ASDA supermarket

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	450060
Project lead and author	Breathing Buildings for ASDA Supermarkets
Report date	2014
InnovateUK Evaluator	Unknown (Contact www.bpe-specialists.org.uk)

Building sector	**Location**	**Form of contract**	**Opened**
Retail	Langley Mill	Design and build	2010
Floor area	**Storeys**	**EPC / DEC**	**BREEAM rating**
Sales: 3675 m^2 GFA: 6293 m^2	Single	A (18) / N/A	Very good

Purpose of evaluation

The scope of the BPE was to primarily assess the energy use and associated thermal comfort and air quality of the Langley Mill store, and compare this with the standard model store used by Asda. Adjoining the sales floor area are two storey storage, administration and café areas. This store was chosen as typical of a modern supermarket in size, usage and building standards, while also acting as a test-bed for natural ventilation.

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

Overall estimated electricity use: 326.9 kWh/m² per annum; overall thermal (gas): 128 kWh/m² per annum. The report breaks down the overall energy consumption into separate consumption by end use (bakery, cafe etc). Process energy usage predominates. 37% of electrical energy is expended on cooled storage, 8% in the bakery, 7% in food preparation and display items, and 4% on distributed catering - in all accounting for 56% of the whole. Of the 44% expended upon infrastructure, more than half of this is expended upon lighting due to high utilisation and illuminance (around 700 Lux) required for product presentation within the expansive sales area.

Occupant survey	**Survey sample**	**Response rate**
BUS, paper based	133 of 171	78%

Occupant satisfaction was high as a result of this. In winter the store was sometimes perceived by occupants to be a little cold compared to the set points. This overall result was not a surprise as issues with the heaters had been experienced prior to the survey. Overall, in terms of thermal comfort the building was within the top 15% of non-domestic buildings surveyed.

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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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1 Introduction and overview

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

The building detailed in this BPE is the ASDA supermarket in Langley Mill, Nottinghamshire. It is mainly a single storey building with a sales area of 3675 sq.m gross floor area (GFA) and a whole store GFA of 6293 sq.m. Adjoining the sales floor area are two storey storage, administration and Café areas. This store has been chosen as it is typical of a modern supermarket in size, usage and building standards, whilst also acting as a test-bed for natural ventilation.

The scope of the BPE is to primarily assess the energy use and associated thermal comfort and air quality of the Langley Mill store, and compare this with the standard model store used by Asda. Keighley was taken as the benchmark store as it is very similar in size and was of the same general build quality and age as Langley Mill.

The store was opened in late 2010 and was procured by ASDA plc under a Design & Build contract with the main contractor (RG Group) working on a tendered framework agreement. Key plant & materials, such as the heating, ventilation and refrigeration systems were specified outright as these impact the life cycle costs of the building and are crucial to operating a successful trading environment. M&E consultancy for the store was provided by David Dickinson and Associates (DDA).

The store heating is provided by a series of gas fired units. Unlike many other supermarkets, there is no mechanical cooling equipment and the main store ventilation is provided naturally in conjunction with a small amount of mechanical extract in the key areas including the Bakery and the Rotisserie. The Natural Ventilation system, including the temperature and air quality monitoring system was provided by Breathing Buildings (BB). The review of the natural ventilation was one of the primary foci for the BPE study.

Operation of the mechanical plant (heating, extract etc.) as well as comfort conditions (temperature and carbon dioxide levels) is monitored by the Building Management System (BMS) and is accessible on-line.

Sub-metered energy usage is also recorded and accessible on-line using EnergyICT.

Key findings:

- Carbon emissions. The energy use from HVAC and chillers was 8% lower on a per sq.m basis than a similar sized benchmark store. However, gas use for heating was higher by 40% resulting in a smaller overall saving in carbon emissions. Reasons for the higher gas use are discussed in Section 7. Carbon emissions at Langley Mill were 1.3% lower than Keighley. Natural ventilation has now been used on a subsequent store taking into account the learnings from this project. The carbon use of Langley Mill is 55% lower than the 2005 Asda benchmark. The target for the store was a reduction of 30% and hence the store has performed significantly better than the target.

- Thermal comfort. The Langley Mill store was notably cooler than Keighley, with benefits especially in the summer months. Occupant satisfaction was high as a result of this. In winter the store was sometimes found by occupants to be a little cold but the temperatures were in fact generally maintained within the set points. Overall, in terms of thermal comfort the building was within the top 15% of non-domestic buildings surveyed using the Arup / TSB BUS Survey.

- Maintenance. The Langley Mill store is well maintained and has not received a significantly higher number of call outs than Keighley, although the type of in-store heaters has not proven ideal for supermarket use due to the difficulty in accessing them during trading hours

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

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

2.1 Pre-Asda

The existing site was occupied by an HGV haulage company and located on the edge of the town centre within a residential area. There were large areas of hard standing for vehicle parking, maintenance workshops and offices associated with the haulage company. There were also some privately owned residential dwellings towards the front of the site. All of the properties were purchased by Asda to assemble the site.

2.2 Design Energy Performance

Asda Langley Mill has an EPC rating of A, scoring 18. In contrast, our benchmark store at Keighley has an EPC rating of B scoring 47. When the EPC scores are compared to the actual usage at the two stores it is apparent that the EPC and energy usage are out of sync. Both SBEM calculations were completed with input level 4 which was common at the time of build, whereas this has now evolved and been superseded with level 5 which gives a far greater detail of systems installed within a dynamic model which would give a closer match between the SBEM and actual use.

A limitation of this is also that the process loads are not included in the SBEM; however, our TM22 analysis has identified that this accounts for 56% of the total usage and the environment within a supermarket can have a detrimental impact on the process loads. A potential area of investigation in future maybe a system that could integrate and normalise across different sectors that includes the level of detail contained within the TM22 and process loads.

2.3 Construction

A significant demolition project was undertaken to remove the existing buildings, foundations and drainage. All usable materials were crushed on site to be re-used as fill during the main store construction programme. Several pockets of contamination, which were identified during the pre-construction site investigations, were remediated and retained on site.

A major railway line runs along the western boundary of the site. This had an effect on the position of the site welfare facilities, site cabins and safe working zones during the construction period.

There was a significant change in levels between the lower end of the site (eastern boundary) and the highest point (western boundary. A cut and fill exercise was undertaken to allow a balance to be achieved and minimise the amount of off-site export generated.

The ground was then treated with lime stabilisation to achieve the required bearing capacities.

The main store was built during an approximate 26 week construction programme.

The build consisted of;

1. Main access roundabout

2. Main access road and Petrol Filling Station

3. Customer Car Park.

4. Main store (3675 sqm GFA sales area)

5. 4 No. Adjacent retail units (1300sq.ft. each)

6. Service and delivery yard.

The store itself is built on traditional pad foundations within the stabilised ground. The main structural frame is a simple beam and stick arrangement. The roof is a mono-pitched aluminium standing seam construction which rises from a low point of approximately 5.6m at the front of the store to around 8.6m at the high point to the rear elevation of the store. The external walls are clad with a Eurobond type composite panel system which is fixed direct to the main frame without the need for sheeting rails to be included.

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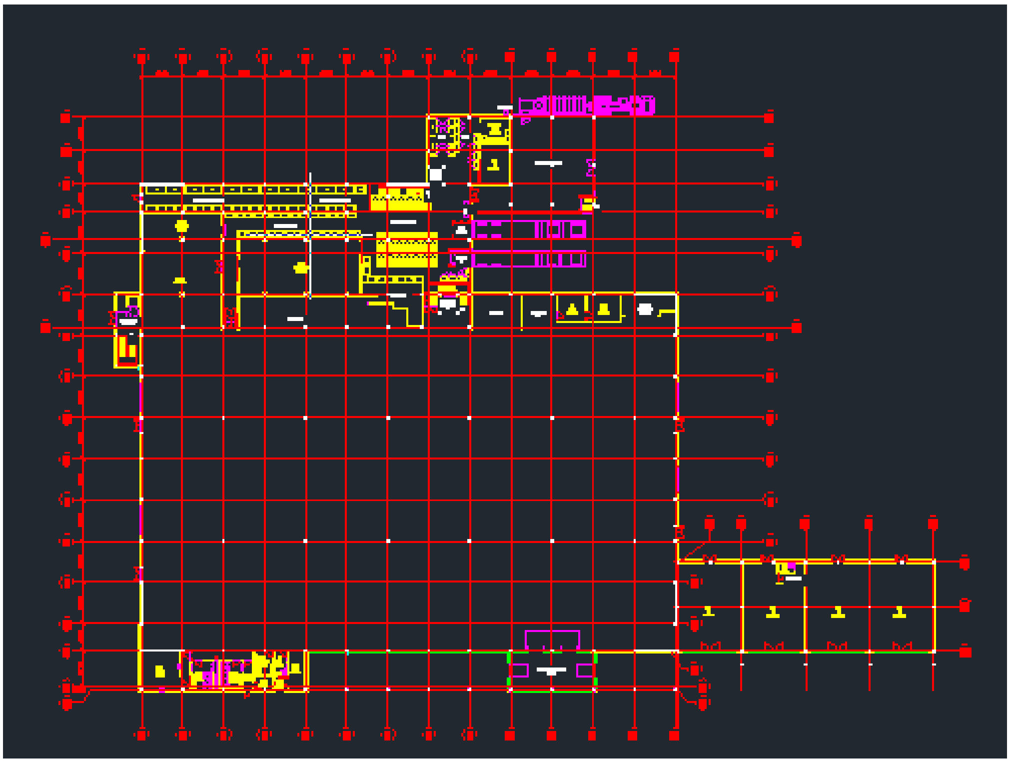

Figure 2.1 Ground floor plan

The sales floor is rectangular in area, with a lobby on the front door. The front door opens onto the car park, with the cash registers at the front of the store to the left of the door shown on the East Elevation, which is comprised of glazing, below.

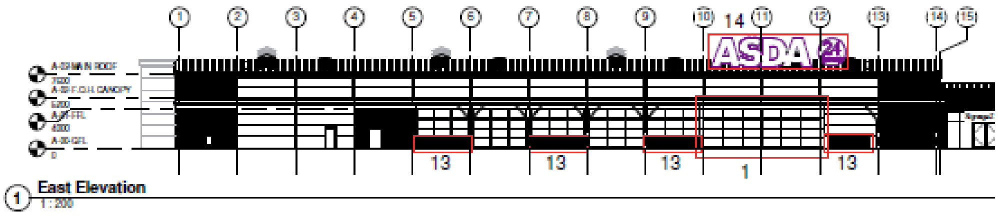

Figure 2.2 East elevation of Langley Mill

The area over the sales floor is left completely open with no ceiling. The void above this area extends to the underside of the roof. In the Back of House area most of the warehousing operations take place on the ground floor. There is a small area of first floor mezzanine which accommodates the office and welfare areas along with the Customer Restaurant. The Restaurant is located on a gallery floor area and overlooks the main sales floor space.

Figure 2.3 East Elevation front of store

The front elevation of the building is orientated to face East. A large area of shopfront glazing to this elevation is protected by a large projecting canopy to allow daylight to enter the building whilst protecting from excess solar gain. Strip rooflights are provided over the main sales area. Daylight sensors are linked to the internal lighting system to allow electrical supply to be reduced as daylight increases.

The site itself is well served by local transport links. The railway station is a short walk from the site and existing local bus stops are in place on the main road directly in front of the site. Several cycle shelters are provided for both Customers and Colleagues.

The Construction programme was phased into demolition, enabling and main build. The proximity of the railway meant there were restrictions on crane over-sailing etc. The building was procured on a D&B type arrangement with the main design team being novated from their development roles into construction appointments. The majority of the complexity on this project related to the demolition and enabling package. As the site was covered in existing buildings there was limited opportunity for boreholes to be taken prior to receiving vacant possession of the site - this lead to a few unexpected foundations/drains which were discovered during demolition. There were no significant delays and the store opened on time and within budget.

The intent of the store is to reduce energy and to create an environment which supports Asda's core retail business.

3 Review of building services and energy systems.

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

3.1 Overview

The building is treated in three separate areas for ventilation;

a) The back of house colleague and customer areas are heated and cooled via individual DX split type Heating & cooling systems and mechanically ventilated.

b) The back of house warehouse areas are heated by LTHW unit heaters served via the ACV Heatmaster 85TC combination boiler.

c) The Sales Area is heated and cooled via 6 No gas fired unit heaters and a Breathing Buildings natural ventilation system to control the environment.

The Breathing Buildings e-stack natural ventilation system is designed to work as follows.

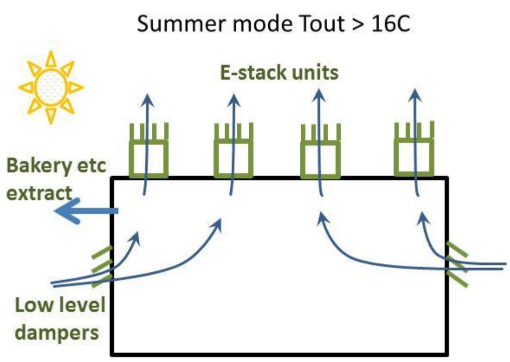

Figure 3.1 Langley Mill Natural Ventilation Summer Mode Tin>Tout

When the external temperature is above 16C and the interior is warmer than the exterior, an upwards displacement natural ventilation strategy is used. Low and mid-level dampers are opened to permit fresh air in at low level. Air is extracted via the mechanical systems associated with the bakery etc as well as the natural ventilation e-stacks atop the store.

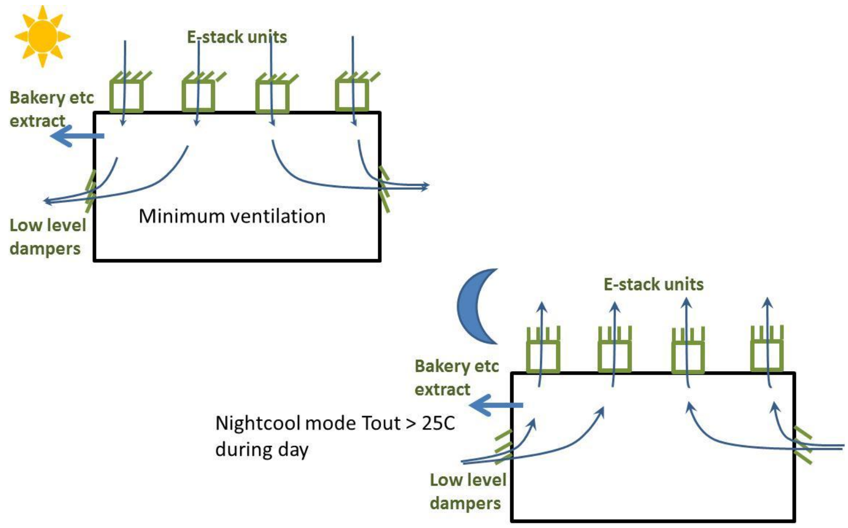

Figure 3.2 Langley Mill Natural Ventilation High Summer

In high summer it is possible that during the hottest part of the day the interior temperatures are in fact lower than the exterior. This is a result of the heat absorption by the night cooled thermal mass within the store as well as the effect of the open refrigeration cabinets. The natural airflow during the day is therefore downwards through the store as depicted in Figure 3.2. In high summer the store ventilates at night in order benefit from the free cooling of cold night air, and the natural ventilation system operates as depicted in the lower part of Figure 3.2.

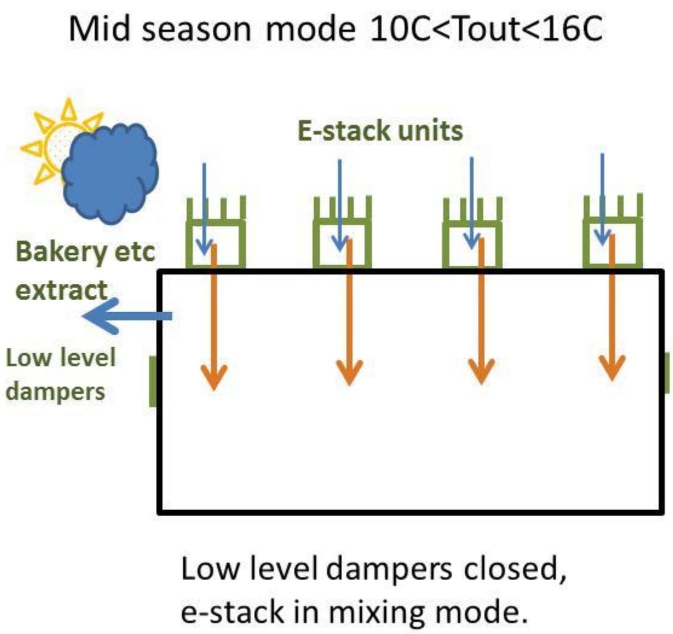

Figure 3.3 Langley Mill mid-season natural ventilation mode

When the exterior temperature is between 10 and 16C, the store operates in a mid-season natural ventilation mode. Air continues to be extracted through the bakery and rotisserie systems. However, air is provided in a low energy way via the roof-based e-stack natural ventilation units. The units pre-mix the cool fresh air with store air in order to minimise the risk of cold draughts. The e-stack units have been designed specifically for the supermarket environment. The low level dampers are closed and the front door operates with a lobby to minimise the risk of cold draughts there.

Below 10C the air is supplied with a full mechanical ventilation system as indicated in Figure 3.4.

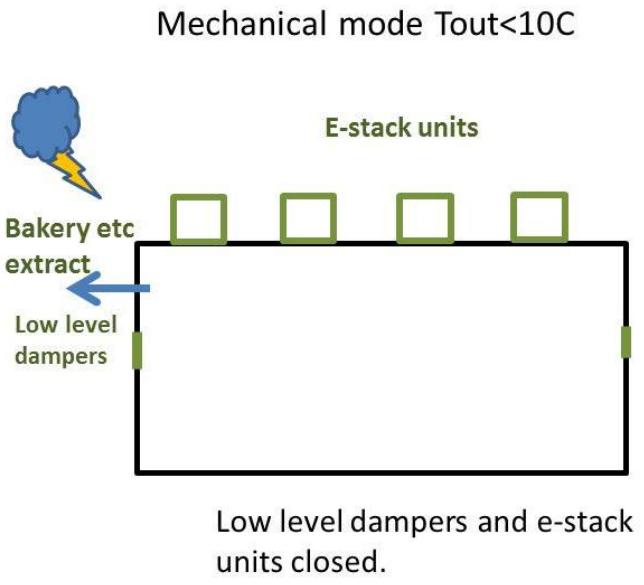

Figure 3.4 Langley Mill Winter Mode

The system installed is represented in figure 3.5 below.

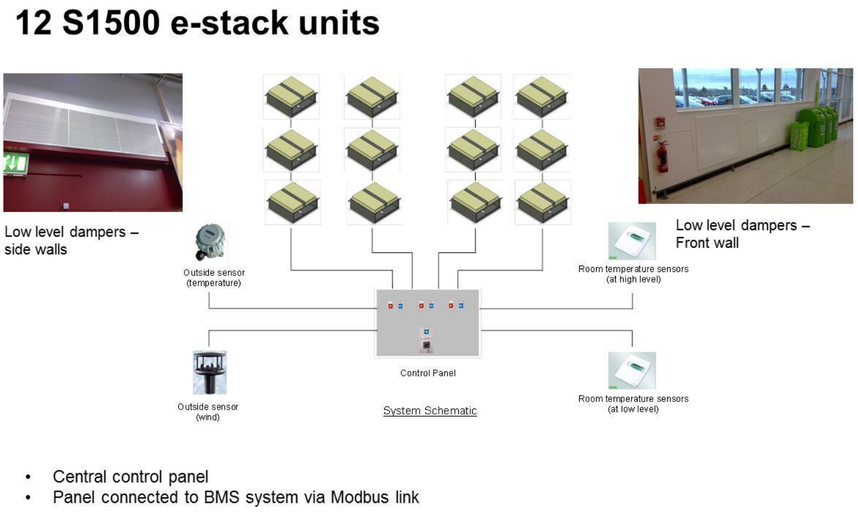

Figure 3.5 Breathing Buildings natural ventilation system

The typical arrangement of the e-stack roof based units is shown in the photograph of figure 3.6.

Figure 3.6 Langley Mill interior

One of the key concerns from the business in adopting the natural ventilation system was whether the internal temperatures would be satisfactory in summer. The results have been extremely positive.

As indicated in the graph of Figure 3.7, which shows the external temperature and a number of measurements inside the store, the internal temperatures were kept well below the peak outside levels. On a 30C day, the internal temperature was reading 23C; the 7C differential cooler interior was extremely pleasing, and cooler than the reference mechanically ventilated store.

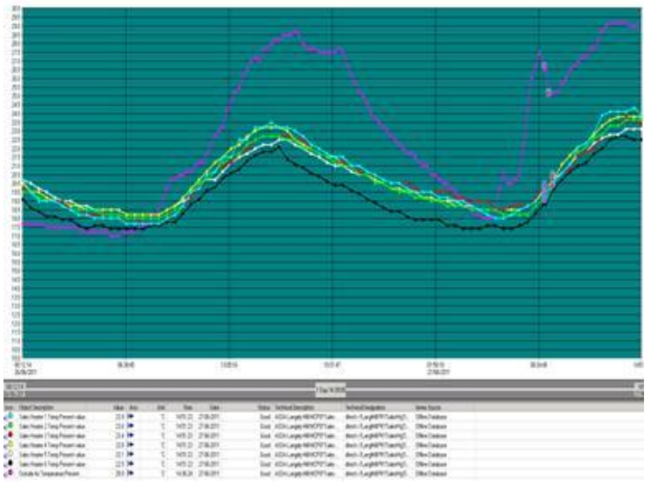

Figure 3.7 Temperature Graph over 2 days; dark blue line shows external temperature, green and light blue lines interior temperature measurements

The sales floor lighting installation is controlled using a 1-10V analogue dimming control system, with an integral DESIGO'PX' controller. The sales floor lighting installation is controlled by four photocells. Three photocells control the left hand section, right hand section and centre section of the 2 rows of lighting above the checkouts. The fourth controls the remaining sales floor lighting.

The DESIGO controller is pre-programmed with standard time schedules for 24 hour and non 24 hour stores. The control system monitors the status of the lighting installation and can be interrogated remotely by the AIMS bureau.

The lighting installation in the cash office, bakery, admin, customer and colleagues areas is controlled by a system of network movement detectors. If no movement is detected the luminaires will be switched off. When movement is detected all lighting will be controlled 'ON'

The lighting installation within the deli is controlled by the sales floor lighting installation, based on preset time schedules.

The lighting installation within the warehouse area is controlled by a system of networked movement detectors. If no movement is detected after 10 minutes the lights are dimmed to 30%. After a further 'timed' period of no movement (10 minutes) all luminaires will be controlled 'OFF'. When movement is detected all luminaires will be controlled 'ON'.

The Refrigeration in store comprises both chilled HT cases and Frozen LT cases on the sales floor. In the back of house areas chilled and frozen food cold rooms are provided. The cases are serviced by Refrigeration condensers and packs that are located within the rooftop plant area.

Electrical sub-metering is provided and logged via EnergyICT which is also configured with virtual meters that are sub-totals of some of the actual meters, to enable a review of subsets of the overall systems within the building. The store has 1 gas sub-meter that serves the DHW and warehouse heating and this produces a virtual meter for gas use on the sales floor. However, the gas sub-meter is no longer maintained and therefore the accuracy of its readings, and therefore of those for the virtual meter, cannot be guaranteed. And in fact they are no longer included in the energy models of the store. Given the focus of the BPE study on natural ventilation in the sales floor area, the absence of the gas sub-meter data (and virtual sub-meter for gas use in the sales area) is somewhat unfortunate.

3.2 Conclusions and key findings for this section

The ventilation system used in the sales floor is the first time a Breathing Buildings e-stack natural ventilation system has been used in a supermarket. The integration of the system with the mechanical ventilation system was completed successfully, but a number of lessons were learned in the process, including:

- Location of external temperature sensor needed to be changed from roof level to north façade to improve accuracy
- Low level dampers provided by contractor were found to jam with the grille screws, and it is now recommended that low level dampers should be provided with integrated louvres and grilles
- No feedback signal was initially available to check whether the burners and fans were operational and to enable the reset of heaters remotely in case of any fault. It is now recommended that a feedback signal should be provided with remote resetting functionality if these heaters are used again
- A reasonably high degree of vertical temperature stratification was observed when the e-stack units were not operating, and the system was changed so that the de-stratification fans could be used to aid mixing when the store is in mechanical ventilation mode

- The BMS integration was challenging. All changes need to be carefully monitored by all parties when they are made with a new system to check for unforeseen component issues

- The carbon savings, which we believe are largely attributed to the installation of the system, were approximately 1.4%. However, the direct electrical energy savings from reduced HVAC and refrigeration load which have been achieved as a result of the natural ventilation system are much greater as reported in Section 6

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4 Key findings from occupant survey

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

4.1 Occupant survey details

The occupant survey at Asda Langley Mill was conducted over the course of two days, 5 and 6 November 2012. 171 forms were handed out to Asda colleagues and 133 were collected. The results of the survey are compared with other buildings in order to help assess the relative performance of the store. The survey analysis and comparison method has been developed by Arup. There are two key graphs types used in the survey in addition to the compilation of comments.

4.2 Conclusions and key findings for this section

The survey examined many different parameters including thermal comfort, noise, lighting, control, air quality, as well as others. The detailed results of the survey are attached to this final report, which uses figures of the type illustrated in figures 4.1 and 4.2. In this final report, we draw out a few high level findings.

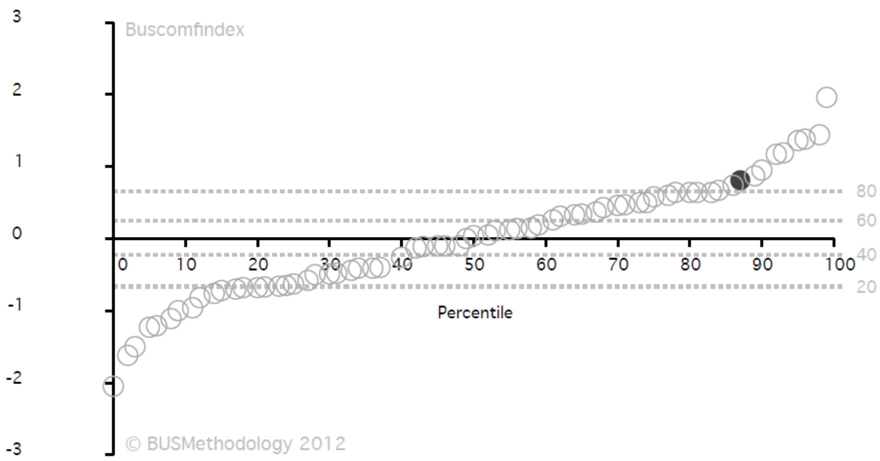


Figure 4.1: Survey comfort index

Figure 4.1 shows the overall comfort index for the building compared with other buildings. It shows that overall the building performs extremely well. It lies within the top 15% of buildings for overall thermal comfort.

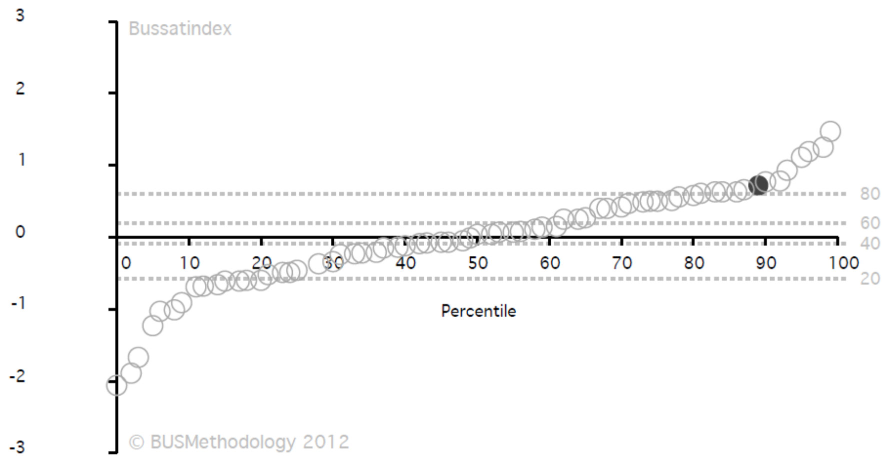


Figure 4.2: Survey satisfaction index

Figure 4.2 shows the overall satisfaction index for the building compared with other buildings. It shows that overall the occupants are very satisfied with the building. The building is ranked within the top 11%.

Finally, in terms of overall performance the survey generates an overall summary. This captures all of the parameters assessed in the survey.

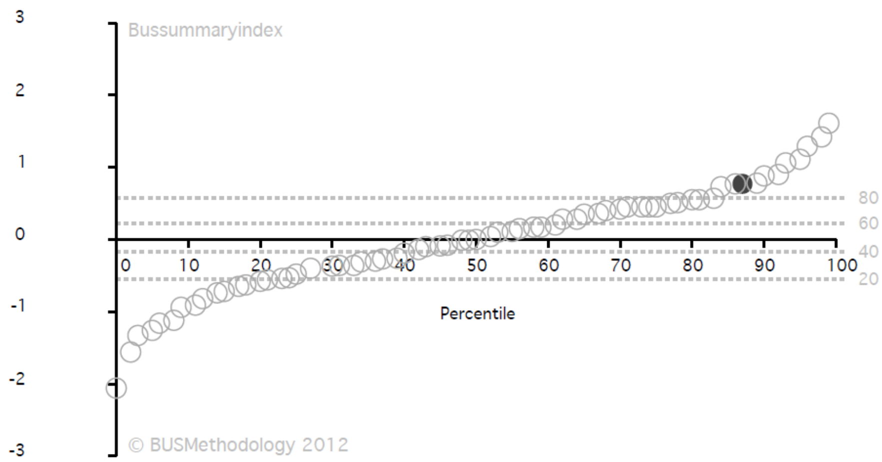


Figure 4.3: Survey summary index

Figure 4.3 shows the building performs very well compared with other buildings. It shows that the building is ranked within the top 12%.

There are a number of areas where the building performs exceptionally well, such as temperature conditions in summer, air quality and the overall image of the store for customers. The one area which was highlighted as being relatively negative was the temperature in the store in winter. It was felt that the store is too cold in colder weather, even though the store was generally kept within the set points for Asda stores. This overall result was not a surprise as issues with the heaters had been experienced prior to the survey but these have since been rectified. The full report is included in the Appendices accompanying this report.

5 Details of aftercare, operation, maintenance & management

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

5.1 Maintenance Service Summary

City FM work in Partnership with Asda to provide a fully comprehensive cleaning and maintenance service. The majority of services, including HVAC, are provided by dedicated in-house resource. Only specialist functions are sub-contracted out such as BMS maintenance or sub-metering maintenance.

5.2 Operations

The HVAC system at Langley Mill is controlled by a Siemens PX fully integrated Building Management System. Major plant is connected to controllers. These controllers carry out some or both of the functions:

- Control how the plant runs
- Act as a time and temperature controller with the plant's internal systems controlling how the plant responds to given environment conditions both internal and external.

The controllers also allow for equipment alarms to be viewed.

The controllers are networked to a BMS front end that collates all the alarms and sensor information generated by the internal control systems of the various items of plant. The front end is connected to an ADSL router which sends this alarm data over the City Engineering Network to the Desigo servers at BAS who are sub-contracted to provide this service.

Local access to plant can be facilitated via the City in-store PC requiring a username and password to view the plant via the graphical user interface on Desigo servers. Plant can also be accessed directly via the PX front end. This is also password protected to prevent changes to equipment set points and time schedules but does allow temporary overrides for maintenance purposes.

5.3 HVAC Maintenance

The City FM HVAC Team is responsible for delivering a comprehensive planned and a reactive service to maintain and repair a wide range of plant and equipment within the HVAC Discipline across the entire Asda estate. The team also provides an emergency out-of-hours callout service for dealing with trade critical and safety issues. The Current structure is as follows:

- National HVAC Manager
- HVAC Supervisors – 6 (1 per Division)
- HVAC Technicians – 45
- SST (Service Support Technicians)
- National HVAC Compliance Manager

Several tasks require specific competencies and must be carried out in accordance with statutory requirements i.e. gas appliance and installation safety inspections and servicing. HVAC Technicians are all 'Gas Safe' registered to deliver servicing and reactive cover for emergencies such as reported gas escapes. The principal industry related legislation is Gas Safety (Installation & Use) Regulations 1998.

Planned Process

Delivery of PPMs is planned by the National HVAC Manager and HVAC Supervisors. The issue of PPM jobs is administered by the Asset/PPM Team in City FM's Glasgow Helpdesk. Responsibility for PPM delivery in each geographical Division lies with the HVAC Supervisors and the tasks are performed by HVAC Technicians.

Langley Mill PPM Frequency

- HVAC Service PPMs - 6 monthly
- Gas Statutory PPM - Annual
- Tightness Testing PPM - 5 yearly
- BMS PPM – 2 yearly

Reactive Process

Reactive calls are primary generated by alarm signals from the store BMS into the Technical Bureau where remote investigation and triaging takes place. The investigation process includes resolving issues by remote fix or taking action to support store comfort conditions whilst engineer attendance is arranged on a prioritised basis. This minimises store impact with an aim that the fault is not noticed by customers or colleagues. Reactive calls are also generated by Asda store colleagues, by HVAC Technicians finding faults/defects.

All calls are then allocated to the In Store Technician (a dedicated multi-skilled engineer) for first look during Normal hours, or to HVAC Technicians outside of Normal hours. The IST will facilitate any simple repairs or resets as appropriate or escalate to the HVAC Technician.

Energy management

Reactive calls can also be raised by the City FM Energy Bureau. Utilising the sub-metering and main utility meter data through an energy management platform together with remote visibility via the BMS, the Bureau are able to identify the causes for stores that fall outside the agreed specification. The Bureau can make a remote fix or dedicate a local engineer to take remedial action. All work is tracked and when shown as complete, verified using the sub-metered data to ensure consumption has returned to expected levels.

The meters themselves are maintained to ensure a high degree of data integrity. Exception reports are generated for meters that do not post data for 5 days triggering an investigation and site visit where appropriate.

The provision of a dedicated vertically integrated energy management and maintenance function means that any local saving opportunity can be trialled and rolled out across the estate. Additionally as the entire estate is networked global changes to set points and time schedules can be facilitated over the whole chain simultaneously.

Generally sub metered data is reviewed and provides target areas for opportunities to reduce energy. The store managers are provided a dashboard report which highlights to them where the energy is being used and where they can target. This area is under review at the moment on how we can efficiently utilise Big Data. Specifically at LM, the Submeters have only been used as an information tool and not to drive further innovation.

5.4 Conclusions and key findings for this section

The key finding for this store, from a maintenance perspective, was access to the unit fire heaters for maintenance purposes. The requirement for a MEWP on the sales floor during the working day is not ideal and Asda changed the design for second generation naturally ventilated stores.

In comparison with the standard model, over the two year monitoring period the Langley Mill store had 52 reactive call outs compared with 41 at Keighley. However, this was due in part to three issues causing multiple jobs to be raised:

- Direction or airflow from a unit heater causing temperatures in a refrigerated case to be affected
- Noise being generated from a unit heater
- Impact of unit heater control failure when the control software was updated to allow for CO2 control

City FM also track the internal temperature performance of the stores across the estate producing a “hot” or “cold” store exception report which gives senior Asda management a summary of stores operating outside the 19 to 24°C set points. Langley Mill featured once in the cold store report due to a sensor fault causing the system to report the store below set point. In reality the temperature control of the store during a period where we have experienced extremes of both hot and cold has been excellent. The store was kept to below the 24°C set point for 98% of the monitored period.

6 Energy use by source

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

6.1 Energy use

The store's energy and emissions performance has been studied using a spreadsheet-based software programme in accordance with the CIBSE TM22 publication entitled 'Energy assessment and reporting method'. This spreadsheet is attached to this report.

The Keighley store is a standard model store used by Asda and of a similar size to Langley Mill and was selected to be used as a benchmark. Hence, within the 'Building and metering data' section of TM22 the 'User specified benchmark data' is that of Keighley normalised to a per m2 basis. DEC's were not available at the stores and so 'raw' CIBSE TM46 'Energy Benchmarks' have also been included as a further comparator. These were also generated on a per square metre basis, based upon building general and specific type floor areas.

The scope of the BPE is primarily to assess energy use and thermal comfort and air quality at Langley Mill vs. comparator facilities, including the performance of the natural ventilation system installed at Langley Mill.

With the timing of the study being after commencement of beneficial operation within the facility, it was not possible to accord with the time sequence of design / in-use / improved on which TM22 is based. However, the process was followed, albeit belatedly, in that 'design' data has been retrospectively loaded. 'In-use' figures are actual values covering the period 1 October 2012 to 30 September 2013 and the 'improved' section has been populated by revising consumption figures within targeted sub-metered groups.

Generally sub metered data is reviewed and provides target areas for opportunities to reduce energy. The store managers are provided a dashboard report which highlights to them where the energy is being used and where they can target.

The Asda Energy Bureau actions reports identifying where energy loads unexpectedly increase. This achieves a saving of circa £2m per year through avoiding increased energy usage. Specifically meters are alarmed to highlight the following:-

- Week on week movement main meter

- Lighting weekly report to identify where night reductions fail

- Lighting dimming report to identify where day time reductions aren't seen (dimming stores only)

- Bakery report identifying night baking

- Tolerance reports on refrigeration, lighting, HVAC, bakery & main identifying where usage falls out of baseline (previous trend & weather normalisation)

The Energy Dashboards & Store Management Information (MI) focuses on variance to plan and indicators. Indicators are areas of the store colleagues control directly:

- Night baking

- Chilled & frozen door open hours

- Night blind usage (chilled cases on non 24 hour stores)

Specifically Asda target 90% of load being sub metered, however this still includes some metering that covers a number of different energy uses. This whole area is currently under review in terms of establishing whether we are getting the benefit from all the data we are collecting; this includes linking metering with environmental conditions and alarms on plant. In some areas of the store we are now trialling circuit level metering in counters, prep & bakery areas where the colleagues control all of the equipment (not remotely). This enables us to investigate and provide reports on each item of equipment, on/off hours and any over night usage.

Outside the current review in terms of the amount and type of data being collected our key learnings are:-

- Need to be maintained

- Only valuable if you use them

- Good robust & meaningful reporting/MI

- Reporting needs to drive action

6.2 The Building

Langley Mill building type is a large food store, with Gross Floor Areas (GFA) of: Sales Floor 3675 m2; restaurants, BOH, offices 835 m2; Bakery, Deli, Photoshop 394 m2; Warehouse 1159 m2; Cold Rooms 230 m2 – producing a total GFA of 6293m2. The facility opened in late 2010 and is fully occupied, with little unconditioned area.

The main activities undertaken within the facility are the storage, preparation and sales of food and non-food goods. In addition there are administrative offices, EPOS / server facilities, a large cooled and refrigerated offer, restaurants, lifts, electrical products displays and an in-store bakery. The core hours of operation are 8.00 – 23.00 hrs; a certain amount of restocking occurs outside of core hours.

The Keighley store was opened in mid-2009.

6.3 Simple Assessment of the Annual Energy Use

- LM gas usage is circa 40% higher than the benchmark store at Keighley

- DHW and warehouse gas usage at LM over 12 month period is 100,500 kwhs
- DHW and warehouse gas usage at benchmark store in Keighley over 12 month period is 102,000 kwhs
- Sales floor gas usage at LM over 12 month period is 661,600 kwhs
- Sales floor gas usage at benchmark store Keighley over 12 month period is 406,000 kwhs
- Keighley has Heat reclaim installed which serves the DHW and Colleagues Air Handling Unit – however the larger gross footage at Keighley and the heating of the colleagues areas account for this reclaimed heat.
- The Gas usage on the DHW and warehouse heating at LM and Keighley are very similar. The additional Gas usage at LM when measured against our benchmark store is Keighley is accounted for in the sales floor heating.

Langley Mill annual energy summary (absolute values)

The total annual delivered energy for each energy type is as follows. There is an in-store bakery, whose energy usage is separately metered, which is a 'special energy use' as identified within TM46 and thus this energy is classified as 'separable'. Energy reclaimed from refrigeration rejected heat is identified below, in effect offsetting thermal (fossil fuel) consumption.

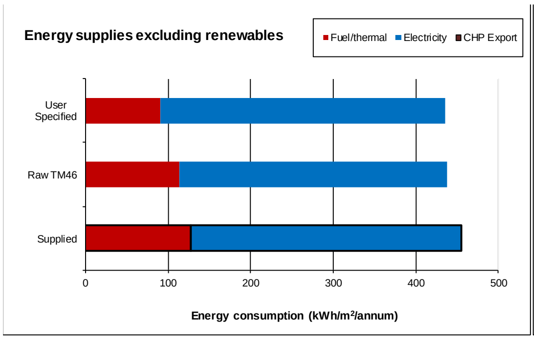
BUILDING ENERGY SUMMARY

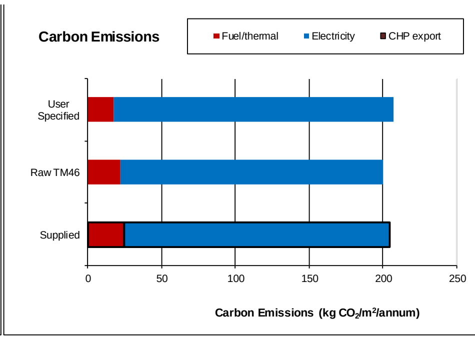
Energy, carbon and cost summary	Units	Electricity	Fuels	Thermal
Non renewable fuel or electricity supplied to site	kWh/annum	2,057,013	805,365	0
Separable energy uses	kWh/annum	167,913	0	0
Renewable energy used on site	kWh/annum	0	0	30,000
Renewable energy exported	kWh/annum	0	0	0
Output from CHP used in building	kWh/annum	0		0
Exported CHP	kWh/annum	0		0

Energy and Emissions – Basic assessment

Uncorrected 'basic' annual energy and emissions are given below. The 'supplied' and 'user specified' figures refer to Langley Mill and Keighley respectively.

Unit values	Energy supplied (kWh/m^2 GIA)		Carbon dioxide emissions (kg CO_2/m^2 GIA)		
	Fuel/thermal	Electricity	Fuel/thermal	Electricity	TOTAL
Supplied	128.0	326.9	24.8	179.8	204.6
Exported CHP	0.0		0.0		
Raw TM46	114.2	323.5	22.2	177.9	200.1
User Specified	91.0	345.0	17.7	189.8	207.4
Benchmark from DEC	0.0	0.0	0.0	0.0	0.0





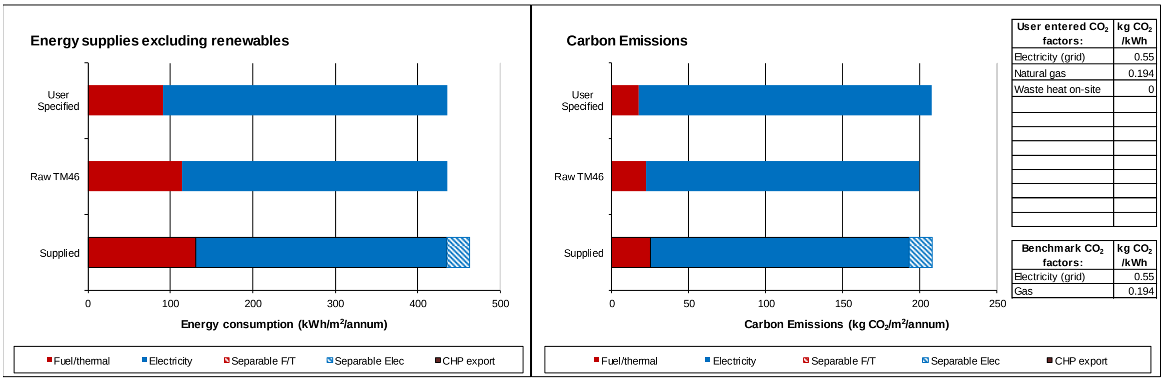
CO_2 factors used in assessment:	kg CO_2 /kWh
Electricity (grid)	0.55
Natural gas	0.194
Waste heat on-site	0

Benchmark CO_2 factors:	kg CO_2 /kWh
Electricity (grid)	0.55
Gas	0.194

Energy and Emissions – Accounting for 'separables'

The data in the table and chart below has been modified to separate-out energy expended within the Langley Mill in-store bakery. Note that no modification to the Keighley data is made, even though an in-store bakery exists there as well.

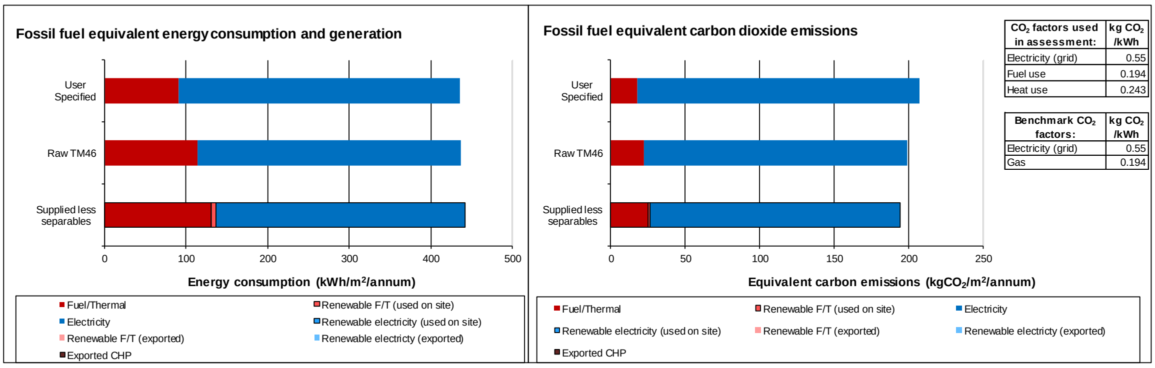
Unit values	Energy supplied (kWh/m^2TADA)		Carbon dioxide emissions ($kg\ CO_2/m^2$ TADA)		
	Fuel/thermal	Electricity	Fuel/thermal	Electricity	TOTAL
Separables	0.0	27.2	0.0	14.9	14.9
Supplied less separables	130.3	305.5	25.3	168.0	193.3
Raw TM46	114.4	322.1	22.2	177.2	199.3
User Specified	91.0	345.0	17.7	189.8	207.4
Exported CHP	0.0		0.0		
Benchmark from DEC	0.0	0.0	0.0	0.0	0.0



Energy and Emissions – Accounting for 'separables' and renewable energy use

The data below is modified further to account for renewable energy usage, as well as the Langley Mill in-store bakery separable energy usage.

Unit values	Fossil fuel equivalent energy (kWh/m^2TADA)		Fossil fuel equivalent CO2 ($kg\ CO_2/m^2$ TADA)		
	Fuel/thermal	Electricity	Fuel/thermal	Electricity	TOTAL
Supplied less separables	130.3	305.5	25.3	168.0	193.3
Renewables (used on site)	6.1	0.0	1.2	0.0	1.2
Renewables (exported)	0.0	0.0	0.0	0.0	0.0
Exported CHP	0.0		0.0		
Raw TM46	114.4	322.1	22.2	177.2	199.3
User Specified	91.0	345.0	17.7	189.8	207.4
Benchmark from DEC	0.0	0.0	0.0	0.0	0.0



Overall position

Overall emissions across Langley Mill, Keighley and the TM46 benchmark are remarkably similar. However, there is a more marked variation in terms of heating energy use. In summary the overall increase in heating energy stems from a high load imposed by fresh air. The flip side to this position is that electrical performance at Langley Mill is better than either of the comparators.

Langley Mill vs. Keighley

As both Langley Mill and Keighley have in-store bakeries, 'basic' data best compares like-with-like performance, which yields:

- Carbon dioxide emissions at Keighley (207.4 kg CO2/M2) are 1.4% above those at Langley Mill (204.6 kg CO2/M2)
- Electrical energy supplied at Keighley (345.0 kWh/m2) is 6% above that at Langley Mill (326.9 kWh/m2)
- Thermal energy supplied at Langley Mill (128.0 kWh/m2) is 40 % above that at Keighley (91.0 kWh/m2)

Langley Mill vs. TM46

As Langley Mill has an in-store bakery, data taking into account bakery 'separable' energy best compares like-with-like performance, which yields:

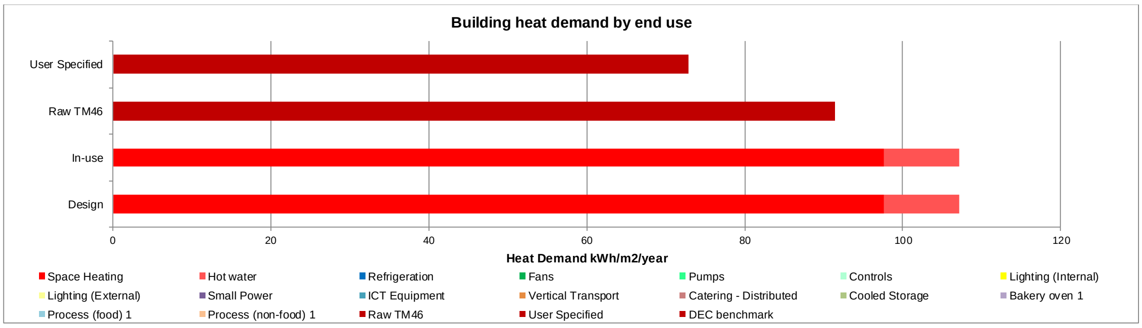
- TM46 carbon dioxide emissions (199.3 kg CO2/M2) are 3% above those at Langley Mill (193.3 kg CO2/M2)
- TM46 electrical energy supplied (322.1 kWh/m2) is 6% above that at Langley Mill (305.5 kWh/m2)
- Thermal energy supplied at Langley Mill (130.3 kWh/m2) is 14 % above TM46 (114.4 kWh/m2)

As overall energy performance across the three comparators is similar, the positioning of Langley Mill within the top 15% of buildings in terms of overall comfort following an occupant survey is most encouraging. Electrical energy performance is slightly better than the benchmarks. Further investigation is required to establish the detailed reasons for elevated thermal energy supply, which might include continued analysis of control performance in respect of Sales Area ventilation modes, fresh air volumes supplied and the operation of the gas-fired heaters.

6.4 Detailed Assessment of Energy Use

Fuel / Thermal Breakdown

End use of heat by fossil fuel fired plant is shown below, again illustrating that Langley Mill heating energy use is higher than that of TM46 and Keighley, thus warranting further investigation. The values in the table are 'end use of heat'. In order to convert back to fossil fuel input values utilised within the regular TM22 analysis, the values need to be divided by the conversion efficiency factor.



Electricity Breakdown

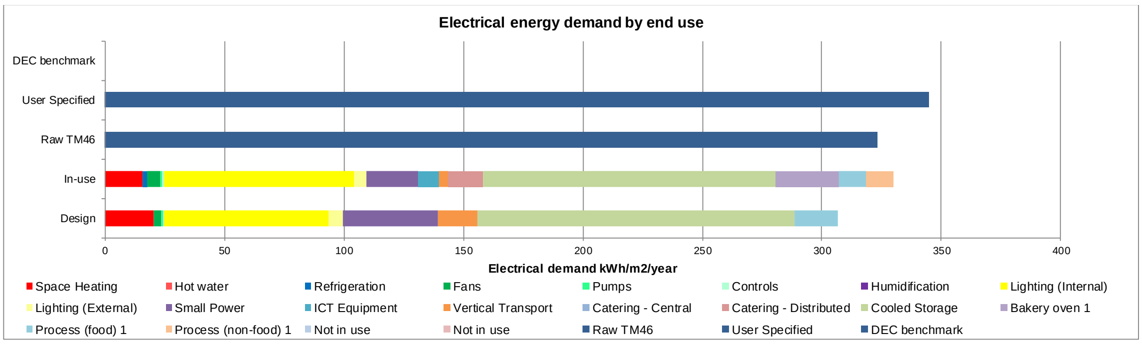
The electrical breakdown which follows depicts a breakdown of electrical demand by end use, compared with Keighley (user specified) and TM46. ISO 12 ECON 19 data is not depicted because the building's activities do not compare closely with that of offices; consequently a comparison of benchmark electrical end use sub-categories is not provided. It is observed that:

- 'Process' energy usage predominates. 37% of electrical energy is expended on cooled storage, 8% in the bakery, 7% in food preparation and display items, and 4% on distributed catering - in all accounting for 56% of the whole

- Of the 44% expended upon 'infrastructure', more than half of this is expended upon 'lighting'. This is not surprising, due in particular to high utilisation and illuminance (circa 700 Lux) required for product presentation within the expansive Sales Area. However, it is worth noting that there is extensive use of PIR's, photo cells, switching, lighting distribution, local task lighting and LED luminaires to limit consumption

- Total and splits of in-use electrical energy consumption compare well with the values included within section 11 'Metering, M&T Strategy' of the Langley Mill Building Log Book. For example 'estimated incoming fuel - electricity' is stated as being 880,000kW hr (44%) for infrastructure and 1,120,000 kW hr (56%) for process out of a total of 2,000,000 kW hr – these values compare extremely well with actual in-use values, as do targeted split electrical consumptions

- Electrical consumption per unit area at Langley Mill is a little lower than at Keighley and vis-à-vis TM46, and occupancy comfort is high. As a further pointer 'virtual meter' readings are available in respect of 'HVAC and chillers', which based on whole store GFA, yields electrical consumptions of 31.9 kW hr / m2 at Langley Mill and 34.7 kW hr / m2 at Keighley – i.e. better performance at Langley Mill



ENERGY DEMAND (kWh/m^2/year)

System	Description	Heat demand (kWh/m2/year) Design (kWh/m2/year)	Heat demand (kWh/m2/year) In-Use (kWh/m2/year)	Electricity demand (kWh/m2/year) Design electricity (kWh/m2/year)	Electricity demand (kWh/m2/year) In-use electricity (kWh/m2/year)	Additional metrics for electricity demand In-use electricity (kWh/year)	In-use % of total	In-Use Full load W/m2	System hours/year	Utilisation
Space Heating		97.6	97.6	20.4	15.8	99,338	4.8%	7.6	2,070	23.6%
Hot w ater		9.5	9.5	0.0	0.0	0	0.0%	0.0	0	0.0%
Refrigeration		0.0	0.0	0.0	1.9	11,826	0.6%	1.9	986	11.3%
Fans		0.0	0.0	3.1	5.3	33,586	1.6%	3.4	1,555	17.8%
Pumps		0.0	0.0	0.6	0.8	5,256	0.3%	0.5	1,643	18.8%
Controls		0.0	0.0	0.7	0.7	4,205	0.2%	0.1	5,256	60.0%
Lighting (Internal)		0.0	0.0	68.7	79.7	501,422	24.1%	19.8	4,031	46.0%
Lighting (External)		0.0	0.0	5.8	5.3	33,113	1.6%	1.9	2,759	31.5%
Small Pow er		0.0	0.0	39.9	21.7	136,656	6.6%	22.2	976	11.1%
ICT Equipment		0.0	0.0	0.0	8.4	52,560	2.5%	3.8	2,190	25.0%
Vertical Transport		0.0	0.0	16.7	4.0	25,229	1.2%	5.1	788	9.0%
Catering - Distributed		0.0	0.0	0.0	14.8	93,031	4.5%	8.9	1,661	19.0%
Cooled Storage		0.0	0.0	132.4	122.5	770,740	37.1%	48.9	2,502	28.6%
User 1	Bakery oven 1	0.0	0.0	0.0	26.3	165,564	8.0%	12.7	2,070	23.6%
User 2	Process (food) 1	0.0	0.0	18.4	11.3	70,956	3.4%	5.7	1,971	22.5%
User 3	Process (non-food) 1	0.0	0.0	0.0	11.7	73,584	3.5%	8.9	1,314	15.0%
Total		**107.1**	**107.1**	**306.8**	**330.1**	**2,077,066**	100.0%	**151.6**		
Metered building energy use			107.1		326.9	2,057,013				
Variance TM22 versus metered total			0.0		3.2	20,053		**Building GIA:**	6,293	
Variance TM22 versus metered total			0%		1%	1%				

Whole building benchmarks

	Energy demand (kWh/m^{2}GIA) Heat	Electricity
Raw TM46	91.4	323.5
User Specified	72.8	345.0
DEC benchmark	0.0	0.0

2005 Asda Benchmark

Carbon emissions at Langley Mill are 55% lower than the 2005 Asda benchmark. The target for the store in this respect was a reduction of 30%, and hence the performance is significantly better than the target.

6.5 Potential for Improvement

In view of the fact that the bulk of electrical consumption is in respect of ‘process’ and ‘lighting’, further potential improvements might be targeted in these areas. The ‘improved’ section of TM22 has accordingly been adjusted to reflect potential changes in these areas. This has been undertaken to ‘test’ the effect that this might have, and further feasibility studies would be require to establish if these might be feasible.

6.6 Conclusions and key findings

Overall emissions across Langley Mill, Keighley and the TM46 benchmark are remarkably similar, although Langley Mill emissions are below its comparators since its overall electrical performance is better. There is a marked variation in terms of thermal performance, the root cause of which would benefit from further analysis in order to identify how to improve this.

The overall performance of the natural ventilation is encouraging with electrical consumption per unit area being lower, occupancy comfort being high and ‘virtual meter’ readings pointing towards improved performance.

The relative proportions of electrical energy use of 56% for ‘Process’ and 44% for ‘Infrastructure compare very favourably with the values included within section 11 ‘Metering, M&T Strategy’ of the Langley Mill Building Log Book. The carbon use of Langley Mill is 55% lower than the 2005 Asda benchmark. The target for the store was a reduction of 30% and hence the store has performed significantly better than the target.

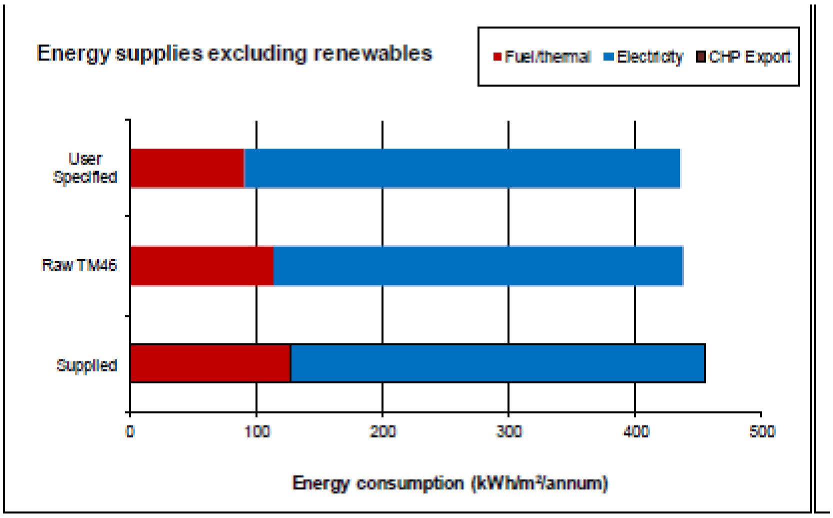
7 Technical Issues

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

7.1 HVAC system design

The Langley Mill project was the first Asda supermarket to adopt the Breathing Buildings natural ventilation system. This has operated successfully, but there have been major learnings.
The first is that the type of in-store heaters used as part of the overall HVAC system are not really well suited to the supermarket environment. The main challenge is that maintenance of them is very difficult during trading hours. A different kind of heating system would be preferred, with easier access for maintenance during trading hours.

The Thermal Energy supplied at Langley Mill (128kwh/m2) is 40% higher than the benchmark store at Keighley 91kwh/m2) which has generally been identified as being used to heat the sales floor. Some of the technical issues identified in section 7.2 have contributed to the higher gas usage, although, Year on Year improvement on Gas usage was not seen despite the learning's taken and changes implemented. However when lower external temperatures and colleague/customer comfort was considered the changes implemented have still been considered a success.



7.2 Conclusions and key findings for this section

The key findings of technical issues are as follows:

Item		Issue	Solution for Future Projects
1	External T reading	At times temperatures from external sensor were much higher than independent weather station readings. This caused the ventilation system to limit the ingress of fresh air (deemed to be hot) in summer to a minimum rather than maximising the air flow to aid cooling. Found to be because sensor had been incorrectly located.	Locate away from roof plant area/area of heat rejecting equipment
2	Sales floor Treading	The sales floor temperature sensor was indicating non-physical, low temperatures. This resulted in the heaters being turned on and gas used unnecessarily. This was found to be due to the cold surface temperature of the element on which the sensor was mounted.	Install insulated pattresses between sensor back box and building.
3	Draughts from mid and low level louvres	Draughts were experienced by colleagues near the mid-and low level dampers, even when they were supposedly closed. It was found that a) the dampers had been damaged during installation, with the dampers mounted on the louvres and b) that housings constructed after installation of dampers sealed poorly allowing leakage.	Provide fully insulated module comprising modulating damper and louvre to be installed complete.
4	Stratification	Temperature readings from various sensors showed that the store was stratified in winter mode, which meant that the heat generated via the heaters was not being delivered as effectively as it could to the occupied zone, resulting in higher gas use. Examination of the system showed that the modulating units were de-stratifying effectively due to varying fan speed.	Heaters to be installed with modulating burner only, fan to operate at 100% when in heating mode. This will de-stratify. Breathing Buildings lower fan unit to operate to assist with de-stratification.
5	Fresh Air input	Review of the supply fan use revealed that in mechanical supply mode 100% fresh air was being delivered even during periods of low extract demand. This is inefficient as the supply fan power was higher than necessary, and the heat input was also higher as all the input air is pre-heated.	Monitor the extract ventilation systems for current demand and operate the make-up air units between 50 and 100% accordingly.
6	Heaters Lock-out	Periods of cold temperatures on the sales floor in colder weather were experienced. Examination of the unit heaters showed that these were locking out and required manual re-set on the sales floor.	Change heater control to allow remote re-set if utilising heaters suspended in the sales. Utilise a ducted gas fired air heating system, the air handling units to be mounted remotely from the sales floor to allow access for servicing i.e. on the roof above.
7	BMS Interface	Analysis of the fan power and e-stack use at night and subsequent discussion at team meetings revealed that different mode descriptions and definitions of nightcooling had been used by BAS and Breathing Buildings. This was found to lead to potentially different set points in the different controllers for heating and ventilation, which in turn could lead to unnecessary heating, in particular during the nightcooling function in non-trading hours in the summer. For example, night cooling, night setback and non-trading all covered the same time periods but each definition was associated with a different function	BAS and Breathing Buildings agreed definitions of terms for future stores
8	BMS Interface	When the system was reset by Breathing Buildings, the BMS system was unable to restart properly. After extensive review this was found to be a result of a Firmware fault.	All changes to be monitored closely by all parties, and someone on-site, with new systems to check for unforeseen component faults

In terms of the technical issues experienced, the sources of the issues could generally be categorised into three areas:-

- Quality of Specification & Installation
- Commissioning and setup
- Service and Maintenance

The Langley Mill Project was a trial for Asda and the first store Asda had delivered with a fully Naturally Ventilated Sales floor. It was always envisaged that the store would not be handed over at Practical Completion and no further interventions would be required. This was a learning process in which the whole construction team were committed too and when opportunities were identified we would implement and take the learning's onto the next project.

Key examples under the above categories are:-

- Specification of the dampers in the walls were not close shut with neoprene seals to prevent draughts for occupants in close proximity
- Construction programmes were optimised to the minimum time, however the consequence of this is that the installations can still be under way right up to Practical Completion which compromises the ability to fully test, commission and set systems up
- The quality and usability of the O&M manuals are not in a user friendly format where the Maintenance Colleagues can easily focus in on an area they are unfamiliar with. Also with new technologies and bespoke systems, a Maintenance Colleague gains experience over time; if this colleague changes the learning process has to start again.

8 Key messages for the client, owner and occupier

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

8.1 Conclusion

The introduction of the Natural Ventilation to the Asda Store at Langley Mill was a new innovation to both Asda and the construction team. When introducing the new technologies such as Natural Ventilation all Stakeholders should be engaged from inception through to Practical Completion and end of defects period. When in a Pre Development/Planning stage the Architects should be engaging with Engineering Consultants, Contractors and Maintainers to ensure that the proposed schemes are not only simple to build but also operate and maintain. During the Design Phase the Consultants and Client should consider the impact of reducing specifications when reviewing proposed Value Engineered solutions. When in Construction there are a number of trades that are involved in the success of the Natural Ventilation system, such as; Specialist Manufacturer, Mechanical Contractor, Electrical Contractor, Specialist BMS supplier, Curtain Walling contractor, Roofing Contractor and the Design Team which includes the M&E, Architects and Structural Engineers. Time should be allowed for regular coordination meetings from as early in the Construction Phase as possible to avoid coordination issues.

Consideration should be given to the Engineering systems design and suitability for the environment in which it is to operate, for example, Langley Mill is a 24 hr store and there is limited time intervals available to get safe access to the Unit Heaters hanging on the Sales floor at high level. To access the heaters for reactive or planned maintenance a lifter or access platform is required, therefore a trading environment does not lend itself to a solution where high level access maybe required at short notice to maintain important things environmental conditions such as the heating and temperature level.

Where a number of controls systems are used such as on the Natural Ventilation system at Langley Mill, by which the Breathing Buildings system controls the Natural Ventilation but interfaces with the Siemens system which controls the heating and other Building Services, these systems should be tested at worktop level to ensure all protocols and terminologies are understood and work correctly.

An important part of introducing any new technology is allowing sufficient time within the Construction Phase to test and commission the systems under various different operating parameters to ensure any trials or monitoring post Practical Completion is from the correct baseline. If test and trials are planned post Practical Completion then this should be worked up in advance with the Pro's, Con's, measures and success's clearly defined, ensuring the metering and measuring tools are in place.

With any new technology it is extremely important that the correct level of training is given to the building users and maintenance company, also the O&M manuals clearly articulate the system requirements. The building user and maintainer must understand the underlying principles of the system, why it was chosen and what they are likely expect. In terms of the building user, these principle should be made as simple as possible; the principles of the Natural Ventilation system installed at Langley Mill are straight forward, however the control behind the system is complicated and these details do not need communicating to the building user.

This has been a valuable exercise and a Breathing Buildings e-stack natural ventilation system has been used on a subsequent store. There are benefits with a natural ventilation system, both in terms of thermal comfort and resulting occupant satisfaction, as well as energy and carbon savings.

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9 Wider lessons

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

9.1 Conclusion

In conclusion, whilst Asda expected a learning curve and changes to be made after occupation to fine tune systems and trial, with better planning for the unexpected from inception through to Practical Completion and post occupancy many of the issues that have been highlighted within the report could have been avoided.

Asda has taken the learning's highlighted in this report and implemented them on another new build project which was a success. The learnings have been shared with colleagues in Wal-mart headquarters in the USA with interest for stores outside of the UK.