, without informing the BPE team, choose to retrofit a reception office in the lobby area. See Fig.5.5.4. It was agreed that further measures might be considered if overheating continued.

Therefore, Climate 35 Window Film was fitted to the office window (1.67x2.22m) by the Window Film Company on December 19th 2012. The manufacturers suggest that Climate 35 Window Film is a solar control film which boasts outstanding solar and UV protection without sacrificing incoming natural light. As well as filtering out virtually all UV rays, the window film reduces heat and glare, which are contributory factors to fading. It is claimed this film significantly reduces incoming heat and provides excellent fade protection for fabrics and furnishings.

Total Solar Energy Rejected	68.0%
Glare Reduction	60.0%
Ultra Violet Light Rejected	99.0%

However, data collected comparing days with similar temperature profiles before and after the film was applied, showed inconclusive results, with some days showing the room cooler with the film Fig.8.5.3 and others such where it was warmer see Fig.8.5.4. Despite this, when the BPE team spoke with the facilities managers they reported they had received no complaints of overheating in the office during summer 2013 as compared with several in 2012 and felt that the film had reduced overheating. They reported they still used fans in the summer months but were not interested in any further improvements at this stage.

This is perhaps not surprising given that solar gains only represented 20% of the overall solar gains. Therefore, even if the film performed as predicted by the manufacturer, the overall temperature would have only be reduced by a maximum of ~14%. Relatively small changes in other factors, such as the number of personnel using the room and the amount of equipment turned on, are likely to have a much greater effect.

The fact that there have been no reported complaints may be due to a placebo effect, resignation or acceptance by the users or possibly, because the film reduces radiant heating received directly via sunlight and therefore decreases the user's perception of overheating.

The experience at Bessemer shows that reception office areas in schools often require more than the minimum space standards and tend to become congested and overheated. See section 5.3 for discussions regarding the Old Building. Designers must therefore carefully reality check the client's brief and discuss possible future needs, as well as ensuring that the design of ventilation and solar control builds in sufficient tolerance to allow for the high heat gains that may occur in these spaces.

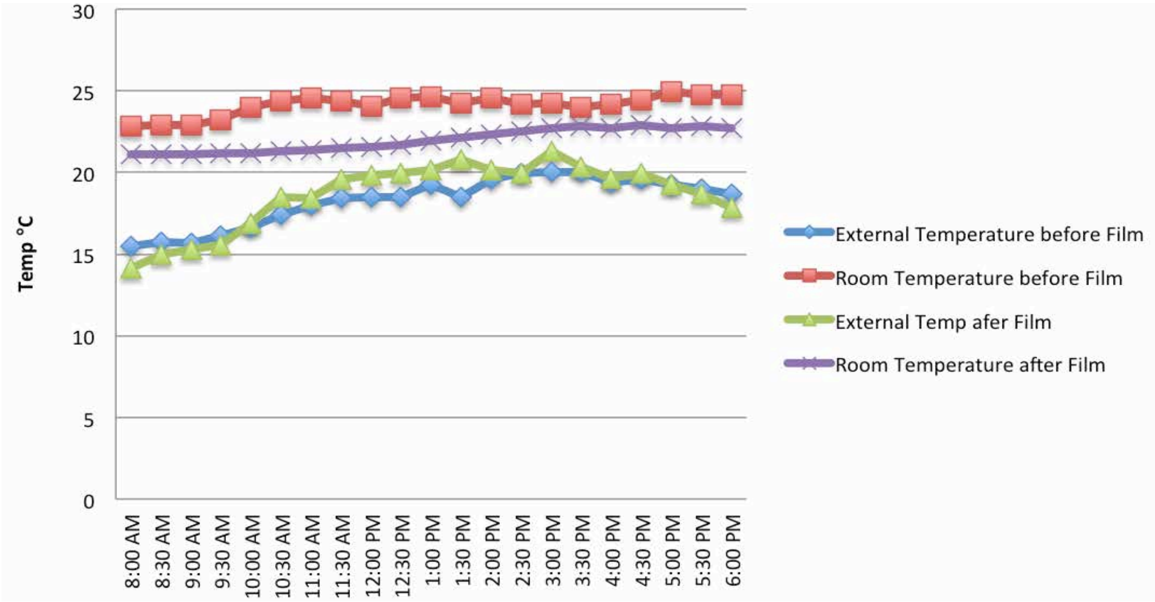


Fig.8.5.3 - Temperature study comparing two similar days (27th September 2012 and 22nd April 2013) before and after the installation of the Solar Control Film. It shows that temperatures on this day were lower in the office after the film had been installed.

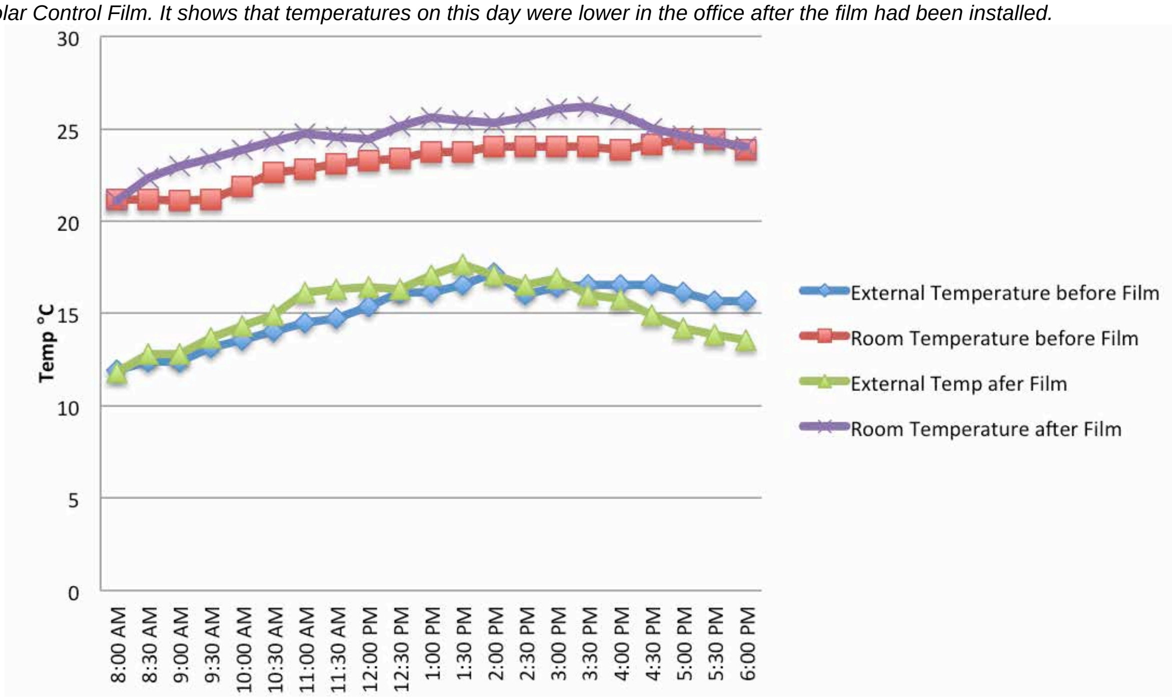


Fig.8.5.4 - Temperature study comparing two similar days (27th September 2012 and 22nd April 2013) before and after the installation of the Solar Control Film. It shows that temperatures on this day were higher in the office after the film had been installed.

9 Message to the School and Local Authority

9.0 Chapter Introduction

During the course of the BPE study various, workshops and meetings were held with the school, the local authority project manager and the Southwark Carbon Reduction Team to try and improve the performance of the building and share the lessons learnt. See notes and copies of the presentations in appendix M.

Suggestions were made as to how to make the most of the value of the asset represented by Bessemer Grange, especially with regard to energy, operations and usability. A summary of recommendations put forward is listed below in Section 9.1.

Importantly, during the course of the BPE study Architype were appointed to design a further new building for Bessemer, see section 9.4.; this time on the site on the opposite side of the road.

9.1 Overall Recommendations

School Facilities Team:

- Undertake works to install the new boiler in New Building to resolve the issue of 'heat creep' and the simplification of metering and controls. See section 8.2. This will reduce wastage of gas, allow more efficient control of the system and improve comfort conditions;
- Once controls problems are resolved with heating systems, put training in place with the heating specialist to ensure staff can control systems effectively and have details recorded in a user guide. This includes having a regime in place for seasonal adjustment rather that just relying on outsourcing;
- Consider installation of daylight dimming controls in the New Building and the upgrading of lighting throughout the Old Building, alongside the careful setting of timer clocks in order to reduce electrical consumption;
- Where they are not already in place, consider installation of two tone blinds in teaching space in order to reduce glare and asymmetry in the day lighting, which leads to visual discomfort and teachers leaving lights on;
- When upgrading external lighting, consider replacement with LED lighting or other low energy type fittings;
- Set procedures for handover of operational knowledge including: user guides, maintenance contracts and system passwords when staff members leave;
- Undertake an annual Display Energy Certificate (DEC) and set targets for improving performance;
- Consider undertaking the cost effective actions proposed by the BPE team to reduce overheating / improve ventilation. In particular, replace handles with non-key- operable handles and purchase and install new control for the roof light on the first floor of the New Building. See sections 9.2 and 9.3.

School Management Team:

- Ensure the school has an environmental policy with clear responsibilities and monitored energy targets as well as procurement policies that ensure new equipment is energy and water efficient. Make a check-up on meter readings/DEC results a regular item on the management agenda for instance.. An example of a school with a comprehensive environmental policy is http://www.ashleyschool.org.uk;
- Undertake an environmental awareness campaign as part of the education experience of the school. In particular, focusing on reducing electricity and turning off lights as there is considerable wastage of electricity identified. This could be done via a member of staff who is an energy champion who will work to promote energy efficiency. There are various programmes that can support these efforts such **as** http://www.eco-schools.org/ **or** www.turnitoff.com**;**
- Work with Southwark to develop a long-term incremental strategy for upgrading the performance of the Old Building; in particular focusing on energy, which is affected by the poor condition of the existing services, external fabric and out dated light fittings;
- Put procedures in place to ensure operational and maintenance knowledge is transferred effectively to guarantee knowledge is retained within the facilities team;
- Support facilities managers in their objectives.

School Finance Team:

- Identify overall maintenance and running costs as part of budgeting process and ensure energy cost and usage is monitored and reported to management;
- Ensure part of the maintenance budget should be ring fenced for energy efficiency measures;
- Work with Southwark Council to identify potential funding for energy efficiency measures or grants available.

Southwark Council:

- Despite obvious shortcomings regarding the condition and environmental performance of building, the Old Building's layout and pragmatic design has proved popular and works well for teachers. Given that the Old Building consumes ~90% of energy used on the site, the greatest opportunities for energy consumption reduction come from upgrading the Old Building's poor fabric;
- The council should consider developing a long-term strategy for upgrading the Old Building including determining usable life of existing fabric, services, structure and possible thermal envelope improvements. In the long term a gradual programme of improvements could offer substantial energy savings and provide a more cost effective option than replacing the entire facility;
- The council should consider using lessons learnt from BPE studies to inform estate management. In particular: the involvement of maintainers in design development and the use of appropriate technology and careful planning when modifying existing systems;
- Support school management teams to develop and maintain green energy policies, including monitoring and reporting energy use. **Example:** Require schools to report improvements in energy performance to an energy league table, such as the LessEn League table by Arup;

- Consider using energy performance data available for schools or other assets across the borough to help inform future feasibility studies and prioritise upgrade works on buildings that perform poorly environmentally;

- The Carbon Reduction Team should consider formulating borough-wide incentives for schools to intensify reduction in energy consumption. Energy costs alone only account for a relatively small percentage of the school's overall running costs and are therefore not a priority. Current loans and matched funded capital currently do not appear attractive enough to help reduce energy consumption significantly.

9.2 Specific Energy and Carbon Recommendations

It is recommended that if serious consideration is to be given to reducing the carbon footprint of Bessemer Grange, then the Old Building must be upgraded. Various recommendations and pay back timescales were investigated for options including: replacement windows, insulation, draft proofing, which are included in Fig.9.21 below. The options, which were seen to provide reasonable pay back periods, are identified in green.

Bessmer Grange
Whole Site Early Stage High Level Energy & Comfort Improvement Options
Draft: For Discussion

	FM Training	Draught-proofing	Old Building-Upgrade Single Glazed Windows	Heat Creap Rectification	Insulating Behind Façade	Externally Insulated Render	Removing Excessive Lighting	New Building-Reduce lift standby energy	Install Solar PVs
Builidng Area	New + Existing	Old Building	Old Building	Old & New	Old Building	Old Building	New Building	New Building	Old Building
Approx Capital Cost Base Cost for 2011: Elec £17.8K, Gas £19.7K	£ 1,348	£ 24,975	£ 472,500 £ 577,500	£10,000	£ 6,000	£ 144,000	£ 1,000	£ -	na
Improve User Comfort	-	Yes	Yes	Yes	Yes	Yes	-	-	-
Yearly Savings	Unkown, estimates around 5-20% more efficent energy systems	Upto 17% savings in heating should be achievable	Upgrading to double glazed should give a 29% reduction in heat loss	Estimated Heat Creep is 5% of heating demand	Insulation could give upto 5% reduction in heat loss	Reduction to 0.27W/m2K should give a 12% reduction in heat loss	Reduce quantity of lights to take to normal lighting levels	TBC	Free electricity saving upto £3400 annually for 25 yrs (gain pvs at end)
Estimated Potential Period on 5% Energy inflation	1 Year	7 Years	34 Years	9 Years	6 Years	29 Years	4 Years	? Years	free
Estimated CO2 Savings by 2020 Base CO2 Emissions: Elec 76 T, Gas 128 T	71 T.CO2	133 T.CO2	260 T.CO2	45 T.CO2	42 T.CO2	108 T.CO2	T.CO2	T.CO2	170 T.CO2
Pros (+)	Quick Win with almost immediate payback.	Simple cost effective improvement of existing windows.	Improve thermal comfort and reduce drafts and condensation.	Reduced discomofort to occupants in summer, and reduces energy. Resolves problems with controls	Short term patching solution to try reduce heat loss of building.	Removing existing and rendering, would improve image, performance and extend build life.	Redesigning lighting, might give perception of downgrade.	99% of energy is in standby. If able to switch off will save energy.	Free PVs which reduce electricity bills also demonstrate sustainablity.
Cons (-)	Difficult to quantify benefit (assumes improvements can be made). Training and handover needed to maintain skills	12 crew (2p) working days to install, probably best to do in a holiday period	Potential issues with weight of windows. Expensive and long payback possibly beyond life of building (structure).	Complicated works to separate existing connection and additional maintance for additional hot water system.	Potential technical problems. Including moisture issues. Not a long term solution.	High initial capital outlay, and long payback period (could be split into small segments).	Redesigning lighting, might give perception of downgrade.	Technical issues make this option difficult.	25 Yrs contract to keep install, potential issues with weight of PVs.

Fig.9.2.1 - Options for improving the energy performance at Bessemer Grange produced by BPE – At the time of writing none of the actions proposed had been implemented.

Grants and Improvements

The Southwark Carbon reduction team attended several meetings with the school and advised that they could provide a grant of up to £50,000 for measures that would reduce carbon consumption, provided the school would match fund their investment. Furthermore, they offered loans for improvement works, see Fig.9.2.2, which could be paid back on the basis of savings recouped from reduced energy bills.

At the time of writing, the school had decided not to apply for the match funded £50,000 grant available from Southwark, as its conditions were too onerous. In particular, the scheme required that services were purchased through approved contractors, whom the school felt were over-priced. Additionally, the grant imposed timescales which the school thought unworkable. It also involved a considerable amount of paperwork which the school felt they did not have time to complete.

The loans were also not of interest to the school who doubted whether the pay could be achieved and they would be left with expensive repayments.
Instead, the school has chosen to focus their funds on a rolling programme of work to improve the relatively poor condition of the existing building ahead of the construction of new facilities, see section 9.3 overleaf. Ten existing classrooms have been redecorated over holiday periods, with faulty lighting replaced and new accessible ceilings installed. Upgrading the environment of the existing building was seen as a priority by the school to retain and attract pupils and keep pace with the improved facilities in the new buildings.

The school felt that the relatively small energy savings that could be achieved through energy reduction measures were not a priority and stated that they were more interested in the longer term, looking to secure a a larger grant for upgrading the existing fabric through replacement double glazed windows and improved insulation.

Scope & Cost of Proposed works:
(1) Old Building Pipework insulation = £1,101
(2) Old Building Boiler load optimisers = £5,550
(3) Old Building Draught-proofing = £24,738
(4) Old Building Lighting upgrades = £14,773

Year	2011/12	'12/13	'13/14	'14/15	'15/16	'16/17	'17/18	'18/19	'19/20	'20/21	TOTAL
Energy Savings (£)	0	11,603	11,951	12,310	12,679	13,059	13,451	13,855	14,270	14,698	117,876
Repayment (£)	0	8,702	8,702	8,702	8,702	8,702	5,906	0	0	0	49,418
Total Saving to Budget (£)	0	2,901	3,249	3,608	3,977	4,357	7,545	13,855	14,270	14,698	68,458

Fig.9.2.2- Payback estimated for £50,000 loan from Southwark via the Salex – provided by Southwark Council. These figures were questioned by the school and the BPE team – The school choose not to proceed with undertaken these improvements.

9.3 Reducing Overheating in the New Building

As part of the workshops, a series of recommendations were put forward by the BPE team to reduce the overheating that was occurring on the first floor of the new building as this was the issue which generated the most complaints/concerns from end users. The recommendations are shown in Fig.9.3.1. The green areas show the most cost-effective options which would have the greatest impact. See sections 8.4 and 8.5 for more details on overheating.

Cost effective actions- not yet undertaken
Cost effective actions- undertaken

	Utilise Existing Ventilation	Open Windows Fully	Two Tone Blind	Apply Film	Brise Soliel	Grilles	Extract Fan / Passivent	Air Con
Office- Overheating experienced	Staff have keys to windows so this already being utilised. However fitting replacement handle would simplify usage of these windows.(circa £15per handle)- via Rational. Reduce density of equipment and occupation. Use low heat output equipment.	Restrictor could be removed by FM manager. Child safety to be managed. Possible easy win but staff commented that it could cause paper to blow around room.	Circa £300 per window. Likely to help but not fully resolve the issue.	Manufacturer claim it will reduce overheating caused by sun by 65%. Cost approx. £100 per window.	Fix Brise soliel to frame to block sun. Circa £1000 (nb planning maybe required)	Replace lower part of window with vent grilles in lieu of glass. Will require openable panel which can be closed in winter. £1200	Replace lower part of window with vent grilles in lieu of glass with powered extractor which can be activated in summer. £1500	£3000. High use of energy + maintenance costs.
Clinic- Room used less often but less overheating	Install replacement handle without key locking (circa £15per handle)- via Rational	Restrictor could be removed by FM manager. Child safety to be managed. Possible easy win but can blow around paper.	Circa £300 per window. Likely to help but not fully resolve the issue.	" "	Fix Brise soliel extral to block sun. Circa £1000	" "	" "	£3000. High use of energy + maintenance costs.
Newly created office - break out space in lobby	Install replacement handle without key locking (circa £15per handle)- via Rational	" "	Circa £300 per window. Likely to help but not fully resolve the issue.	" "	" "	" "	" "	
Entrance Lobby- Warm but not overheating	Fix actuators not working and wire all controls to single control. Approx £500-5000. Elmec and window master need to visit site.	Not possible windows on actuators which limit area window can open.	Windows would require powered blinds and wiring. This is likely to be costly. Circa £750 per window.	" "	Not required	" "	Not required	Not required
Corridor- Warm but not overheating	Control lost. New control fixed to wall. From Velux cost £68+Vat includes fixing to wall. Need to reset main rooflight by pressing button on window. Product KLR100. Tel. 01592 77 22 11	Not possible no windows present	Blind would reduce amount of natural light but could reduce overheating. preferable in th£242inc VAT. + installation. Need a tower + man. £200 install	Would need a tower to be erected. £200	Not required	NA	Not required	Not required
Training room- Warm but not overheating	Install replacement handle without key locking (circa £15per handle)- via Rational	Not appropriate - children possibly present		Manufacturer claim it will reduce overheating caused by sun by 65%. Cost approx. £100 per window.	Fix Brise soliel extral to block sun. Circa £1300	Replace lower part of window with vent grilles in lieu of glass. Will require openable panel which can be closed in winter. £800		
Creche- Warm but not overheating	Install replacement handle without key locking (circa £15per handle)- via Rational	OK	Blinds already fitted	Discuss with school could help reduce overheating a little.	Not required		Not required	Not required
North facing rooms	No problems experienced.							
PRICE £								

Fig.9.3.1 - Spreadsheet showing activities to improve overheating on the first floor of the building (2012-2013).

9.4 New Project - 'Building 3':

As seen above, only a few of the proposed recommendations to the school from the report have been undertaken by the school, the majority have not. By contrast, the design for the additional building, as detailed below, did include a considerable number of improvements recommended by the BPE study.

After the success of the extension at Bessemer, the popularity of Bessemer Grange increased dramatically. As part of its wider primary expansion programme, Southwark council chose to increase Bessemer Grange's roll from 500 pupils (2FE plus 3 bulge classes and 46 nursery) to 676 pupils (3FE plus 46 no. nursery).

After a competitive process, Architype were re-appointed by Southwark to design this further expansion. A series of feasibility studies were then undertaken to identify the best location for expansion. Southwark made the decision that the new expansion would be best placed on the site of the old children's centre on the opposite side of Nairne Grove. Initially, this appears ironic given that one the original premises of the extension was to consolidate the school's facilities on one site. However, provided that years 5 and 6 occupied the site, the school felt that it could work well giving the older years some separation from the younger pupils. The real driver for using this land however, was the school's desire to hold onto the additional space and avoid the site being sold off or used for alternative facilities. Furthermore, the school wanted to avoid disrupting the main school buildings whilst works were being undertaken.

The proposed new facilities see Fig.9.4.1 to 9.4.4, incorporate: six classrooms, WC's, group rooms, a small staff area, storage and plant rooms. The proposals received planning permission in summer 2013 and are due to start on site in April 2014 as a design and build contract led by Balfour Beatty. Architype have been retained as checking architect working for Southwark. This procurement route was selected as it is perceived as being less risky to the client and requires fewer resources from Southwark's in-house project managers. Whether it will provide enough attention to detail to build on the lessons learnt from the New Building, remains to be seen.

Fig.9.4.1- Perspective of new extension scheme.

The design built on lessons learnt from the extension project and the BPE study. Key elements that were incorporated into the design were as follows:

- Classrooms rectilinear in shape to suit school's preference;
- Increased area of storage provided;
- A separate gas heating system, with clear metering is provided;
- Mechanical heat recovery is included in order to reduce $C0_2$ levels in classrooms;
- The building is clad in brick to be more robust;
- A timber frame structure is used but cross laminated timber was not used due to cost;
- Openable handles to windows have been specified without key locking;
- Healthy materials retained (although its downgrade is being considered as part of value engineering);
- Colour scheme retained;
- Soft Landings requirements included in tender.

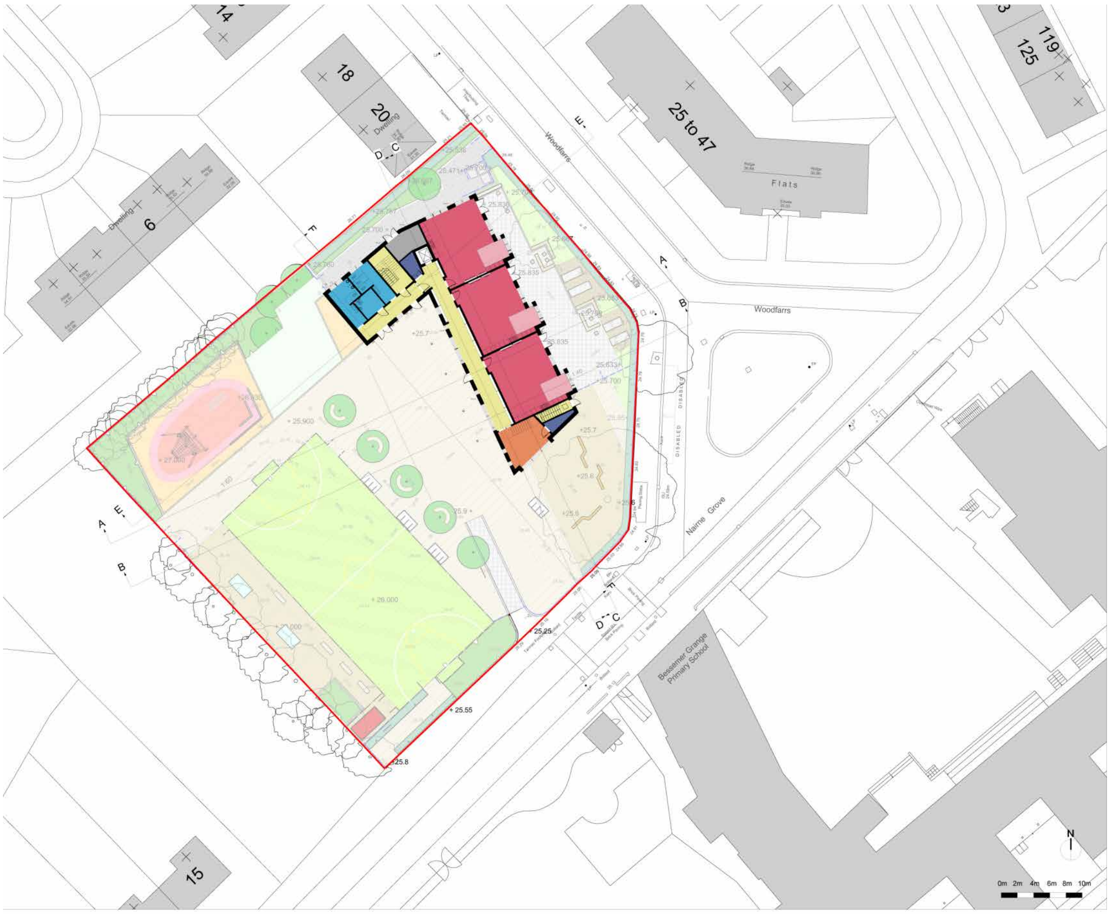


Fig.9.4.2- Proposed site plan for new expansion project showing the building positioned relative to the existing buildings (grey).

Fig.9.4.3- Proposed elevations for new proposed elevations for future expansion project – using a similar style and palette as the New Building.

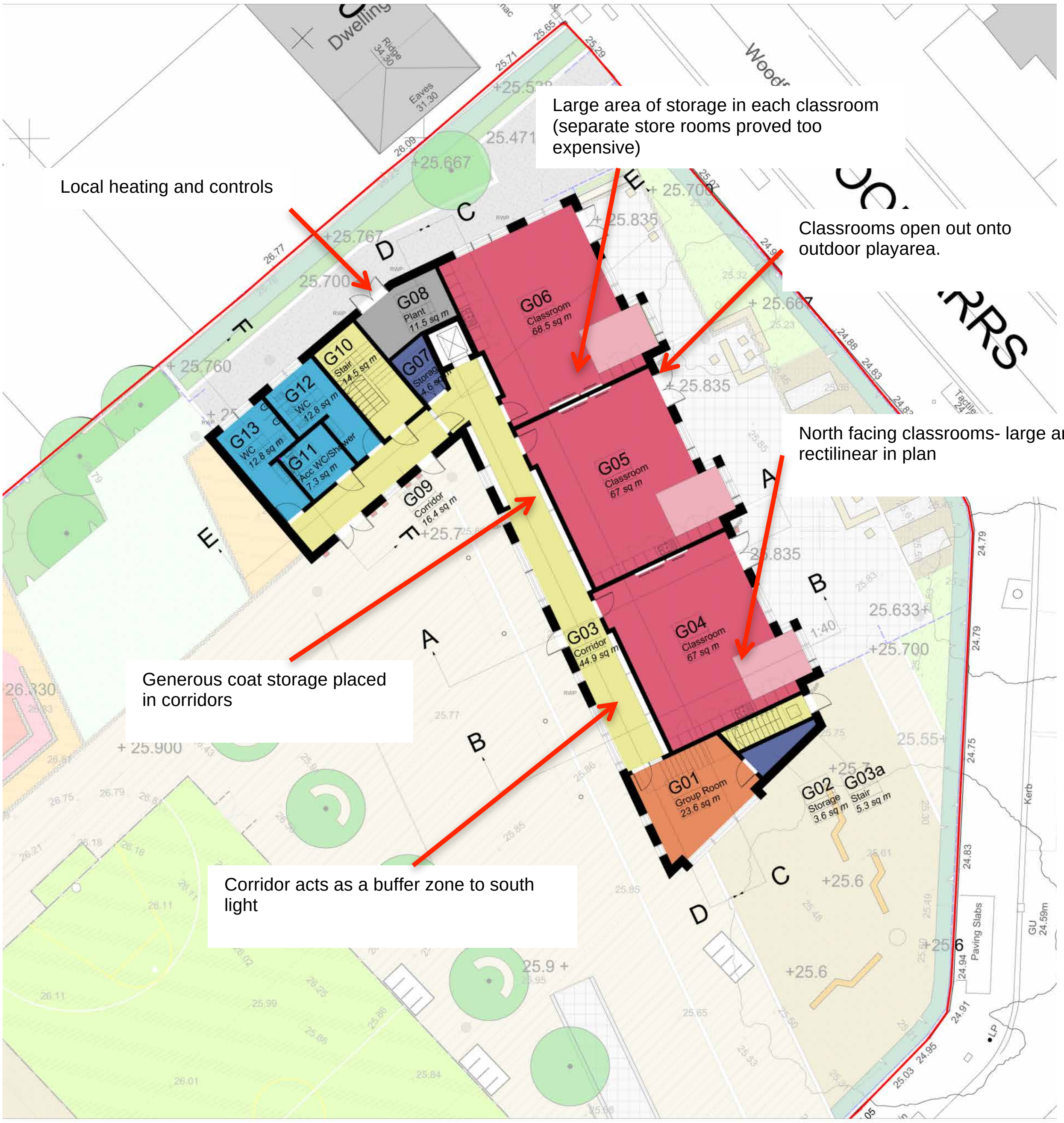


Fig.9.4.4- Proposed ground floor plan for future expansion project. Showing rectilinear shaped classrooms and simple circulation.

10 Wider Learning

10.0 Chapter Introduction

This chapter relates the findings back to the original aims of the project, see section 1.1, and sets them into a wider context. It is split into three sections: Wider Learning and the School Sector, Developing Post Occupancy; and End Statement.

It focuses on the TSB core aim '*to accelerate economic growth by stimulating and supporting business-led innovation'* (TSB, 2013). A detailed summary of the building's performances, including metrics, for use in comparison with others study (a core aim of the BPE programme) is included in the executive summary on pages 4-9, with more detail found in individual chapters.

10.1 Wider Learning and the School Sector

The case study at Bessemer Grange may allow for some reasonable generalisations to be made regarding the school sector. These may also be relevant to the wider industry. Findings focus on the aims set out in section 1.1, which are:

- Meeting the government's energy targets;
- Aiming to identify potential innovations and improved processes, which could narrow the gap between; theory and practice;
- Improving quality in construction and making UK industry more competitive;
- Review of the extending of schools - a solution frequently adopted in the education sector in view of spatial and budget restrictions;
- Review of the use of innovative materials, including a cross-laminated timber frame and a palette of natural materials, including insulation chosen to for its low embodied energy.

Finding Real Value in the Race to Build

The New Building at Bessemer Grange was generally seen as highly successful. See chapter 5. Detailed consultation conducted in the early project stages, was an effective approach. It ensured that that, coupled with thoughtful design, the building broadly met the user's needs and aims and that it provided good value overall.

Despite the positive impact of the consultation, some problems in the project did nevertheless originate from the early stages and briefing. The client's insistence that a staffed reception desk on the first floor of the Children's Centre would not be financially viable proved to be unfounded and a year after opening, a poor quality reception area was retrofitted. See section 5.3. Having case studies such as this provides useful evidence, which can be used to influence designers and clients and highlight the long-term impact of design issues such as the flexibility of space.

Furthermore, following the initial briefing process the project took two years of development before reaching site- twice as long as originally expected - because of the need to raise additional capital as the project was over budget. See section 2.12 for further details. This hiatus created a lack of continuity in personnel and made for a rushed process of value engineering.

Decisions made in value engineering impacted negatively on energy performance, co-ordination of information and some aspects of the design and represented poor value. There was no established protocol to gauge the likely consequences of the amendments in design, so that the value engineering process was insufficiently rigorous. Decisions made quickly to save cost such as the omission of the storage and daylight dimming has been found to create problems in the long term. Conversely it was found that in other areas of the New Building, there was an over-specification of products or numbers of light fittings that could have been omitted with little negative impact. Improved and more intelligent value engineering, based on a bank of evidence rather than crude assumptions, might have helped improve decisions.

Interruptions created due to the stop-start nature of the project also affected the flow of information, especially as there was a radical turnover in both the design team and the school staff during the course of the project. See section 2.12. This meant knowledge was lost and information gaps appeared at certain junctures. Better processes for 're-briefing' and 'pit stopping' (Bunn, 2011) the project at key gateways may have helped reduce the impact of these issues.

The Environment – A Real Priority?

At Bessemer Grange, as with many schools, awareness of the environment is an important part of the children's education. However, the environmental performance of the school itself can be a different matter. Due to the many competing demands on the school's staff, energy saving and the environment was not a priority and became only a fiscal exercise. See chapter 9. Provided the energy costs fit the budget, there is little incentive for improved energy efficiency as in monetary terms it represents just 2% of overall operational expenditure.

Schemes such as the 'Eco-schools' programme (2013) can provide support and resources to help schools, however, there appeared to be no real appetite for this at Bessemer Grange due to the everyday demands. Works recommended to improve the environmental performance of the New Building were also not seen as a priority as the building generally functioned reasonably well and the school was more focused on coping with the rapid expansion in numbers along with upgrading the Old Building's appearance to attract and retain pupils and parents.

Based on evidence at Bessemer Grange, saving energy is largely ignored and only driven forward by staff members that have a particular interest in the green agenda. If the government wishes to encourage reductions in day to day energy consumption they will need to consider further incentives or penalties and schemes, such as energy league tables, that highlight poor performance and incentivise improvers.

Incentives for longer-term improvements do exist in the form of capital investments. For example, the London Borough of Southwark attempts to encourage energy saving and tries to mitigate its own liabilities under the Carbon Reduction Commitment (CRC). See chapter 9. However, the current grants and loans available were unattractive to the school due to the conditions applied. The school wanted total freedom on how to invest and improve their facility. Furthermore there was disincentive for the school to gradually improve energy consumption as larger funding for major refurbishment or upgrade is often distributed on the basis of need. Therefore smaller gradual improvements made by the school may have reduced the chance of more significant funding.

Importantly at Bessemer Grange, evidence showed that the basic layout and design of the Old Building was popular and if it could be upgraded to improve environmental performance, would provide a good teaching environment. Such an investment may represent better value than running down and replacing the facility. This may be the case at other schools.

The availability and type of capital funding from government will need to be increased radically if major reductions in energy consumption in existing building stock are to be achieved.

‘How much energy should my building be using - and who cares anyway?’

A key question is - how can school staff at Bessemer Grange (or any other) school know whether the performance of their building over any given time period is good or bad? The answer is not easily.

As the case study shows, the absence of realistic targets and benchmarks, along with the absence of informative metering, meant that a true picture of energy performance was difficult to obtain. The range of different types of energy analysis, e.g. EPCs, DECs, operational energy predictions, is often very confusing for clients.

While the CIBSE TM54 (2013) guidance on operational energy prediction will prove valuable, it is not mandatory, although perhaps should be for larger buildings. The level of analysis can be complex and expensive (for example, to get building occupancy profiles signed-off for various different activities within a given building or, say, for detailed modelling of controls, services and plant). The costs of conducting the analysis must be matched by the benefits in terms of operational energy prediction.

Furthermore, the buildings including the New Building were never designed to be metered and monitored in detail. Therefore, even if accurate predictions were in place, it would be difficult to compare these against the actual performance.

Effective metering strategies following CIBSE TM39 (2006) rarely seem to be implemented even on supposedly low carbon buildings whether small or large buildings (as the Carbon Trust’s Low Carbon Buildings Programmes – LCBA and LCBP – also demonstrated). Designing these also requires a good understanding of the predicted breakdown of energy use by fuel type.

More importance needs to be placed on the design of buildings for metering and monitoring by the users, facilities staff and the design team. It should be a key part of good practice in MEP design, rather than an afterthought. Clients and developers also have an important role to play, as they can stipulate a need for good metering and monitoring in the brief and contracts.

At schools such as Bessemer, making information on the environmental performance of the building accessible (even just total gas and electricity consumption) on an interactive public display and perhaps on mobile devices could play a major role in not just understanding consumption but, helping change behaviours in school and out of school as well as assisting facilities staff and senior management. This need not be expensive and could have more value than say, introducing a Building Management System (BMS).

However, this needs to be tempered against the fact that even if good predictions and meters were in place, users and facilities teams are less interested in the finite performance of the building than designers and post occupancy researchers. For them, it is just a place to work and provided it meets basic needs they are in general, less interested in the actual energy performance, lighting levels or temperature. Even legally required schemes such as the DEC (Display Energy Certificate) had not been undertaken at Bessemer Grange- showing a lack of knowledge, interest and enforcement. Therefore, to ensure energy consumption is reduced there will need to be not only better prediction and monitoring but also enforced penalties or incentives to ensure changes in behaviour are implemented.

Over Consumption of Electricity and Big Base Loads

At Bessemer Grange there was an overconsumption of electricity. In part this was due to the over specification of lighting. See section 8.1. Particular focus on reducing electrical consumption was important given the higher carbon factor of electricity versus gas (Carbon Trust, 2013). The use of TM22 analysis on future projects may assist in this.

Electrical base loads at Bessemer Grange accounted for 50% of consumption. Whilst it is acknowledged that reducing base loads is difficult, this high proportion of usage consumed when the building was not operational is wasteful. Further research is needed into reducing energy consumed out of hours.

‘Invisible’ Renewables

The roof-top solar thermal system installed in the New Building was a classic case of ‘out of sight, out of mind’ and there was no way of measuring the actual solar yield or the savings in carbon it was delivering.

On future projects it is important for the design team to ensure sensors to monitor the useful yield output of renewables are included as standard, along with a graphical display for users/maintainers. Maintenance and fine-tuning should also be factored into contracts and any paybacks calculated. Whilst these considerations would undoubtedly make the system more expensive and increase the payback time, they appear essential if systems such as this are to be operated effectively.

Making Systems Work in Reality

The modification of the existing systems to serve both buildings for hot water and heating led to wastage and discomfort, as well as disputes and delays. See section 8.2 for details of ‘heat creep’ and 8.3 for details of the underperformance of the solar thermal.

The decision to extend the Old Building's heating system based on the spare capacity, see section 3.2, made some sense in terms of avoiding additional capital expenditure. However, the client went against the advice from the MEP engineers, see section 2.12, to replace all of the existing pipe work. This in turn initiated a chain of events that meant that the heating system could not be controlled and wasted energy. See section 8.2. If the correct valve had been installed, then in theory the system might have functioned correctly. In reality however, the complex arrangement of the system increased the likelihood of problems.

Therefore an important lesson is the need for engineers to put greater emphasis on designing simple, controllable and commissionable MEP systems, rather than prioritising capacity and lowest cost. In addition, clients need to be made aware of the potential risks involved in modifying existing systems.

Appropriate Technologies and Good Ventilation

Window controls and handles were too complicated to operate which meant that the natural ventilation strategy did not work to full effect. This caused some overheating in certain spaces. See Section 8.4 to 8.5.

Overheating in classrooms is a common problem in the industry and has lead to several major disputes between designers, contractors and clients. See Aedas vs Carillion (2013) as an example. In the fast track process of design, ensuring ventilation and solar control function is crucial in modern, well-insulated buildings that retain heat well. Designers should therefore place greater emphasis on ‘reality checking’ solar control and ventilation design and, if in doubt, over ventilate. This allows for a tolerance in designs as computer models do not reflect the real world.

Actuators and their controls were also problematic and fell into a grey area of responsibility. Architects, engineers and sub-contractors need to be explicit about who is taking responsibility for designing and specifying controls and their labelling. Equally, manufacturers need to improve the quality of design for their controls and labelling and assist specifiers to ensure that full systems are more easily specified.

Ventilation controls were not the only systems that caused users difficulties. In the New Building, the under floor heating system proved problematic. Its slow response time caused much confusion amongst users. Furthermore, there was no direct user control. This caused frustration as many teachers like to have control over their direct environment. Underfloor heating also has the disadvantage of complicating the moving of walls, as fixings cannot be placed into the screed containing the underfloor heating for fear of damaging the pipes within. The reorganisation of rooms however, is frequently required in schools. Simple radiators with thermostatic valves were popular in the Old Building and appear to be a better solution in educational buildings as they are more familiar to users. However, this has to be balanced against losing wall space.

There is also a need for more high quality affordable standardised product systems to help simplify the maze of different products - particularly in public buildings. This is an area that manufacturers need to be encouraged to develop. Some manufacturers are already working in this direction; for example, integrated door sets and ironmongery are now available from ironmonger Laidlaw and Door Manufacturer Leaderflush. However, such items are often the first to be sacrificed in cost cutting exercises and the challenge is to identify which should be retained.

In summary, technology must be applied with discrimination and priority must be placed on simplicity, practicality and robustness in the choice of materials and systems in school design. Users must also attempt to understand and accept new technologies where appropriate. It is hoped manufacturers will respond to more discerning and exacting designers and users so that they remain competitive in the long run.

Useful Information and Usable Controls

As part of this report, it was found there was a lack of good signage and user-friendly information. General signage was not included within the main building contract (and therefore not designed) and had been put up in an ad-hoc manor, which created visual clutter. In order for users to be empowered to take custody of their buildings'; there is a need for an improved provision of information – this should be seen as a suite of information including labelling, signage, user guides, technical guides and operation and maintenance manuals. Architype are developing standard templates for this. See section 4.5.

Interfaces and controls were also identified as being poor and none intuitive. Greater focus should be given to improve user interfaces with MEP services. See section 4.3 – page 49.

The Real Cost of Maintenance

In this case study it became apparent that insufficient attention was paid to the cost and burden of maintenance at the design stage, despite the fact that these costs are significantly higher that energy costs. See section 4.6.

Whilst maintenance costs at Bessemer Grange are elevated because of works on the Old Building, there remained a perception that some aspects of the new design were unhelpful. In particular, the cost of replacements for some systems such as the waterless urinals, thermostatic valves for radiators and light fittings were considered excessive.

Facilities staff stated a preference for cheaper standard products that could be purchased from builders' merchants or local suppliers. This is an important issue to consider. Having a well thought out environmental policy developed in dialogue with the client, who also specifies better procurement, appears to be essential in driving down energy in the long term.

Maintaining the solar thermal system and actuators requires entering into sub-contracts, which were also disliked by the school and undermined the confidence in 'green' technologies.

Minor defects and design issues such as ironmongery and door seals, dampened the enthusiasm for the building. Greater focus on robustness of fixtures and fittings was seen as highly important.

Knowledge and Outsourcing

While at Besssemer Grange maintenance of the heating systems is outsourced, (saving the facilities staff considerable time, especially given the day-to-day demands of running a busy and expanding school), knowledge of the buildings at Bessemer Grange has clearly been lost as facilities staff have departed. For example, no one was sure how to access the main boiler room controls panel.

Without someone on site having an intimate understanding of the building and the tools to fine-tune systems (whether it be the heating system controls, BMS or other systems), very good environmental performance combined with high occupant comfort will be difficult to attain. Improving training and knowledge for facilities staff appears key if the performance of buildings is to improve.

Innovation and Embodied Energy

The project at Bessemer Grange utilised a range of natural construction materials including a cross-laminated timber frame. The natural paints and stains proved popular and have lasted well - with the exception of the rubber flooring which was disliked by facilities staff as it was found more difficult to clean than standard PVC vinyl products. The cross laminated structural frame was found to be cost effective and quick to erect – however accuracy was not as good as hoped for. On 'Building 3' the use of a cross laminated timber frame was ruled out on cost grounds; a drop in exchange rates meant that importing the timber from abroad had become more expensive.

In chapter 7, an analysis of embodied energy demonstrated that the embodied energy of materials and products in construction, increasingly represent a significant contribution towards carbon emissions. If the government wishes to hit its targets for reducing carbon consumption then it may wish to target these emissions, especially as they contribute to climate change now whereas theoretical operational savings may never be realised.

The study showed that natural materials and timber could significantly reduce embodied carbon emissions produced.

The need for the UK government to release a roadmap to the decarbonisation of the energy grid - in order that accurate predictions can be made on carbon emissions was also identified.

More research and case studies are needed in this area, so that proper benchmarks and possibly legislation can be introduced to set targets for embodied carbon emissions for new buildings in the UK.

Summary of Key Findings Relating to the School Sector and Beyond:

1. Consultation served to provide crucial information for the design team and helped create more appropriate designs. Streamlining user involvement as suggested in the James Review (2011) may be to the detriment of the quality of design, construction and as-built performance;

2. Developing a knowledge bank of case studies based on built construction projects could be highly useful in order to inform clients and designers of some of the problems that can occur and may improve value engineering processes as well as the quality of future designs;

3. The importance of good storage in schools was highlighted;

4. The need to manage a complex stop start design and construction process with a high turnover of staff was highlighted. Utilising techniques such as BSRIA BG27/211 Pit stopping (Bunn, 2011) and 're-briefing' could assist in this;

5. Energy saving was not seen as a day-to-day priority for the school. Further incentives or penalties will be required if schools are to reduce energy consumption;

6. The Old Building at Bessemer Grange had many positive attributes and was well liked by staff. If the environmental performance could be upgraded, retaining the facilities may offer good value for money. This may be the case at other schools. In education projects more strategically targeted funding, more time and the use of user feedback to assess what is worth retaining and what is worth replacing is needed;

7. Better predictions of operational energy usage are needed if schools are to be empowered to take control of their energy use;

8. The range of different environmental programmes and assessments (EPC's, DEC's, BREEAM, CRC etc.) was seen as highly confusing. Simplifying regulation and ensuring better enforcement could help to reduce energy consumption;

9. Greater focus is needed on the design of metering strategies so that they are clearly understandable and can be related back to predictions. Consideration should be given to linking readings to visual displays and linking them to mobile devices;

10. Electrical consumption was high in both buildings studied. Reducing consumption in new buildings with a high density of equipment is a challenge. As Lighting was the biggest consumer – more research and careful design is needed in developing passive design strategies which maximise and balance natural light, avoid overheating and incorporate daylight dimming;

11. A high proportion of electricity is consumed when no-one is using the building. Further research is needed into reducing consumption of electricity from base loads;

12. The solar thermal system at Bessemer Grange had numerous problems and could not be monitored. On future projects the useful yield output with graphical displays for renewable systems should be included as a minimum to ensure systems such as this are to be operated and maintained effectively;

13. Technology needs to be employed with discrimination. Only appropriate technology should be used in schools where maintenance support is limited. In general simple-to-operate and robust controls should be installed and fragile automatic systems should be avoided;

14. Consider the impact of high occupancy/density areas on ventilation design, particularly in reception and office areas. 'Reality check' overheating results;

15. Designers must prioritise the design of windows, their controls, signage and shading. Getting the intricate detail right has a far reaching impact on the environment of the building including glare, overheating, good daylight and CO_2 levels;

16. Greater emphasis needs to be placed by engineers on designing MEP systems for simple control and 'commissionability' – rather than just considering capacity and cost;

17. Manufacturers need to work to simplify systems and provide more standardised components in order to improve quality in the industry;

18. Information provided to users at the end of a project is often very poor. There is a need for better and clearer information provided, such as a suite of linked documents and signs, so that users can be empowered to control and maintain their systems effectively;

19. The cost of maintenance of buildings needs to be given greater importance by designers with estimates produced at design stage;

20. More training and support needs to be given to facilities managers if they are expected to manage the reduction in energy and carbon in the buildings they oversee;

21. If the government is to meet its commitment to carbon reductions, the role of embodied carbon should be given a greater priority as it makes a significant contribution to carbon emissions now, whereas operational carbon savings may occur much further in the future or never be realised.

10.2 – Building Post Occupancy Capacity

This section considers key objectives set out in section 1, including: building capacity and knowledge in the UK construction industry in the field of building performance evaluation, discussion of the success of the SL4; pilot and considering Architype's ongoing work to integrate post occupancy work into everyday practice.

The BPE Study and Post Occupancy

Undertaking a detailed building performance study has proved to be challenging at times and has taken more time and resources than expected. This is in part due to BPE being a relatively new field of study and the fact that researchers have been learning 'on the job'. Clearer objectives and a less ambitious scope may have helped focus efforts more efficiently.

Systems and metering at the buildings were not set up to allow for simple monitoring and problems with equipment hampered this report. As highlighted elsewhere, designing buildings to allow for simple monitoring is crucial if the costs of studying buildings are to be reduced.

Large data sets also led to 'data indigestion'. Focusing efforts on important information takes experience and over -monitoring buildings may cause as many problems as a lack of metering. The key is developing sensible and well thought through systems.

Many of the key findings in this report could have been identified using only the BUS survey, a forensic walk through and some basic energy monitoring. Looking to streamline POE processes is crucial if there is to be wider taking up as currently undertaking this type of research is highly unprofitable.

More in-depth studies need to be supported by universities and governments otherwise they are very unlikely to continue, as the investment costs and potential negative outcomes will put off most professionals from undertaking this type of work. Universities should include training on post occupancy as part of their professional course in order that the next generation of professionals are better trained for this work.

Soft Landings Pilot

As shown in section 4.3 the Soft Landings 6-week residency pilot was useful but had limited impact as it had not been embedded from the start of the project and there was no contingency for addressing any defects that fell in an area between brief, design and installation. Having a post occupancy contingency available is crucial to overcome persistent issues, which often remain unresolved if they become subject to a dispute.

One of the most significant benefits of undertaking the Soft Landings residency, was the up skilling of the people involved. There is a new sensibility and awareness of how to anticipate and address problems, as well as an understanding of how best to empower others. Specific problems can also be addressed and lessons learnt for future projects. A bank of case studies using Soft Landings process as taken from inception to completion would provide valuable information to demonstrate the value of the process.

Operationalising Soft Landings and Rapid POE

During this study it became clear to Architype that to improve handover, significant efforts needed to be placed in developing systems, requirements and protocols well before handover to ensure that there were mechanisms and funding in place to implement findings.

Studying a building with no funds for remedial action, no contractual clauses to require commissioning or return to site, is potentially dangerous. It can mean that whilst issues can be identified, there is no process in place to provide solutions, thus increasing liabilities. Therefore, the Soft Landings process needs to be refined to include specific requirements. To this end, Architype are currently working to integrate a basic level of Soft Landings (or aftercare) into their service as standard. Addiotnal services and studies are charged separately. See section 4.5 -4.6.

Systems for managing and sharing the information collected are being developed, which is vitally important if information is not to be wasted. Architype have therefore developed their own in house intranet website

‘Archiwiki’, See Fig.10.2.1, to share project information and lessons learnt. However, there is the potential need to develop further tools for sharing learning and knowledge across the industry. This might be an opportunity for universities and other research projects.

However, it remains to be seen whether there will be wider take-up of these services offered by Architype and further support from institutions may be necessary to encourage implementation if a reduction in energy and improvements in performance are to be achieved. Looking forward, it will also be important to develop processes that can work alongside the new ‘Government Soft Landings’ programme ((BIM Task Group, HM Government, 2013) due to be implemented on all central government procured buildings from 2016 onwards. See Fig.10.2.2.

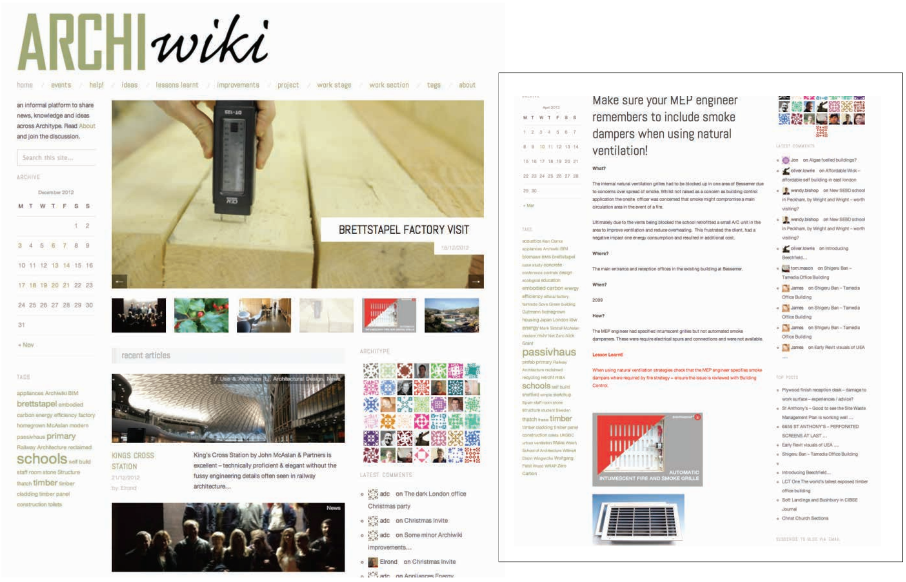


Fig.10.2.1 - Pages from Architype’s Archiwiki intranet website which allows the management of information and sharing of lessons learnt

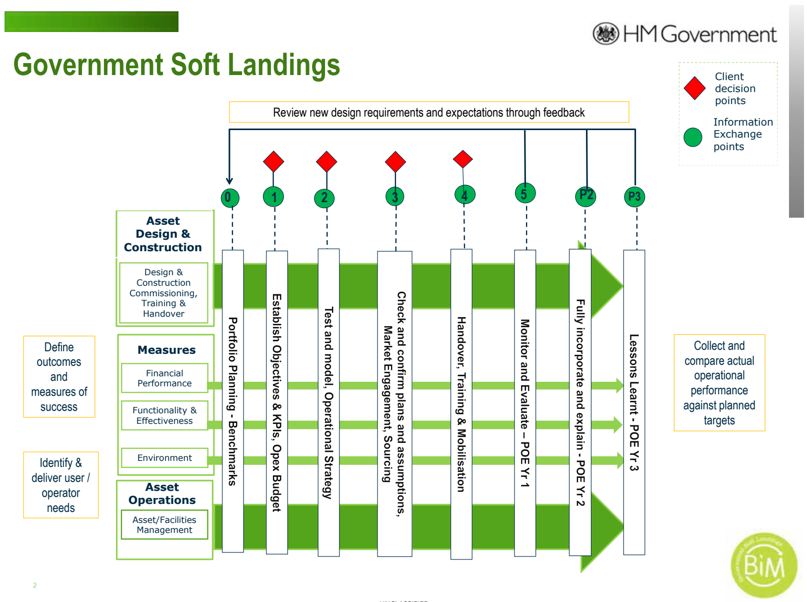


Fig.10.2.2 - Diagram explaining the proposed Government Soft Landings process, which links with BIM (Building Information Management).

Summary of Key Findings Relating to Post Occupancy and Soft Landings:

1. Post occupancy studies need to be clearly focused and have specific objectives to avoid brief creep, which can make them unaffordable;

2. Designing buildings with monitoring in mind and equipment in place, would significantly reduce the cost of post occupancy work;

3. Utilising post occupancy tools such as CIBSE TM22 and TM54 as design tools would help reduce costs, as post occupancy could become a verification process rather than a laborious data entry process;

4. Using a few well-focused techniques can reveal the majority of findings. Too many investigations can convolute the process;

5. There is a need to standardise and benchmark post occupancy approaches and techniques to reduce costs and allow greater access;

6. Universities and government should continue supporting detailed post occupancy as it is currently seen as unaffordable by the industry. Universities should also include post occupancy techniques as part of their syllabus;

7. The development of case studies which apply Soft Landings from inception to post occupation, would be very useful to demonstrate value to clients;

8. There is a need to refine the Soft Landings methodology to make it more accessible and include additional tools and resources to assist early adopters;

9. There is a need to persuade clients and funders of the importance of embedding Soft Landings/post occupancy approach into a project from the outset of the project as a central thread. Designers may have to take the lead on this;

10. Focus should be given to the development of rapid and effective post occupancy methods that can be used in practice. The TSB Building Performance programme has provided a useful start to this process but this needs to be followed up and supported if it is to take route into the industry;

11. There needs to be a development of knowledge sharing platforms to ensure data and lessons learnt from post occupancy studies can be shared with a wide audience. This needs to be supported by institutions and universities.

10.3 End Statement

Given the UK government's ambitious carbon and energy targets, see section 1.1, and it's current drive to reduce government debt, the success of a public building project in the 21st century depends to a large degree on how sustainable, affordable and manageable it is. It is therefore useful to summarise the learning from Bessemer Grange in terms of the aspirations expressed in the Usable Buildings Trust (a charity dedicated to improving building performance in-use) notes on designing for manageability. See Fig.10.6.

In these terms, the New Building at Bessemer Grange is successful and displays many of the characteristics of a 'Type B'. However, to move it fully into this category and away from a 'Type C', it would have required less convoluted MEP Services, better planning for maintenance, clearer controls, improved metering and more robust systems for ventilation. A full implementation of the Soft Landings process, including contingency from the outset, with knowledge fed back from previous projects could have helped improve the buildings' performance and offered a logical route to reach the 'Type B' building.

With the government's policy of cutting the UK deficit including driving down the square metre price payable for school buildings, see James Review (2011), and its radical restructuring of how educational buildings are produced, the James acknowledges post-occupancy studies as a key factor in achieving better buildings in terms of design and procurement. It also emphasises the fact that the end user must take custody of the building's performance.

Therefore, the challenge for the industry is to develop a simplified and affordable approach to post occupancy and Soft Landings that can be integrated into practice and which can empower users to manage their buildings. Regardless of party political issues, it is highly likely that in the future, building in the school sector will have to deliver ever-increasing value for money as well as more energy efficiency, in the face of rising costs and international commitments. The hope is that post occupancy can assist in identifying intelligent measures that will reduce costs, improve quality and avoid a legacy of poor buildings that underperform and may require premature replacement.

> *"…TYPE A: These are complicated, require lots of management to look after the complication, and get it. They can work well, but tend to be expensive to run and fragile, as their performance can collapse in bad times.*
>
> ***TYPE B: These are less complicated, require less effort to run, and are more robust. We need many more of these, particularly in the public sector, as high maintenance is ultimately unaffordable and unsustainable.***
>
> *TYPE C: This is unfortunately where all too many buildings that aspire to be Type A end up. They are too complicated, need too much money and management to look after, and end up delivering poor value.*
>
> *TYPE D: These buildings receive more care and attention than they deserve. They are procured, designed, built, operated and often occupied by dedicated enthusiasts. They can achieve excellent performance- and sometimes they are demonstration projects - but they are not necessarily replicable in the real world.*
>
> *As a general rule, beware Type A, try to do more of Type B, avoid Type C, and question Type D..."*

Fig.10.6 - Usable Buildings Trust Building – Note on Manageability (Bordass, Way & Bunn, 2009: p.10)

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