CIBSE JOURNAL

The official magazine of the Chartered Institution of Building Services Engineers

April 2016
www.cibsejournal.com



# SEEKING PERFECTION

**Architype learns lessons from previous Passivhaus projects to scoop school prize**


**CAMBRIDGE FIRST**
Designers strive for university's high ideals at primary training school

**STIRLING EFFORT**
The performance services behind prize-winning Burntwood School

**SCHOOL AND EDUCATION** SPECIAL

# Learn by example

Congratulations to Architype and building services engineer E3 Consulting for another triumph at the CIBSE Building Performance Awards. They won Project of the Year: Public use with the Passivhaus-standard Wilkinson Primary School, just three years after the same design team lifted the trophy with another Passivhaus entry, Bushbury Hill School.

We do not apologise for featuring an Architype school project again (page 4) because it demonstrates just how important the feedback loop is when designing buildings. The architect's latest school incorporates lessons learned from five previous projects, resulting in a 70% cut in thermal-energy demand compared with the first school designed by the team.

Another award-winning educational building is Burntwood School, which won the Stirling Prize in 2015. The last school to be refurbished under the government's Building Schools for the Future scheme, it achieved a 20% reduction in its carbon emissions through passive measures and energy-efficient systems, including solar thermal and biomass (page 20).

With its groundbreaking circular form, no doors and a learning street instead of corridors, the University of Cambridge primary school is fused with the client's educational vision. The university wanted to incorporate teacher training and research aspects into the design of its training facility (page 16) and architect Marks Barfield created a building based on the principles of educationalist Alison Peacock. Its form was dictated by the aspiration for children to move freely between teaching and learning spaces, while sustainability remained at the core of the design.

On page 10, Shaun Fitzgerald outlines the elements to be added to Building Bulletin 101 – an essential document for anyone designing educational buildings.

**Liza Young, deputy editor**
lyoung@cibsejournal.com

## CONTENTS







CIBSE JOURNAL

Supplement

**www.cibsejournal.com**

**Editorial**
**Editor:** Alex Smith
**Tel:** 01223 378034
**Email:** asmith@cibsejournal.com
**Deputy editor:** Liza Young
**Tel:** 01223 378048
**Email:** lyoung@cibsejournal.com
**Designer:** James Baldwin
**Technical editor:** Tim Dwyer

**Advertisement sales**
**Sales manager:** Jim Folley
**Tel:** 020 7324 2786, jim.folley@redactive.co.uk
**Sales executive:** Darren Hale
**Tel:** 020 7880 6206, darren.hale@redactive.co.uk
**Sales executive:** Patrick Lynn
**Tel:** 020 7880 7614, patrick.lynn@redactive.co.uk
**Senior sales executive:** Paul Wade
**Tel:** 020 7880 6212
paul.wade@redactive.co.uk
**Advertising production:** Jane Easterman
**Tel:** 020 7880 6248
jane.easterman@redactive.co.uk

**For CIBSE**
**Journal production manager:** Nicola Hurley
Tel: 020 8772 3697, nhurley@cibse.org





*CIBSE Journal* is written and produced by CPL (Cambridge Publishers Ltd) Tel: +44 (0) 1223 378000. www.cpl.co.uk
1 Cambridge Technopark, Newmarket Road, Cambridge, CB5 8PB.

**Editorial copy deadline:** First day of the month preceding the publication month

**Printed by:** Warners Midlands PLC





CIBSE, 222 Balham High Road, London SW12 9BS
Tel: +44 (0) 20 8675 5211. www.cibse.org
©CIBSE Services Ltd. ISSN 1759-846X

**Subscription enquiries**

If you are not a CIBSE member but would like to receive *CIBSE Journal*, subscribe now! Costs are £80 (UK) and £100 (international). For subscription enquiries, and any change of address information, please contact Nicola Hurley at nhurley@cibse.org or telephone +44 (0)20 8772 3697. Individual copies are also available at a cost of £7 per copy plus postage.

The 2016 US annual subscription price is £100. Airfreight and mailing in the US by Air Business, C/O Worldnet Shipping NY Inc, C/O Air Business Ltd / 155-11 146th Street, Jamaica, New York, NY11434. Periodical postage pending at Jamaica NY 11431. US Postmaster: Send address changes to *CIBSE Journal*, C/O Air Business Ltd / 155-11 146th Street, Jamaica, New York, NY11434.

**Cover image: ©DennisGilbert/VIEW**

ABC audited circulation: 18,625 January to December 2015


Lessons learned from previous Passivhaus projects have earned Wilkinson Primary School energy reductions of around 90% compared with CIBSE benchmarks, plus a coveted CIBSE award. **Andy Pearson** reports

# A LESSON IN PASSIVHAUS

It should be no surprise that Wilkinson Primary School is an exemplar of sustainability; it incorporates lessons learned from five projects, two of which were Passivhaus-certified schools – including previous CIBSE winner Bushbury Hill School – and all of which have been designed by the same architect, building services engineer, structural engineer and landscape architect. They were also all built by the same contractor and specialist contractors, for the same client: Wolverhampton City Council.

This continuity has allowed the design and construction process to improve in iterations, resulting in a reduction in thermal energy demand in Wilkinson of almost 70% compared with the first school designed by the team (see Figure 1). This achievement was recognised at this year's CIBSE Building Performance Awards, where the school was named Project of the Year: Public Use.

This second-generation, 420-pupil school is located on the former iron works of John Wilkinson, a Black Country industrialist and the school's namesake. The new facility was needed after an arson attack in 2010 destroyed the previous school. Given its industrial heritage – and the more recent incineration – non-flammable corten steel was chosen as the primary cladding material. Beneath its rust-like appearance, Architype designed the school to comply with strict Passivhaus low-energy criteria.

The new, two-storey school has been built so that all of the rooms face either north or south, with the circulation and hub space in between. Key Stage 1 classrooms and a nursery are on the ground floor, and share the hall facilities and external soft-play areas. Key Stage 2 rooms are on the first floor.

The design team successfully argued that,

CIBSE BUILDING PERFORMANCE AWARDS 2016

WINNER

Entries for the CIBSE Building Performance Awards 2017 open on Monday 9 May. The deadline for entries is Thursday 15 September. Visit **www.cibse.org/bpa**

A carefully developed shading strategy prevents summer overheating

ALL PHOTOGRAPHY / ©DENNISGILBERT/VIEW

because UK schools have a higher density of children than German schools, the Passivhaus Institute should accept a higher internal gain factor for Wilkinson to optimise its design.

Fundamental to the success of Passivhaus design is a highly insulated, airtight building envelope. The optimised building envelope at Wilkinson builds on previous Passivhaus projects. 'We learned lessons about construction,' says Mark Lumley, associate director at Architype.

For example, in previous school designs, the first floor was supported on top of the ground-floor wall cassettes; the second floor was then built up from this deck. This made the airtightness line convoluted, because the airtightness membrane had to be wrapped around the floor cassette and taped to the oriented strand board (OSB) inner skin, which exposed it to potential damage and failure during construction. By working with the timber-frame suppliers, the architect has developed a solution, which enables the ground-floor wall to extend up past the first-floor structure, to ensure the OSB airtightness layer could remain continuous. 'We worked to simplify the construction,' says Lumley – and it worked. When it was tested, the school fabric air-leakage rate was just $0.66m^3 \cdot h^{-1} \cdot m^{-2}$ at 50Pa.

The airtight envelope meant that limiting heat gains through a carefully developed shading strategy was critical to prevent the school overheating in summer. The objective is to minimise solar gain in summer, without impacting on daylight levels in the rooms, or on winter solar gains, when temperatures are lower and the heat gains useful.

Using building simulation modelling, the team set out to control solar gains by increasing the roof overhang on the south-facing façade on the first floor. The school also includes a 'play canopy', formed of a translucent linear strip running the length of the southern façade and aligned with the highest window transom. This extends out over the playground to shade that area and its 15° pitch helps to reflect light up into the classrooms.

A reduction in the total glazed area has also helped the school maintain comfort conditions. Post-occupancy evaluation of the completed schools found that the Passivhaus buildings had to work hard to maintain

comfort conditions on warm autumn and spring days, when the angle of sunlight is lower. At Wilkinson, the amount of low-level glazing has been reduced to limit summer heat gains. 'We learned that we could reduce the amount of south-facing glazing,' says Lumley. High-level glazing has been retained, however, to ensure daylight can reach deep into the classrooms and that there is sufficient solar gain in the winter.

When there is insufficient daylight, artificial light is used. The lighting scheme includes daylight dimming in the areas adjacent to the windows to reduce energy demand further. In the circulation spaces, passive infrared sensors are used to ensure lights are not left on when the space has adequate daylight levels. The average power for lighting in the classrooms is $5.6W \cdot m^{-2}$, and $6.9W \cdot m^{-2}$ for the building overall.

## Ventilation

The school uses a mixed-mode mechanical ventilation strategy. In winter, the building is mechanically ventilated using a centralised ventilation system with heat recovery. Fresh air is ducted to the classrooms and exits, through acoustic transfer grilles, into the internal circulation spaces. Extract is through the hub toilets. 'The ventilation strategy chases the children round the school,' explains Hugh Griffiths, a partner at consulting engineers E3. 'The same air is drawn through from the classroom to the hub space; if the children are not in the classroom, they are likely to be in the hub space.'

A similar strategy is used to ventilate the school hall, which connects to the hub. A shunt fan – controlled by $CO_2$ levels in the

**The ventilation strategy chases the children round the school**

hall – draws fresh air from the hub and into the hall. Vitiated air passes back out to the hub through attenuated transfer grilles.

In summer, the school is, mostly, ventilated naturally, with air entering through open windows and exiting into the internal circulation spaces and hub through acoustic transfer grilles. The windows are opened by staff; however, the mechanical ventilation with heat recover (MVHR) runs year round, bypassing the heat exchanger in summer, to ensure fresh air levels are maintained even if teachers don't open the windows.

'What we've found is that running the supply fans in the summer removes any requirement to communicate to the staff that the ventilation is in summer mode, so they need to open windows,' explains Griffiths.

This emphasis on manual control is a change from the team's previous Passivhaus schemes, where window opening was controlled by the building management system (BMS). Post-occupancy evaluation showed that the most effective ventilation solution was for staff to regulate internal conditions. The classrooms' secure night vents are also dependent on being opened by staff. However, in the hall and circulation spaces, actuators are used to open and close the high-level windows under the control of the BMS – although staff can override this.

In the kitchen, there has been a major change to the control strategy, where the volume flow rate is controlled by the BMS based on kitchen temperature. Electric – not gas – induction hobs are used for cooking, which means the combustion make-up air requirement is reduced significantly, so the extract ventilation rate is much lower than for a standard kitchen. Heat generated in the space is also reduced, which improves comfort for the catering staff. 'They have the facility to boost the ventilation rates if necessary,' says Griffiths. This is a self-contained system; the kitchen extract incorporates a runaround coil heat recovery system that tempers the kitchen supply air.

## Hot water

Another innovation was the use of local electric heaters on the domestic hot water system. Radial microbore copper pipework, sized to suit the flow at the tap, connects the heater to the outlets. This keeps dead-leg volumes to a minimum and eliminates the need for electric trace heating or hot water return pipework. 'It significantly reduces domestic hot water heat losses,' says Griffiths.

Perhaps the most significant – and surprising – modification has been to the thermal performance of the external sprinkler pump house. At Oak Meadow and Bushbury Hill schools, the sprinkler pumps, their control gear and diesel fuel tank were

**Improving performance outcomes show how the project team is learning from past projects**

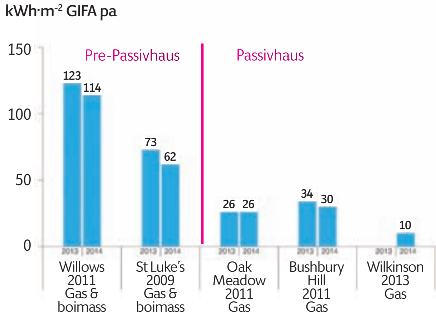



**Figure 1: Total thermal energy consumed for space heating and hot water in Architype's pre-Passivhaus and Passivhaus schools**

**Temperature monitoring**

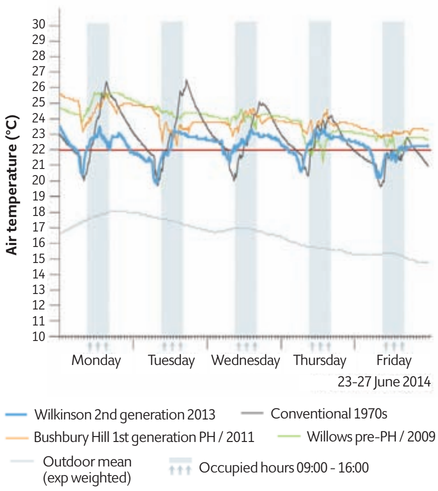



**Figure 2: Summer temperature during the same week in all studied schools**

**$CO_2$ monitoring**

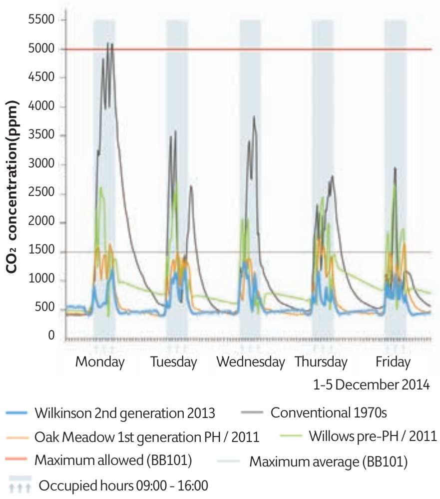



**Figure 3: $CO_2$ levels in the test classroom during the same week in winter. Wilkinson Primary remains consistently below 1,500ppm**

## Future features in CIBSE Journal

| | |
|---|---|
| May 2016 | Air conditioning, air movement & ventilation<br>**Commercial heating supplement** |
| June 2016 | Chillers<br>Air handling units<br>**BIM supplement** |
| July 2016 | Air conditioning<br>Fire and smoke design/management/ventilation |
| August 2016 | Heat pumps<br>Healthcare |
| September 2016 | Air conditioning, air movement & ventilation<br>Heat recovery systems |
| October 2016 | Pipework, pumps & valves<br>**Hotel & leisure facilities supplement** |

Editorial submission: Please send editorial proposals/ideas three months before publication date, eg, 1st May for August publication.

Send to: editor@cibsejournal.com.

The final editorial copy deadline is one month before publication date.

**For advertising opportunities contact:**
**Jim Folley – 020 7324 2786**
**or email jim.folley@redactive.co.uk**

housed in an industry-standard GRP pump house. To keep the temperature above the 10°C minimum for the diesel-powered pumps, the enclosure incorporated an electric thermostatic heater. 'As much heat was being used to heat the pump house as to heat the entire school,' says Lumley.

At Wilkinson, the architect designed a simple, well-insulated box to accommodate the pump and its associated kit. This was designed along Passivhaus lines, with a continuous insulation layer to prevent thermal bridges. It was airtight, too. The design was so successful that it has been retrofitted to the previous Passivhaus schools.

As part of the soft-landings process, the school has been monitored, season-tested and its systems tweaked over its two years of operation. It is not only meeting design conditions, but exceeding the performance of all the other (well-performing) schools in Architype's year-long monitoring study, and achieving energy reductions around 90% compared with CIBSE benchmarks.

Metered data shows the iterations have been successful; at a heat energy consumption of just 10kWh·m$^{-2}$, the school is more energy efficient than its predecessors and superior to a conventionally designed school. Carbon dioxide levels are maintained below the 1,500ppm limit, rarely peaking above 1,000ppm (see Figure 2) and summer temperatures have stayed within design limits, generally starting at 21°C at the start of the day and peaking below 23°C (see Figure 3).

According to Architype, the school's Passivhaus requirements 'incurred no additional design or construction costs' – a remarkable feat when you consider that Wilkinson is expected to save £40,000-£50,000 per year in energy and maintenance costs compared to a conventional school.

The rooms in the two-storey school face north or south

## PROJECT TEAM

- **Building services engineer:** E3 Consulting Engineers
- **Building owner:** Wolverhampton City Council
- **Project manager:** Carillion and The Local Education Partnership
- **Quantity surveyor:** Smith Thomas Consulting
- **Brief consultant:** Jacobs
- **Architect:** Architype
- **Interior designer:** Architype/ School
- **M&E engineer:** Coalway
- **Contractor:** Thomas Vale Construction
- **Landscape architect:** Coe Design
- **Structures and civil:** Price & Myers

# USING WINDOWS FOR CLASSROOM VENTILATION

High-level openable windows can provide useful ventilation for summer cooling, SE Controls' natural ventilation design manager, **Dr Chris Iddon**, explores accessibility requirements for window-opening mechanisms

For decades, windows have furnished the preferred – and sometimes the only – method of ventilating classrooms to ensure carbon dioxide, temperatures and pollutants can be vented and replenished by fresh air. There's no denying that the system works.

However, although this approach is simple, effective, widely used and ensures that students have a readily accessible supply of fresh air, the process of manually opening windows – like all ventilation methods – is not perfect.

This, in some respects, was supported by SE Controls' own studies into classroom air quality. These found that one of the main reasons why carbon dioxide levels exceeded the existing guidance significantly for prolonged periods, particularly during winter months, was that windows were not being opened because of inclement weather, to conserve heat or avoid draughts.

The Priority Schools Building Programme (PSBP), and the impending update to BB101, are changing the school building and refurbishment landscape, to ensure schools are energy efficient and well ventilated, but also provide excellent occupant comfort.

Hybrid and mixed-mode systems are now being used more widely in new-build school projects, as the individual benefits of fan-assisted and natural ventilation combine to offer a solution that is practical, economic, adaptable and controllable.

Windows, however, still remain an important part of the ventilation solution because they can supply greater airflow rates than fan-assisted systems, which are generally designed to meet indoor air quality (IAQ). Windows provide the capacity for purge ventilation required by Building Regulations Approved Document F – for example, to purge the odours from spillages – and for the greater flow rates required for cooling during the warmer, summer months, both during the day and as part of a night-purge strategy.

Because of design risk assessments, the opening of low-level windows is often restricted to prevent clash and fall risks. To create a sufficient openable area to deliver increased flow rates, high-level windows, which can be opened wider, are often used.

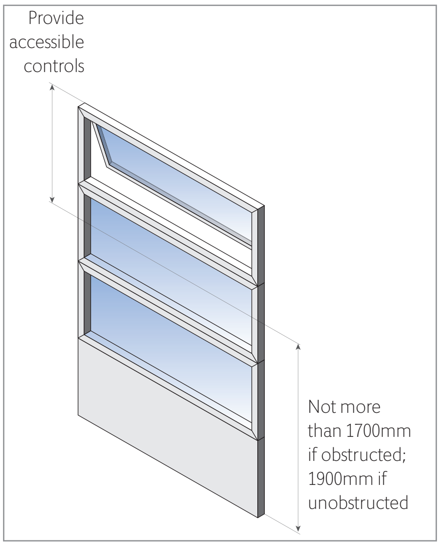



**Figure 1 - Building Regulations, safe opening and closing of windows**

## Ensuring openable windows comply with Building Regulations

High-level windows also promote cooling of the exposed thermal mass during night purging. Designers should be aware that Building Regulations Part K (Part N in Wales) stipulates that controls to open windows sited 1,900mm above floor level (AFL – or 1,700mm AFL if obstructed – should be accessible, as shown in Figure 1.

So ordinary window handles on such high-level vents do not meet building control requirements and alternative opening control methods should be considered. This applies not only to new-build, but also to any refurbishment projects incorporating the replacement of high-level openable windows.

At SE Controls, we offer a range of solutions for the operation of high-level windows, using push-button operated electrical actuators – either stand-alone or linked to automatic IAQ monitors, such as our NVLogiQ system – or via a manual winding mechanism. We can also give assistance to help designers specify the most appropriate solution.

Whichever method is used to open windows, they still present a simple, effective and economic route to air quality and temperature management, while ensuring the all-important ability to be controlled by occupants.

Ventilation is not just about ensuring that fresh air can enter a building, but also about enabling contaminants to be removed, or at least diluted, to improve overall air quality. Although there are numerous methods of improving air quality in schools and maintaining adequate ventilation levels, opening a window is one of the easiest and most accessible to us all.

● **DR CHRIS IDDON** CEng MCIBSE, natural ventilation design manager with SE Controls

# LEARNING IN COMFORT

Schools built under PSBP1 have benefited from improved ventilation design guidance that is now being incorporated into the revised Building Bulletin 101. **Shaun Fitzgerald**, of Breathing Buildings, outlines the origins of the Facilities Output Specification

Shortly after the coalition government formed in 2010, the Building Schools for the Future (BSF) programme was scrapped. We all remember the reasons given at the time – the cupboard was bare, there was simply no money left. Furthermore, it became apparent that the amount of money being spent on BSF schools, on a per square-metre basis, was rather more than our counterparts in the rest of Europe were achieving.

After the axing of BSF, there was much consternation among those in the Department for Education, as well as in the construction industry. To the government's credit, however, it did not stand still; a different procurement mechanism was devised and the Priority School Building Programme (PSBP) was launched in 2011.

This was established to invest more than £5bn between 2011 and 2015 to create new school places, and then £3.6bn of 'basic need' funding between 2015 and 2018, to help local authorities establish new school places they will need by September 2018. Most of the 260 schools included in PSBP1 have also benefited from enhancements to Building Bulletin (BB) 101: *Ventilation of school buildings* – additional design requirements laid out in the Facilities Output Specification (FOS).

It is interesting to ponder why the FOS was drawn up and why most of the 260 schools needed, then, to meet the requirements of both the FOS and BB101.

Several research projects had been undertaken on schools designed on the basis of BB101, and the Education Funding Agency (EFA) wanted lessons to be learned from these, and incorporated into the designs for new schools funded by PSBP.

With only limited time available to draw up the necessary documentation for the launch of PSBP, a complete rewrite of BB101 was not feasible, so it was decided to develop the FOS and have this as an additional requirement that PSBP-funded schools needed to meet. The plan was always to incorporate the new insights into BB101 when it was revised... and the time for that is now upon us.

So what are the new insights and changes that designers will need to factor into their designs? Broadly speaking, they can be categorised as follows:

- Summertime overheating criteria
- Air quality requirements

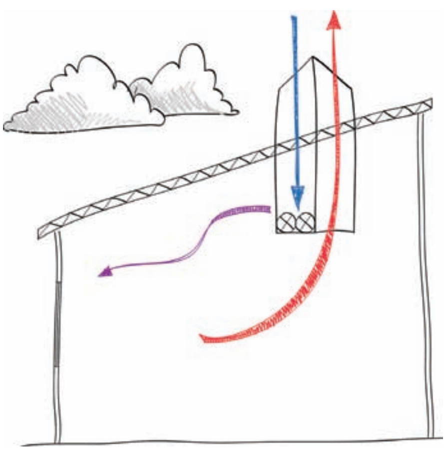


**Figure 1: Air must be pre-mixed with interior air before reaching occupants**

BIKERIDERLONDON / SHUTTERSTOCK

> The cold-draught solution used by many designers for natural ventilation – namely pre-heating the air with a radiator or a heating element in a low-level damper – has resulted in excessively high heating bills

- Limits on allowable draught levels
- Requirements for natural ventilation systems

## Summertime overheating criteria

In 2013, CIBSE launched TM52 *The Limits of Thermal Comfort: Avoiding Overheating in European Buildings*. This recommended adaptive thermal comfort as a more appropriate way to assess the likelihood of a building overheating.

The new regulations use a design methodology that is extremely similar; in fact, the approach to be followed – and the criteria to be met – are identical but for one small difference relating to the number of hours allowed for an exceedance level. The new approach is based on:

- acknowledgement that there are a number of ways to assess the degree to which a building may overheat so a number of criteria are used
- an appreciation of the fact that, as a heat wave develops over several days, people can respond to this – for instance, by dressing differently – especially when they have some control over their environment

Under Criterion 1 of CIBSE TM52, the number of hours allowed for an exceedance level is 3% of the occupied hours between May and September (see Figure 2) – whereas the level is greater in BB101, and has been set at 40 hours. This is because many schools are empty in the six-week summer holiday, so the design approach is to assume the school is occupied and to have more hours when Criterion 1 can be exceeded than in TM52.

## Air quality requirements

Research undertaken by various authors has shown that while some schools designed under BB101 guidelines have met the air quality targets, others have not. So the new regulations stipulate not only the daily average $CO_2$ levels that must be met, but also the maximum length of time that the $CO_2$ levels can be more than 500ppm above this.

It is acknowledged that naturally ventilated schools can be subjected to greater variations in air quality on a given day because of the dependency on wind and buoyancy to drive the flow – even if, on average over a year, the system can deliver the same or even better air quality than mechanical ventilation systems. So the new regulations have different levels depending on the type of ventilation system.

## Limits on allowable draught levels

Schools that are naturally ventilated, and which do not have pre-heating systems, have been shown to have problems with air quality in winter months. It has been found that, even if the systems are automatically controlled, they are turned off in winter. This is not surprising because the natural response from anyone subjected to a cold draught from a ventilation system is to turn it off, even if that means finding the isolation switch! Draughts, especially in colder weather, are simply unacceptable and people would rather put up with inadequate air quality.

The new regulations, therefore, include limits on the extent of cold draughts that are allowed. These limits depend on air temperature and speed of the air at occupied level, but also on sensitivity of the occupants. More onerous limits are applied to spaces with less-than-normal activity or in which people wear less clothing, for example.

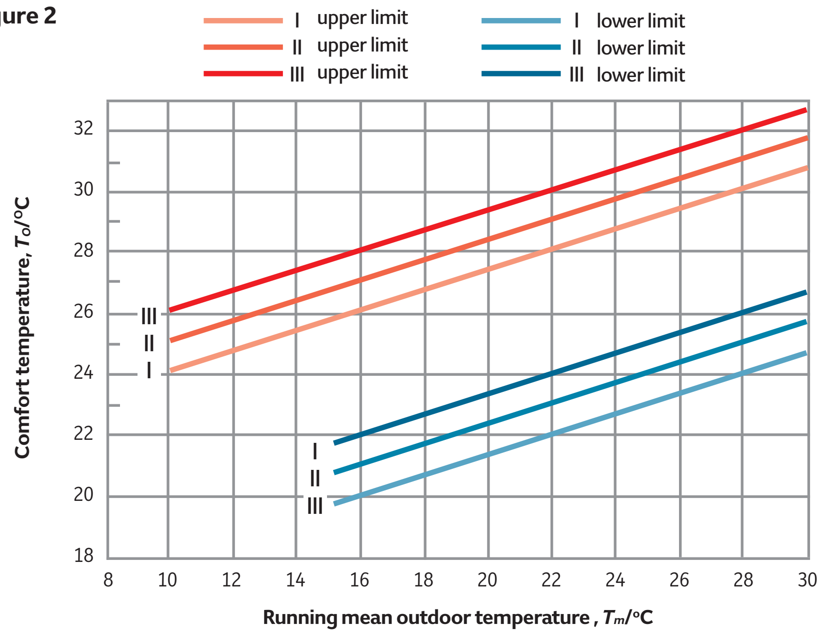
## Requirements for natural ventilation systems

One of the most significant research findings is that the cold-draught solution used by many designers for natural ventilation – namely, pre-heating the air with a radiator or a heating element in a low-level damper – has resulted in excessively high heating bills.

To make matters worse, the improvements in insulation levels have actually caused heating bills to rise in some cases. Although this may seem counterintuitive, it is simply a result of the fact that most modern schools have relatively high heat gains in the space, so need air to be moved through the space to cool it, especially if the air entering it has already been pre-heated.

Higher levels of insulation have resulted in greater volumes of air being needed for cooling, and this has meant heating bills for

**Figure 2**




**Categories:**
I = High level of expectation only used for spaces occupied by very sensitive and fragile persons. Range ± 2K PMV± 0.2
II = Normal expectation (for new buildings and renovations). Range ± 3K PMV± 0.5
III = A moderate expectation (used for existing buildings). Range ± 4K PMV± 0.7

**Limiting values for the operative temperature in buildings operating without mechanical cooling systems as a function of the exponentially-weighted running mean of the external temperature (CIBSE TM52, 2013)**


**Monkseaton High School uses the Breathing Buildings e-stack mixing system**

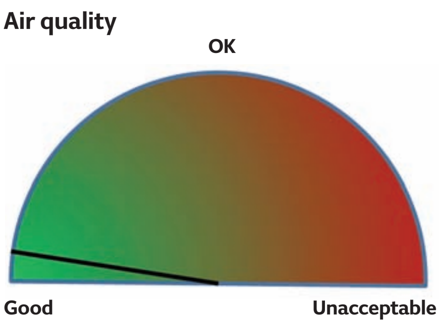
some buildings are two or three times more than expected.

The new regulations simply say that the designer must avoid cold draughts and excessive heating energy consumption in the heating season. With a natural ventilation scheme, the air must be sufficiently pre-mixed with the interior air before reaching the occupants (see Figure 1).

## The future

There is a growing need for more school places. In May 2015, the government announced it was investing an extra £2bn in rebuilding and refurbishing school buildings in the very worst condition, through phase 2 of PSBP. It will also provide £4.2bn between 2015 and 2018 through school condition funding allocations. The future of schools looks very promising – more investment, and improved guidance on design.

**SHAUN FITZGERALD** is chief executive officer at Breathing Buildings




**Air quality dial used in schools**

# Intelligent solutions for educational establishments

Medem is top-of-the class when it comes to gas safety and air quality monitoring and control. Our range of educational solutions for school laboratories, kitchens, boiler rooms and general teaching areas ensure safety in all locations, at all times.

we design it, we build it, we back it up

Medem's gas safety and environmental monitoring systems can be tailored to a school's requirements and are suitable for new build or refurbishment projects.

All Medem products are designed, built and individually tested in-house here in the UK to the very highest standards. All designs are independently tested and CE approved.

- Easy to use - panels give real time information
- Patented differential gas proving
- Failsafe valve and relay checking
- Full service and technical support
- Minimum 5 year warranty

We are rightly proud of our reputation for excellent products and great, friendly service. Call us today - we'd love to tell you more.

0161 233 0600

enquiries@medem.co.uk

Confidence built in 5 Year Warranty

Made by Medem

Certified ISO 9001

CIBSE CPD


medem
Production kitchen
SEC-K
Ventilation interlock
Gas proving
$CO_2$ monitoring
Boiler room
SEC-B
Gas proving
Gas detection
Auto restart
FA test mode
www.medem.co.uk

# LEARNING **WITHOUT** LIMITS

The UK's first university training primary school – built for the University of Cambridge – incorporates a groundbreaking design that has created a space where learning has no limits. **Liza Young** talks to the design team

With its circular plan, classrooms without doors and a 'learning street' in place of corridors, the design of the new University of Cambridge Primary School (UCPS) is synonymous with its educational vision.

Julia Barfield, principal at Marks Barfield Architects, described the building as democratic – also the school's pervading philosophy. The children's voices are listened to, so they also have a say in how – and where – they are taught. The learning street, which has breakout spaces, library areas and soft seats, can be used by the pupils if they wish to remove themselves from the classroom setting while studying.

A circular, one-storey building contains the classrooms, forming a central outdoor courtyard, in a nod to the Cambridge college courts. An adjoining two-storey structure houses the dining room, sports hall, offices and training facilities.

The form of the school influenced the design of the passive services strategy. Its classrooms are organised along the double-sided, shared learning street, where the high roof allows natural ventilation via the stack effect. A temporary oil-fired boiler is in use now, but will soon be connected to the district heating network currently being built. Rooftop PVs provide more than half of the building's electrical energy requirements.

The first primary to open as part of the government's flagship university training schools, UCPS is sponsored by the University of Cambridge, and explicitly focuses on research-based teaching and learning practice. With three forms per year – and a nursery – it will serve 3,000 new homes on the university's 150-hectare North West Cambridge Development. It will also be a base for its faculty of education research.

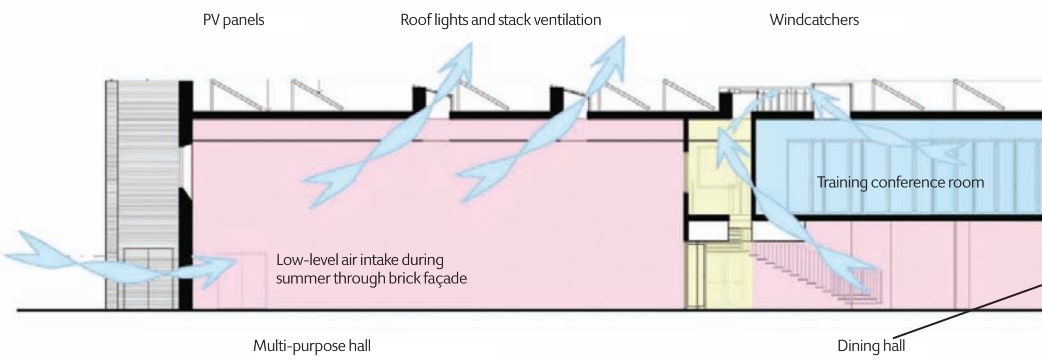
Barfield and her team kept an 'open mind' about how the design would fulfil the university's vision, visiting eight schools to establish what worked and what didn't.

Instead of rectangular classrooms, UCPS has irregular-shaped teaching rooms – with dedicated practical and quiet areas – that cater for varying group sizes. The 'Polo mint' form of the school means users can move around it more efficiently, and this has freed up space. As a result, the architects have been able to create a separate dining hall, where children and teachers eat together, so pupils can play sports in the main hall at lunchtimes.

Marks Barfield also worked closely with

## PROJECT TEAM

- **Client:** University of Cambridge
- **Architect:** Marks Barfield Architects
- **Landscape architect:** Colour UDL
- **Structural engineers:** URS, Parmarbrook M&E consulants: Briggs & Forester, Building Services Design, URS (now Aecom)
- **Quantity surveyor:** Gardiner & Theobald
- **Main contractor:** Willmott Dixon
- **Superviser:** Calford Seaden
- **Furniture:** Hampshire Council Architects




**Environmental section**

educational specialist Alison Peacock. Her book *Creating Learning Without Limits* focuses on teaching without grouping children by their test scores.

The £11m BREEAM Excellent school – completed in January – welcomed its first intake of 118 pupils last September, and will be fully occupied this autumn.

## Creating a community

The school is divided into three clusters, each with one class from every year group, creating a small-school atmosphere. Like building blocks, the classrooms fit together around the inner and outer rims of the structure, creating a central learning street (see diagrams, right).

Barfield was keen to ensure visual access throughout the open-plan building, so dozens of windows allow pupils to look past the limits of their classrooms into the courtyard or 'wildwood' beyond. The large windows allow high daylight factors, while solar gain is controlled by a glazed cloister with etchings – by artist Ruth Proctor – of sky photographs from points around the world. It also acts as a canopy for children playing outside, and an alternative route to class.

Barfield says: 'The fluidity of the space enables activities to spill out and become different types of learning. The pupils don't blink an eye when visitors walk around and look into the open classrooms, which – in a university training school – is fundamental to the design.'

## Renewables

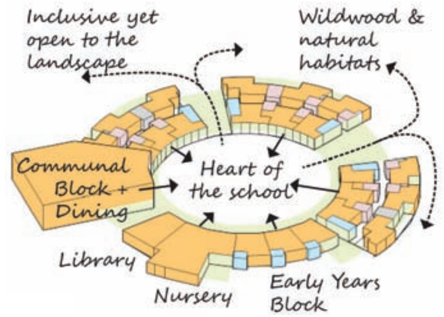
The south-facing portion of the roof and the two-storey element have been allocated to meet the requirement for 25% – more than 900m$^2$ – of the building footprint to be fitted with photovoltaic (PV) panels.

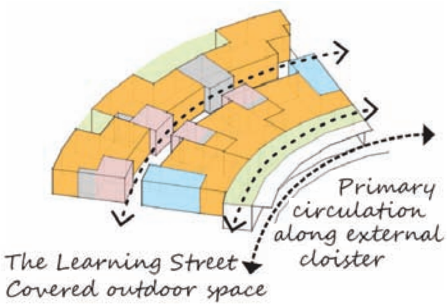
The array, comprising 514 panels, can generate up to 136 kilowatt peak (kWp), offsetting more than half of the estimated 258kWp demand for the building. Generally, what is generated onsite is used to back up the mechanical plant and the electrical demand, including lighting and equipment.

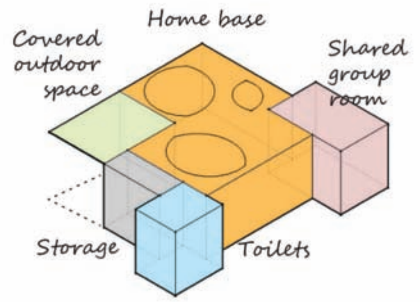
## Ventilation

The main drivers for the ventilation strategy were Building Bulletin 101 (BB101): *Ventilation of School Buildings*; BB93: *Acoustic Design of Schools*; and future-proofing up to 2050.

Under BB101, minimum flow rates of 3 L·s$^{-1}$ per person had to be achieved for all teaching and learning spaces, up to 8 L·s$^{-1}$ per person at occupied times.

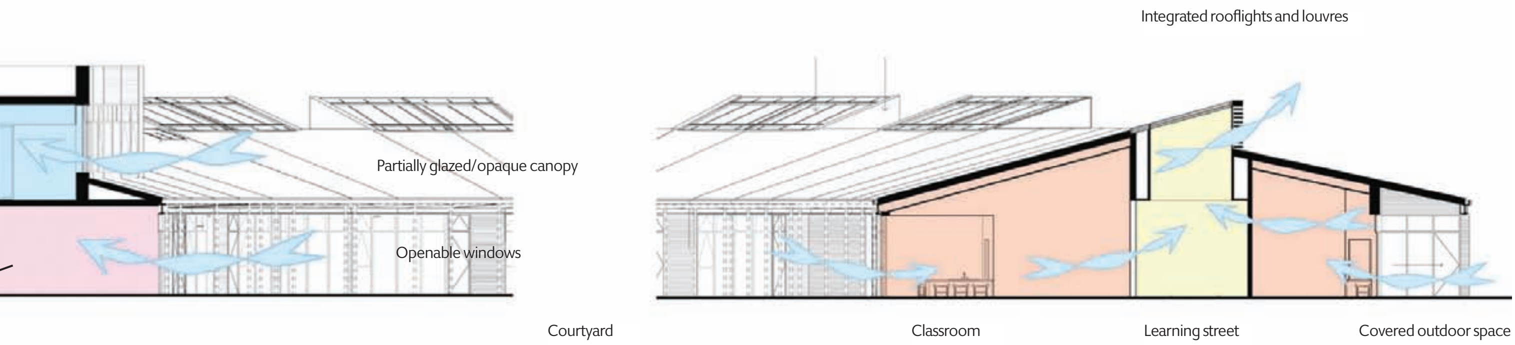


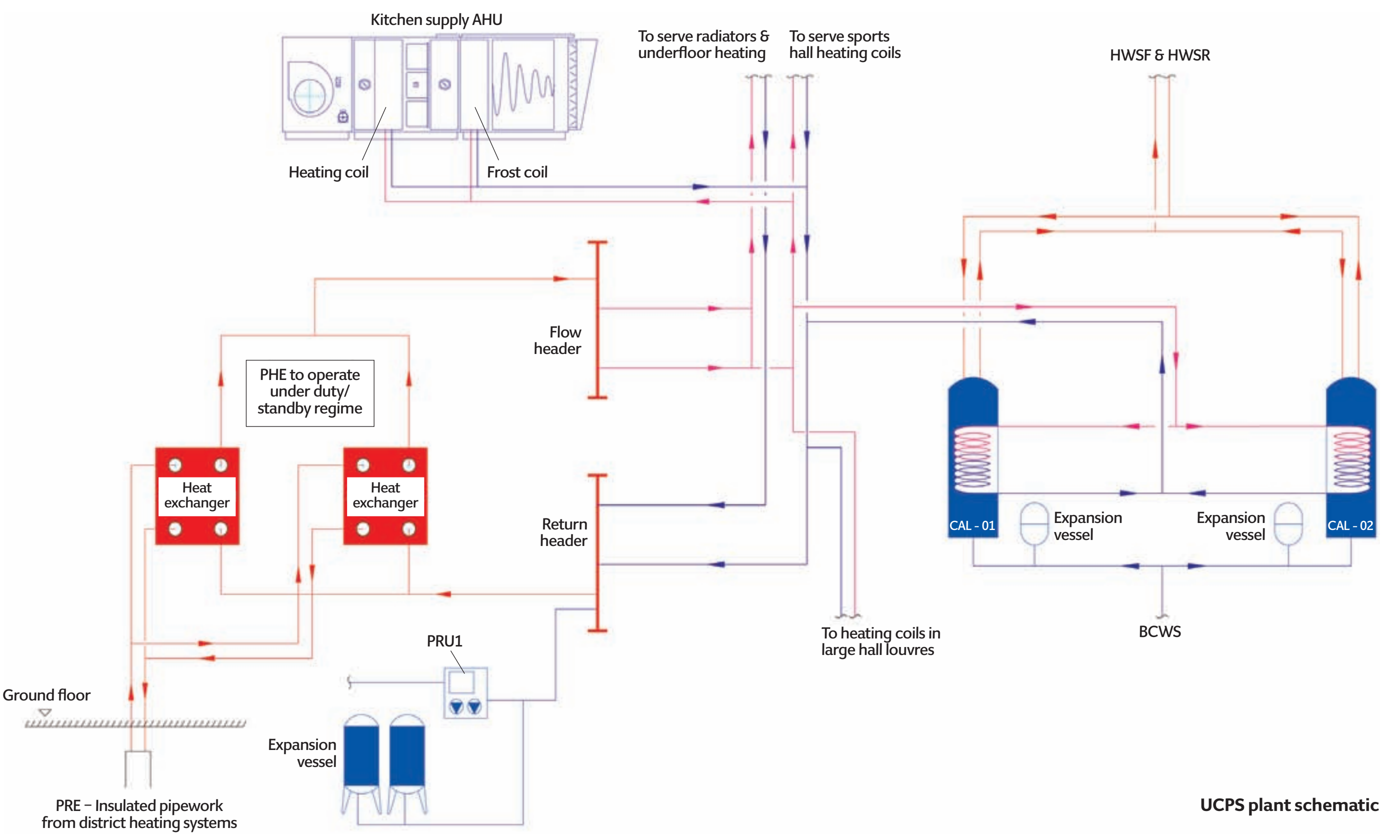



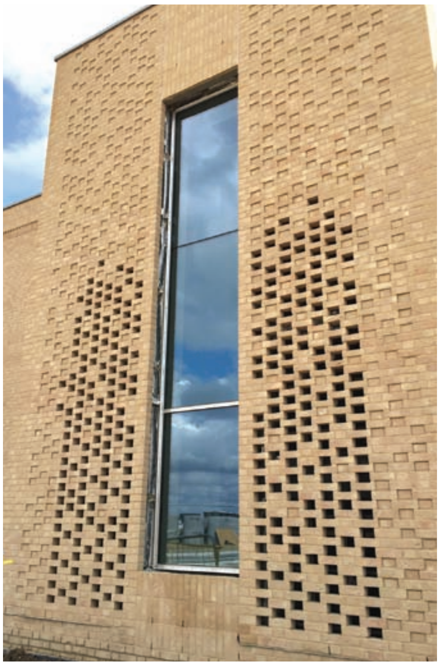

The high roof of the learning street allows natural ventilation via the stack effect, with air expelled through large louvres. In the classrooms, teachers can control their environment by opening both the side windows and the high-level louvres in the learning street to create a draught. A traffic-light system in each room helps staff and pupils understand when the room has low, medium or high levels of $CO_2$.

Principal design engineer at Briggs & Forrester, Sasan Dehghani, says: 'When people are in charge of something, they manage it






**UCPS plant schematic**



much better because they know they can change it, rather than being dictated to by the control on the wall.'

As well as current weather files, the building has been modelled against the mean predicted temperature for 2050 to combat future overheating. The learning street louvres have been oversized – and are partially blocked – so the ventilation strategy can remain viable when global temperatures rise.

Natural ventilation is achieved in the main hall through a chequerboard of bricks and voids on the school's western elevation (see image, left). This allows fresh air intake through integrated louvres with dampers, while the roof light draws warmer air up and out.

The louvre hidden within the brick façade mixes the inside air with incoming fresh air – getting it to within 4-5°C of the room temperature – to prevent draughts in winter.

After a computational fluid dynamics model identified potential cold spots, a coil was put inside the louvres to temper the air gently. This will ensure it is not too cold on a late – or winter – evening, when a parents' meeting might be held in the hall.

An automatic supply and extract air unit on the roof of the conference-room, within the same block, incorporates a small fan for when there isn't enough prevailing wind or movement to drive the flow – especially when the conference room is fully occupied.

## Heating and hot water

For space heating, Dehghani says the team wanted to use radiation and conduction, and hardly any convection, which generates circulation that could cause problems for people with asthma.

Underfloor heating is used throughout the school – apart from on the first floor, which has radiators. 'It works very well in buildings that are well insulated; once you warm the concrete mass, it maintains the heat, and only needs to be gently topped up every so often,' says Dehghani.

A thermostat in every classroom allows users to control the amount of hot water that is injected into the flow-and-return manifold, while time control is set by the Trend building management system (BMS).

The underfloor heating loop is a weather compensator, so the hot-water temperature inside the loop goes up or down depending on outside conditions.

Although currently supplied by temporary boiler plant, the low temperature hot water for both heating and primary hot water will eventually be delivered through the site-wide district heating network under construction.

Dehghani says the PVs, building insulation and extensive natural ventilation have all contributed to producing an efficient facility, with a building emission rate (BER) of $2.7kgCO_2 \cdot m^{-2} \cdot year^{-1}$ against the target emission rate (TER) of $18.4kgCO_2 \cdot m^{-2} \cdot year^{-1}$.

Its predicted energy consumption is calculated at 85.62kWh·m$^{-2}$, against the notional 109.85kWh·m$^{-2}$, while the fabric air-leakage rate is predicted to be 7.4m$^{3}$·h$^{-1}$·m$^{-2}$ at 50 Pa – very good, says Dehghani, for a building with so many openings.

## Acoustics and monitoring

The building is set back 10m from the street to stop pollutants getting into the ventilation system, and to reduce noise levels from the civic elevations of the communal block.

The open-plan arrangement of the school was also tested acoustically. Marks Barfield director Gemma Collins says: 'Because we don't have doors on the classrooms, it was not a quick, tick-box exercise – we had to go through a rigorous process of demonstrating that we have considered it.' Acoustic-absorbing material was put on the ceilings, and at high level in the classrooms and learning street, where it has the most impact.

Heena Mistry, Marks Barfield project architect, says the team hope to compare the school's performance against others through data monitoring and benchmarks. 'You can do a calculation to prove it is efficient, but we want to test that against actual data.'

The electrical and mechanical systems have ample metering, she adds, with data stored in the BMS for the client to look at, monthly or quarterly, to assess the systems' performance. A monitor near reception also displays the energy use to educate the children about what is happening in the building.

Barfield says education and architecture united on this project to create a flexible, open school, where every voice matters.

Learning street

# LOW-CARBON LEARNING

The Stirling Prize-winning redevelopment of Burntwood School modernised the campus while achieving a 20% reduction in its carbon emissions, says **Saud Muhsinovic**

Burntwood School, in south-west London, was the last in the government's Building Schools for the Future (BSF) scheme, under which UK secondary schools were rebuilt or refurbished to create modern learning environments. And it was certainly in need of refurbishment. The school was housed in four, 1950s four-storey blocks, including classrooms, a sports hall and a performing arts centre. These buildings had all the problems typical of the era, including an inefficient thermal envelope, uninsulated pipework and outdated services. Energy efficiency was very poor, with the impact on the school felt in eye-wateringly high energy bills.

In 2008, consultant Mott MacDonald was brought into the contractor-led design and build team for the £41m redevelopment. All existing buildings – apart from the sports centre and the assembly hall – were demolished, and six new teaching blocks were constructed.

A key part of the brief – set by clients Burntwood School and Wandsworth Council, and contractor Lend Lease – was that the new school should achieve a 20% cut in carbon emissions to meet Part L 2A 2010 targets. This was a substantial challenge, which was met through a combination of active and passive energy efficiency measures.

## Optimising design for passive reductions

Building new structures on the site meant the design team could make interventions to cut

### PROJECT TEAM

- **Clients:** Burntwood School, Wandsworth Council
- **Contractor:** Lend Lease
- **Architect:** Allford Hall Monaghan Morris
- **Structural engineer:** Buro Happold
- **M&E engineer:** Mott MacDonald
- **Landscape architect:** Kinnear Landscape Architects

**Burntwood School's old 1950s campus has been transformed**

**Exposed thermal mass in soffits allows night-time purging of heat**

energy demand. Maximising daylight in classrooms can reduce the amount of artificial lighting required. However, solar heat gain can mean more energy is needed for cooling systems. We optimised the design of the building envelope – playing with form, shape and orientation – to balance the two.

Windows are recessed into the building envelope by 600mm, allowing for sufficient daylight, while the deep reveals reduce direct sunshine on glazing by 23%. Using solar glass with a G-value of 0.37 further mitigated solar gain, cutting heat gain by an estimated 40%. This was done while optimising daylight availability – the light transmittance level is more than 65%, ensuring that most teaching spaces achieve an average daylight factor above 2.0%.

**Burntwood's light transmittance level is more than 65%**

The hybrid ventilation system combines active and passive elements. During the day, the system measures the temperature and $CO_2$ levels in each classroom, which informs the amount of heat and air pushed into each room. This system works with exposed thermal mass in soffits, allowing night-time purging of heat, storage of 'coolth', and ventilation with fresh outside air. For this to work, all concrete walls and ceilings are exposed, with no false ceilings or other obstructions to these processes.

Windows can also be opened for immediate ventilation or passive cooling. This was important for psychological reasons; we wanted building inhabitants to feel 'engaged' with the outside environment. During the heating season, heat from exhaust air is recovered within the air handling unit and transferred to supply air.

## Renewables cut fuel costs

Combined heat and power (CHP) was considered, but a biomass boiler working in tandem with a conventional, high-efficiency gas boiler – plus solar water heating – was considered more appropriate because these systems require less maintenance than a biomass CHP. The use of CHP was also discouraged because the swimming pool is not connected to the site-wide heating network – and the case for CHP is typically made on hot-water use.

We specified a Herz BioMatic BioControl 350 boiler unit, with heat output from 79-350kW and an efficiency of more than 90%. This is linked, via the centralised site-wide heating network, through an energy centre to all six new buildings and the existing assembly hall, improving the energy efficiency of the whole site. The biomass boiler was sized to operate at optimum capacity, and currently produces 50% of the school's annual heat demand, reducing $CO_2$ emissions from heating by more than 30%.

The swimming pool was not part of the original scope of work because of budgetary constraints. However, the facility was retrofitted with a more efficient boiler of equivalent power, and the school hopes to replace the pool altogether in the future.

Carbon was cut further through the use of a solar water system, serving four of the six new buildings – those housing kitchen areas or shower rooms – which have high hot-water use, and is estimated to meet 60% of all hot-water demand on site.

## Keeping Burntwood open

The biggest challenge was minimising disruption to Burntwood School, which had to remain open throughout the project. Noise had to be kept to a minimum to avoid disturbing the teaching. As we transitioned from the old campus arrangement to the new, by replacing two large teaching blocks with four smaller structures, we didn't want to move people more than necessary.

The design team put a lot of thought into phasing work, reducing the cost and inconvenience of housing people in temporary onsite accommodation. A project of this size would normally take two years to complete, but we phased the project over four years to minimise disruption during the school year. The phased delivery of the project allowed the contractor to be fully involved in operation and maintenance of the first phase while progressing with construction of phase two.

## A positive future

Burntwood School is now bigger and better, accommodating 2,000 students – 200 more than before – with more classrooms and teachers. The 21,405m$^2$ school now has 15% more teaching space, and the smaller buildings have created a more intimate campus, with several defined spaces and seating areas to encourage social interaction between students and staff.

Mott MacDonald worked closely with architects Allford Hall Monaghan Morris, and provided building services, specialist acoustics, security, daylighting and sustainability advice, as well as detailed environmental monitoring. In addition to the 2015 Stirling Prize, the school won the 2015 Civic Trust Award and the education category of the New London Architecture Award 2015. It achieved a BREEAM Very Good rating, and was prepared for cost-effective future retrofits to improve energy efficiency and climate resilience further.

Dynamic thermal modelling was carried out to ensure teaching spaces meet BB101 overheating criteria. Although sufficient for the foreseeable future – based on current summer year weather files – we investigated the potential for installing a ground-sourced cooling system, for which there is onsite capacity to locate boreholes should the school take the idea further. Air handling units with sufficient space for cooling coils linked to the potential ground-sourced cooling system have also been specified. Also, PV panels can be added to the solar power network, supplying extra electricity to boost the carbon performance of the site.

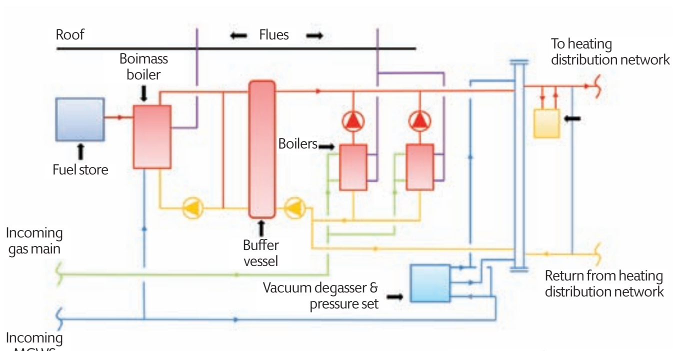
The project is subject to an ongoing post-occupancy evaluation by The Bartlett, University College London. Mott MacDonald is involved in this process and will use outcomes to enhance the operation and performance of the building.

Placing carbon reduction at the heart of the brief has led to greater fuel efficiency, lower bills and increased sustainability.

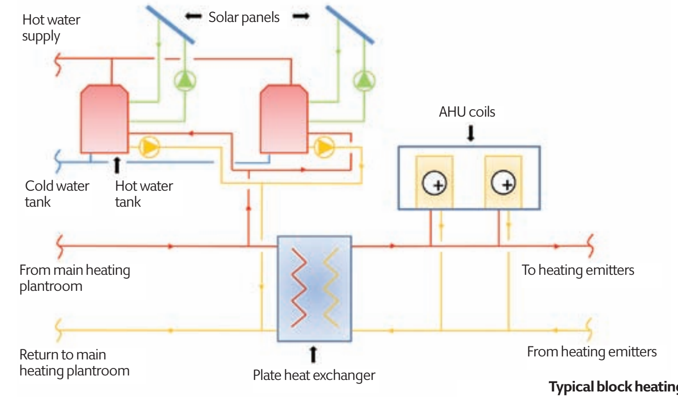
**SAUD MUHSINOVIC** is a business development director, buildings and infrastructure, at Mott MacDonald

> Windows can also be opened for immediate ventilation or passive cooling. This was important for psychological reasons; we wanted building inhabitants to feel 'engaged' with the outside environment

**Schematics of energy systems**




**Primary energy centre**




**Typical block heating**

# A CASE STUDY IN LEARNING

Commissioning systems properly is essential to ensure optimal performance. Medem's Stuart Mason highlights the benefits

During a recent CIBSE CPD we presented on 'The Safe Use of Gas in Education' (April 2015, **CIBSE Journal**) a question was asked about the need for commissioning when our gas control systems were installed. The engineer asking the question had experience of our systems, understood they were designed to be simple to install and that with LCD information, was displayed clearly for installation diagnostics and user operation.

We spoke of the need for commissioning as laid out within the standards but also explained that for us at Medem, safety is always our primary concern and that within the gas industry we should never assume systems have been installed correctly no matter how simple they are to install.

There are many positives to commissioning, not just confirmation of correct operation.

For instance where our systems are commissioned by a Medem engineer not only do we ensure the items are installed and operating correctly, double our industry leading five year warranty to 10 years, provide a 24-hour telephone support number but importantly we also check to ensure the correct system type is installed.

From the original site design to installation a specification can pass through several revisions, a change of design team, take several months and in some cases years before completion on site. This means that the originally designed use of a room or type of installed appliances may differ from the original concept, so the gas safety panel requirements may also now be different.

Classrooms that have changed from laboratories to home economics rooms, classrooms with brazing equipment or kilns that were not on the designs when the gas controls systems were specified and chosen are just a couple of examples.

Because we develop and manufacture our products we have designed flexibility within gas safety systems so that we can enable or disable options during the commissioning to reduce or remove potential handover delays.

> Replacing the water heater was not feasible due to budget restraints so the question was, how do we solve a problem like time?
>
> **Stuart Mason**

Although not every site change is as simple as sliding an option switch.

We recently attended site to commission a system within a boiler room of a school which had gone through a partial refurbishment, the old boilers had been replaced for shiny new and more efficient ones.

Due to its rural location and the site being prone to power cuts of fluctuating lengths, the specification included for a Medem SEC-B system, detectors and commissioning. For those that don't know, the SEC-B is a gas detection and gas pressure proving panel specifically designed to help the site meet parts of Building Bulleting 100: Design for fire safety in schools. Monitoring the boiler room for gas leaks, it can also, crucially, automatically restart the gas supply after a power cut.

Once installed the SEC-B was turned on, a downstream integrity test completed and a signal was provided for the boiler plant to start and within a couple of minutes the heating was on and everything was operating correctly.

As you would expect, part of the commissioning is to test all operations of the gas control panel, so power was removed imitating a power cut. When power was restored the system automatically started a gas pressure test – normally a routine operation for a boiler room. However the panel began alarming and indicated a test fail condition – there was a drop in downstream pressure being registered!!

Now fortunately the boffins at Medem have designed in an easy way of displaying the real time pressures on the display to confirm exactly what is happening. Another unique Medem design feature based on site feedback and experience.

So within a matter of seconds, gas pressures had been viewed and the pressure was confirmed to be reducing downstream of the valve. Now the puzzling part for all onsite was that the gas pipework and appliances had only just been tightness tested.

So after retesting and much head scratching what was the cause of this mystery? It turned out to be the water heater which had not been part of the refurbishment so it was still the original unit. When the 'power cut' was replicated to simulate a momentary loss of power the flame safety device within the water heater didn't respond fast enough in closing its local solenoid. So when the gas test began at start up it showed as a test fail and the gas valve remained isolated.

Replacing the water heater was not feasible due to budget restraints so the question was, how do we solve a problem like time?

The answer was a delay. It's an annoying thing if you're waiting for a train or plane but ideal in this instance.

With the ability to write our own software and make use of modern electronics in our designs – and not just using relays – we were able to reprogram an SEC-B, creating a delay before the auto restart. The flame safety device then had time to operate, the gas pressure test was then performed, integrity confirmed and the gas supply and boiler plant were reset safely reducing the potential for cold classrooms or even damage due to frozen pipe work.

We have taken the information gained from the latest standards, listening to design engineers and the end user – from onsite commissioning and our own experience – and filtered this back into the 2016 V3 range of control panels.

Adding fail-safe valve and relay checking, fire alarm and time delay auto restarts are just some of the new developments making Medem systems continue to be the most reliable, safest and flexible available today.