CIBSE JOURNAL

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MONITORING CROWN ESTATE OFFICES

FRESH THINKING FOR SCHOOL VENTILATION

PROFESSOR ALAN SHORT INTERVIEW

STATE OF THE ART

The role of digital engineering in the restoration of the Mackintosh Building

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Lessons of the past

Publicity about the diesel-vehicle emissions scandal and high levels of nitrogen oxide (NO_x) in our cities has put the issue of air quality at the top of news agendas in recent years. As well as forcing automobile manufacturers to bring forward their plans for electric cars, the topic is making legislators and engineers think more carefully about indoor air quality (IAQ).

For example, the new BB101 guidance on ventilation in schools features tough new targets for maximum CO_2 levels in classrooms. It's a challenge for engineers and particularly for manufacturers supplying systems to ventilate schools. In our feature on page 45, we speak to suppliers about three types of ventilation system – mechanical, hybrid and natural – to gauge the benefits of each, and to find out what the new guidance means for specifiers trying to create cost-effective healthy environments.

A pioneer of natural ventilation is the subject of our interview this month. Professor Alan Short and his collaborators bucked the trend in the 1990s and 2000s by designing large naturally ventilated buildings. His Contact Theatre in Manchester featured a naturally ventilated auditorium, while the Queen's Building at De Montfort University had naturally ventilated laboratories when the norm was air conditioned, sealed rooms.

Short's buildings are complex and require close collaboration with project teams from the beginning, to ensure the physics of a building allows the necessary movement of air. He has collaborated with some of the best minds at the University of Cambridge – where he is professor of architecture – to accurately model and monitor buildings.

Short has also researched extensively naturally ventilated buildings built before the advent of air conditioning, and laments that he often finds details of his 'innovations' written up in long-lost Victorian papers.

He has been closely associated with research on the resilience of hospitals and is now focusing on the threat of antimicrobial resistance (AMR) to human wellbeing. He won a grant from the Global AMR Innovation Fund to understand the impact of air movement on pathogens.

On page 19 Hywel Davies summarises the considerable amount of CIBSE guidance on indoor air quality (IAQ). He also references a CIBSE web page (bit.ly/2ioxQRG) containing a review of the peer-reviewed guidance and relevant *Journal* articles. Finally, the University of Nottingham's Benjamin Jones summarises a workshop in Brussels that looked at the importance of robust IAQ metrics.

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CONTRIBUTORS

Hywel Davies
CIBSE's technical director looks at the Institution's extensive guidance on indoor air quality

Mitch Layng
Energy consultant says many building owners could have worse EPC ratings than they realise

Liza Young
Our deputy editor speaks to manufacturers about the affect of new guidance on school ventilation

Tim Dwyer
The professor reports from ASHRAE's summer conference and focuses on hot water in his CPD

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CHARTERHOUSE REVEALS PLANS FOR £21M SCIENCE AND MATHS FACILITY


A render of Charterhouse School

A famous independent school in the heart of Surrey is to benefit from a new £21m science and mathematics facility.

Sweco and Design Engine Architects are consulting on the first phase of the project for Charterhouse School, which was founded in 1611.

The scheme will provide an additional 50% of teaching space for the science and maths departments, and the brief was to develop a low-energy design using natural ventilation and high-performance glazing and thermal insulation.

Three chimneys will ensure fumes from the building are not recirculated, to avoid compromising the natural ventilation. A dynamic thermal model has also been created to optimise the timber shading on the upper floor, which will help minimise solar loads and prevent overheating.

Mayor outlines zero carbon aim for new London buildings

Khan proposes an 'urban greening factor' for new developments

All new buildings in London will have to be zero carbon from 2019, under proposals unveiled by the Mayor, Sadiq Khan, in his draft London Environment Strategy (**bit.ly/2wau3uA**).

Khan has proposed a series of measures to make the city 'a greener, cleaner and healthier place' by tackling pollution and making London a 'zero-carbon city' by 2050. The strategy, which is open for consultation, contains plans for more energy-efficient buildings, and cleaner transport and energy, as well as more recycling.

If the strategy is approved, all new buildings in London will have to be 'zero carbon' – and large-scale schemes 'air quality positive' – from 2019. The draft also proposes an 'urban greening factor' for new developments.

Khan has said he will make London the world's first National Park City and install more green roofs, while also 'making our streets greener'. He said the capital's 'green infrastructure' of parks, nature reserves and communal gardens was 'a vital asset that improves air quality, boosts quality of life, conserves wildlife and attracts thousands of visitors'.


King's Cross offices: the next generation may be zero carbon

The UK Green Building Council (UK-GBC) welcomed the draft strategy, which policy director John Alker described as 'important and ambitious'.

'Cities are leading the way in the absence of policy ambition and clarity from central government,' said Alker. 'UK-GBC strongly welcomes this type of leadership.'

Cladding fails latest government test

The latest wall-cladding combination to be examined as part of the government's series of large-scale fire-safety tests in the wake of the Grenfell Tower blaze, has failed, and does not meet current Building Regulations guidance.

Aluminium composite material (ACM) cladding – with a polyethylene filler with limited fire-retardant properties (category 2) and phenolic foam insulation – failed the BS8414 test, carried out by BRE. Other combinations that failed are:

- ACM cladding with polyethylene filler (category 2), and polyisocyanurate (PIR) foam insulation
- ACM cladding with a polyethylene filler with no fire-retardant properties (category 3), and stone-wool insulation (a form of mineral wool)
- ACM cladding with polyethylene filler (category 3) and PIR foam insulation

Two combinations have passed the test:

- ACM cladding with limited combustibility (category 1) polyethylene filler and stone-wool insulation
- ACM cladding with polyethylene filler (category 1) and PIR foam insulation.

Each test involves building a nine-metre-high demonstration wall with a complete cladding system, including cladding panels, insulation and cavity barriers. This is subjected to a replica of a severe fire inside a flat as it spreads out of a window, to see whether it meets the requirement to resist vertical fire spread.

Results of the final large-scale test – ACM with polyethylene filler (category 1) and mineral wool insulation – and consolidated advice to landlords based on all the seven tests, will be published shortly.

Contractors hold steady despite payment problems

Engineering services contractors are being hit by delayed payments and rising costs, according to a survey by the Building Engineering Services Association (Besa), the Electrical Contractors' Association and the Scottish trade body Select.

Nearly two-thirds (63%) of respondents said they were not paid within 30 days by public sector bodies during the second quarter of this year. This contravenes the government's prompt-payment legislation. Four in 10 said 3% of their turnover was held in retentions by companies further up the supply chain and that cash-flow issues are being exacerbated by rising costs. Seven in 10 firms reported a rise in material prices and almost half said their labour costs had gone up.

However, eight in 10 (81%) said their turnover had increased or stayed the same in Q2, compared to Q1. Besa chief executive Paul McLaughlin urged firms to 'hold their nerve' as growth 'would definitely have to be hard won'.

Biased capacity market system 'failing businesses', says ADE

Manufacturer Remeha backs call for level playing field to encourage CHP investment

The Association for Decentralised Energy (ADE) has accused the capacity market auction system of discriminating against combined heat and power (CHP), and costing UK organisations as much as £750m a year in missed energy savings.

According to ADE's *Lightening the load* report, the government's auction system is 'failing businesses' and needs to be changed to level the playing field. It says CHP can offer a more energy efficient commercial heating process and could help deliver a more balanced national electricity network.

Manufacturer Remeha has added its voice to ADE's campaign, with national sales manager Paul Wilson claiming that CHP could reduce energy bills by around 20% compared with conventional power generation. 'If the capacity market is to encourage low-carbon, reliable supplies of electricity, it must be structured in a way that gives CHP a level playing field in the auctions,' he said. 'This would give businesses – especially those who operate buildings with long running hours – an incentive to invest in CHP.

'By using CHP, these businesses could produce electricity at gas prices, which is approximately eight pence cheaper per kWh compared to buying it from the grid.'

Big Six urged to speed up shift to smart power

A group of 'wise minds' has told the Big Six energy companies they must stop relying on centralised fossil-fuel generation and focus on local, renewable sources and smart energy grids.

In a report for international think tank Forum for the Future, the group – which includes former energy ministers Ed Davey and Charles Hendry – said the suppliers had been surprised by the speed of the energy sector's transformation. As a result, the large firms had dropped from 99% market share in 2013 to 85% in 2016 – a period that coincided with coal ceasing to be the main fuel used for power generation.

The report said there was a 'clear trend' towards distributed power production, with the UK boasting more than 900,000 energy-production sites. Community-led, local generation is another growing trend, with consumers also benefiting from digital tools that give them more control over their sources of power.

'There is now a 'prosumer' revolution, where ordinary people and businesses are producing more energy, with households and communities becoming generators, actively creating their future energy system,' the group said.

However, low-carbon heating is taking longer to bed in than anticipated. 'Decarbonising urban heat, currently made up of millions of boilers supplied by the gas grid, is a challenge the UK is yet to agree on,' said Davey.

Electric cars are only part of the air quality solution

Ban on gas-heated buildings is faster air-quality solution

Sensible electric heating policies a quicker fix than electric cars

Converting all buildings to electric heating is a quicker way of improving air quality in UK cities than the government's plan for electric vehicles, according to the consultancy WSP.

Such a move could cut emissions by 40%, which is about the same as if all vehicles were to become electric by 2040, in line with the government's latest pollution policy.

In central London alone, 38% of nitrogen oxide (NO_x) emissions come from buildings using gas power, WSP said.

'It will take a long time to improve our cities' air quality by converting to electric vehicles,' said the firm's associate director for sustainable places, Barny Evans. 'Alternatively, we can phase out existing gas-heated buildings and make all new buildings electric – with no cost implication and significant health benefits.

'It is not possible for everyone to go out and buy an electric vehicle tomorrow, but we can mandate that all new buildings are electric only.'

WSP said that electrifying transport was 'only half the solution, and one that is dictated by technology advances'.

'It would be faster and cheaper to improve the air we breathe through sensible electric-heating policies, which can take effect now as the technology is already available and being used,' added Evans.

'Power station' homes could cut bills by 60%

A design concept that turns homes into power stations could cut household fuel bills by more than 60%, according to electricity market research.

Swansea University unveiled the UK's first 'energy positive' classroom last year and the same concept will be used on a development of 16 new homes to be built by social housing group Pobl, in Neath.

A combination of solar cells, battery storage and a revolutionary steel frame draws solar-heated air through tiny perforations for heating and warm water. According to Andris Bankovskis, of the government's Panel of Technical Experts on Electricity Market Reform, savings of more than £11bn over 40 years could be achieved if the same principle was used in one million new homes.

He scaled up the Neath scheme and calculated that average savings would be £600 per household – 'and that's before you factor in the opportunities for investment and job creation'. The concept could cut carbon dioxide emissions by 80 million tonnes over 40 years and reduce peak electricity demand by 3,000 Megawatts, which is roughly equivalent to the output of a very large power station.

'The combination of photovoltaic cells and battery storage means the homes could harvest energy from sunlight, and hold it until it is needed at times of peak demand,' said Bankovskis. 'Provided we can make smart networks a reality, we can better control our energy and share it more easily around a locality, reducing stress on the grid.'

First solar roofs on Tesla workers' homes

Technology giant Tesla has completed its first solar roof installations in the homes of company employees.

Tesla has been accepting online orders in the US since May, with $1,000 deposits paid for its smooth-black and textured-glass roof tiles. Designed to look like standard roofing materials, the Tesla tiles allow light to pass through onto a solar cell. By installing them in the homes of employees first, the company hopes to iron out any problems before launching to a wider market.

Tesla has been building the systems at its Fremont solar plant in California, but will move production to a new factory in Buffalo, New York, later this year, to work with Panasonic.

Company founder Elon Musk said early sales would be limited by manufacturing capacity, but he is aiming to increase production next year, before extending sales to the rest of the world.

STA wants greater urgency over storage

The solar industry has welcomed government plans for boosting energy storage, but has called for greater urgency in removing barriers to its wider deployment.

The Solar Trade Association (STA) said the 29-point plan was largely a restatement of existing commitments and would only enable 'modest progress'. However, it said it 'welcomes the announcement of battery storage and reviews to the rules making it easier for homes and businesses to install the technology alongside PV panels'.

The government will legally define storage in primary legislation and it will be unbundled from network operators to allow competitive markets to develop.

However, the STA said there was still confusion about the amount of VAT chargeable on domestic installations, and clearer consumer data was needed to ensure accurate assessments of possible onsite consumption and storage.

For large-scale projects, the STA also wants to see: 'fair business-rate treatment for onsite storage; changes to the rules governing access to markets, so that the role of storage in network management is unlocked; and rapid resolution of the current double charging for storage'.

STA policy manager Chris Hewett said a favourable policy framework could 'drive down costs very quickly and create markets'.

Builders feel the pinch from exchange-rate fall

Rising material prices are eating into 'already razor-thin margins'

Consumers may fall into the trap of employing rogue traders as a result of building firms passing on the cost of rising material prices, the Federation of Master Builders (FMB) has warned.

A third of small firms say 'soaring prices' are squeezing their margins and almost a quarter have passed on price increases to customers, according to the FMB's latest survey. More than one in 10 builders said they had lost money on projects because of material price increases.

FMB chief executive Brian Berry said the fall in the exchange rate since the EU referendum last June had put builders under 'severe pressure'. Small firms had seen significant rises in the cost of timber, insulation, bricks, blocks, windows, plasterboard/slate, boilers and radiators, and porcelain products. A third of builders surveyed said the price increases were eating into their 'already razor-thin margins' – and this is on top of increased wages and salaries stemming from long-term construction skills shortages.

As many as 85% of builders believe that homeowners will be tempted to hire rogue traders who are quoting a lower price, but Berry said: 'We are calling on homeowners to hold their nerve. They are better off commissioning a more modest project from a professional builder than a high-spec project from a cowboy.'

Up to £1m on offer to show energy-efficient technology

The Carbon Trust is to manage a new four-year, £9.2m programme that will support innovative energy-efficiency solutions.

The Industrial Energy Efficiency Accelerator (IEEA) aims to lower costs and increase the number of available energy-efficient technologies through demonstration of 'near to market innovations'. It will also address technical and commercial challenges by offering 'tailored incubation support' to technology developers and start-ups.

It will make co-funding of between £150,000 and £1m available for demonstration projects across the UK, and will seek to raise up to £11m of private sector investment.

The IEEA is funded by the Energy Innovation Programme – led by the Department for Business, Energy and Industrial Strategy – and will be delivered by the Carbon Trust with support from engineering firm Jacobs and infrastructure specialist AMEC Foster Wheeler. It expects to support between 15 and 30 pilot projects, selected via a competitive application process and from different industries. Results from each of the projects will be incorporated into sector guides and presented at regional events.

The IEEA will run an open application process until January 2018, with organisations encouraged to apply in collaboration with a technology developer. A fast-track process is available for industrial companies already engaged with a developer and looking for funding and advice to help run a demonstration.

ISTANBUL TOWER LIT WITH LED LIGHTING

One of Istanbul's most famous sites is now being illuminated by architectural LED lighting from Philips Lighting.

The 63m, 14th-century Galata Tower is one of the most recognisable landmarks in the Turkish city, and is popular with local people and tourists because of the commanding views it offers.

Its top is now lit by Philips Colour Kinetics lighting, as part of a design by Nergiz Arifoglu Lightstyle, which aimed to emphasise the tower's many architectural features.

Originally built as a lighthouse by the Byzantines in the fifth century, the Galata Tower was destroyed in 1204 and rebuilt by the Genoese, before being modified during the Ottoman Empire.

Soaring demand for smart HVAC in small premises

Smart systems a cost-effective alternative to building automation

The market for smart connected HVAC systems is growing at more than 25% per year in the US and is forecast to be worth US$1.8bn by 2021, according to a BSRIA market intelligence study.

Most of the market value is accounted for by maintenance and managed services, as smart HVAC equipment can be accessed and controlled remotely. Real-time monitoring and analysis allows service managers to monitor and optimise performance and, in some cases, to predict and prevent failures.

The strongest demand is in buildings of less than 50,000ft^2 and it is most popular in the retail sector. 'The majority of the value is derived from packaged rooftops, though there is also a significant market for chiller systems and air handling units,' the report said.

Smart systems are 'rapidly becoming a cost-effective alternative to full-scale building automation and controls (BACS),' said BSRIA's senior market research consultant Henry Lawson.

This is attractive to organisations managing a portfolio of small buildings in different locations, where HVAC outages will impact on their operation and where maintenance costs are a challenge.

By 2021, the smart HVAC market in the US will be worth $1.8bn

Overheating research to help DCLG

The Department for Communities and Local Government (DCLG) has commissioned Aecom to research overheating of new homes.

Phase one aims to identify – using CIBSE TM59: *Design methodology for the assessment of overheating risk in homes* – the types of new properties that are at risk of overheating in England. Aecom is modelling different building types in various locations across England, and assessing the impact of occupant behaviour and projections of future climate.

A possible second phase would involve cost-benefit analyses of measures to reduce overheating risks, to inform DCLG about whether further guidance, regulation or other measures are needed.

EU countries slack over smart-building policies

BSRIA is attempting to answer the 'how, what and why?' of 3D printing with its latest 'At a glance' guide.

The publication explains the basics of 3D printing – including design tools, processes, methods and applications in construction – and is aimed at architects, building surveyors and designers, manufacturers, system integrators and building services engineers.

BRSIA says 3D printing is at the forefront of product development and has opened up new markets because of the increases in speed, accuracy and range of materials that can be used. 3D printing also makes possible the manufacture of different shapes, such as hollow structures.

ASHRAE calls for input on legionella guide

ASHRAE is seeking public comments on its new guide for reducing the risk of legionella bacteria in building water systems.

Guideline 12-2000 *Minimizing the risk of legionellosis associated with building water systems* is open for a 45-day public review until 11 September at **www.ashrae.org/publicreviews**

The guidance is intended for use by building owners and those involved in the design, construction, installation, commissioning, management, operation, maintenance and servicing of centralised building water systems and components. It is also designed to help with the implementation of ASHRAE's Standard 188 for legionellosis control.

The society says there are between 8,000 and 18,000 cases of Legionnaires' disease in the US every year, with more than 10% proving fatal. The majority of outbreaks are linked back to building water systems.

IN BRIEF

Support for applicants

CIBSE's membership department has introduced two initiatives to help applicants with their reports for Member or Associate grades.

It now offers a half-day, report-writing workshop, to help people get started on the Engineering Practice Report for Associate and Member applications. These are run with CIBSE interviewers who will help guide applicants in the right direction.

Upcoming workshop dates include 25 September and 26 October, from 9am-12:30pm, at CIBSE, Balham – timely for the 1 February application deadline. Visit **www.cibse.org/briefings** for more dates and booking details.

CIBSE also offers 'phone surgery' appointments during the year to discuss draft engineering practice reports. A phone call with a CIBSE interviewer will be booked for you, to discuss your report application. For details and to book, email **membership@cibse.org**

Final call for symposium abstracts

The deadline for submissions for the 2018 CIBSE ASHRAE Technical Symposium is 11 September.

CIBSE is seeking papers, reviews and case studies on research and development relating to any human-controlled environment, including all types of buildings, occupied spaces and vehicles – terrestrial or otherwise.

Submissions are encouraged from young and experienced industry practitioners, researchers and building users.

The symposium will be held on 12-13 April 2018 at London South Bank University. For full details and to submit your abstract visit **www.cibse.org/symposium**

Career guides to inspire engineers of tomorrow

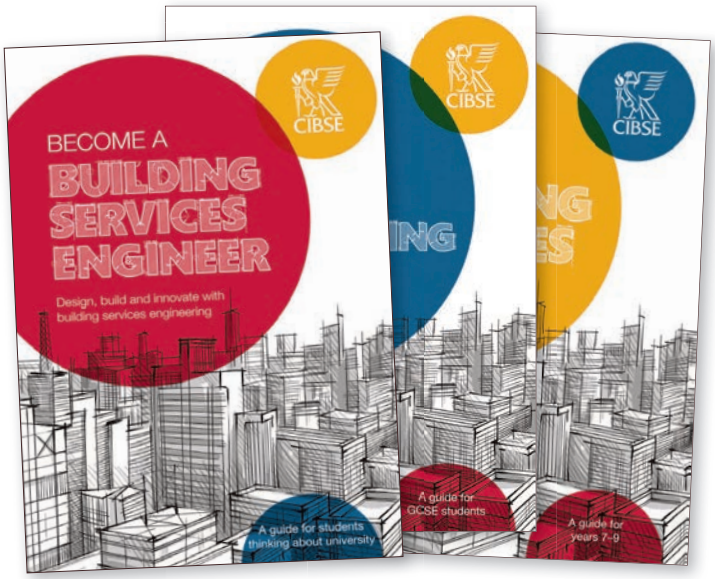
Fact sheets aimed at a range of age groups, as well as students' parents

CIBSE has published a new set of career booklets designed specifically for students.

The literature, sponsored by CIBSE Patrons, explores what it is like to work in the building services industry. It highlights the benefits of working within the sector and gives clear guidance on how to develop a career as a building services engineer.

There are three sets of fact sheets, aimed at different age groups:

- 7-9-year-olds – This booklet poses questions such as: How do you keep cool in a desert, and how does water get to the top of a tower? It also includes facts about the world's largest airport, as well as details of unusual projects that involved building services engineers, including Wild Wadi Water Park in Dubai.
- GCSE students – This includes information on why building services matter, what a typical working week might be, and study routes into the industry.
- A Level students – This fact sheet has information on a typical working life, expected salary, case studies from engineers about how they got into industry, and advice on applying to college or university.



CIBSE has also produced two guides for parents who have children interested in a career in engineering. Aimed at people with children in school years 7-11, and at parents of A-Level students, the guides complement the career fact sheets by helping parents support and encourage their children as they explore the opportunities the industry has to offer.

If you would like some of the literature to promote building services at a careers event – or if you are interested in the parent guides – please request hard copies from the Membership Department at **membership@cibse.org**

Copies are available to download at **bit.ly/CJSept17careers**

Inclusivity panel to develop diversity framework

The recently formed CIBSE inclusivity panel held its inaugural meeting on 19 July. All members of the panel attended, with some joining the meeting remotely via video link.

Current members of the panel are: chair Atif Rashid, CIBSE board members John Field and Lynne Jack, co-vice-chairs Jo Edwards and Mikal Ahmed, Karter Singh, David Stevens and Annie Marston.

The panel reviewed the Royal Academy of Engineering progression framework, which has been published to support professional engineering institutions as they develop their approach to inclusion and diversity.

The framework offers a clear model to help institutions assess their progress towards improved diversity and inclusion across a number of key areas of activity.

The inclusivity panel agreed that CIBSE should take part in the Royal Academy's benchmarking exercise, which allows organisations to assess their current position against the framework criteria.

It hopes this will make it easier to define clear objectives for CIBSE to improve inclusion and diversity, and to prepare an action plan for approval by the CIBSE board in November 2017.


Nada Issa

CIBSE members in top 50 women in engineering list

Inspiring women working on high-profile engineering projects are rising stars

CIBSE members Pavlina Akritas and Nada Issa have been recognised in the Top 50 Women in Engineering under-35 list, compiled by *The Telegraph* in collaboration with the Women's Engineering Society (WES).

Akritas CEng MCIBSE, associate at Arup, specialises in designing sophisticated natural lighting systems for museums, galleries and other large buildings. She is currently working on the lighting redesign of Abu Dhabi International airport. Her work on projects that filter natural daylight into large galleries has won awards for design and innovation. Akritas also volunteers to mentor junior colleagues, and to inspire schoolchildren.

Issa, a graduate CIBSE member working at Chapman BDSP, arrived in London in 2004 as a refugee from Somalia. She went on to achieve a first-class degree and become president of her university engineering society.

Issa has worked on plans for the Battersea Power Station development in London and was lead engineer on the British Postal Museum project.

She works to promote diversity in the sector, and teaches maths to disadvantaged children.

The list features the UK's top rising female engineers – chosen from more than 500 nominations – and was announced on International Women in Engineering Day, on 23 June.

To view the full list, visit **bit.ly/2vRTi7s**


Pavlina Akritas

Bronze medal winners named

The Napier Shaw and Carter Bronze Medals have been awarded to academic papers that explore energy use in HVAC components and design summer years to assess overheating risk. The prizes will be awarded at the CIBSE President's dinner in October.

Ian Knight, from Cardiff University, won the Carter Bronze Medal for his paper *Operational energy use and power demands in European HVAC components*. This looked at how a gradual move from energy management at building level to component level requires specific energy-consumption and power-demand benchmarks.

Knight's paper gave a methodology for collecting and collating the data needed for producing benchmarks, and showed that data can produce benchmark ranges of operational energy consumption and power demands at individual component level.

The University of Exeter's Matthew Eames – who won in 2012 – was awarded the Napier Shaw medal for his paper *An update of the UK's design summer years: Probabilistic design summer years for enhanced overheating risk analysis in building design*. Eames presents a method to create probabilistic design summer years data that can be used to inform designers of the risk of overheating to occupants. It can also be used to generate new near-extreme weather files for the UK.

CIBSE members can access *BSERT Journal* – where the papers are published – and *LR&T* journal at **www.cibse.org/knowledge**

Deadline looms for BPA nominations

All Building Performance Awards 2018 entries must be received by 15 September. The accolades – which are judged on actual, in-use performance – are free to enter.

By asking for data on how entries perform, the awards ensure that only projects, products, initiatives and innovations backed by evidence can win.

Two new awards are being introduced for 2018: Data Centre Project of the Year, and a Learning and Development Award. In total, 16 categories are open for entries.

The shortlist will be revealed at Build2Perform Live, at London's Olympia, on 21 November, and the winners will be announced at the awards night on 6 February 2018. For the full list of categories and to enter, visit **www.cibse.org/bpa**

Get your entries in for Façade 2017

The 2017 Façade of the Year competition is open for entries. Run by the Society of Façade Engineering, the international contest recognises, rewards and promotes excellence in façade design, engineering and application.

Entries must be received by 1 October, and the winners will be announced at the Glass Supper, which will be held at Tate Modern, London on 7 December. For details, visit **sfecompetition.org**

Special interest group meets

The first committee meeting of the new HVAC Systems Special Interest Group will take place on 8 September, at Hoare Lea, London.

The group's mission is 'to support and encourage the efficient design, installation and operation of heating, ventilation and air conditioning systems'.

Anyone interested in becoming a member of the group, or taking part in the committee or group activities, should contact Nyree Hughes on **nhughes@cibse.org**

New members, fellows and associates

FELLOWS

Hopton, Tom
Bath, United Kingdom

Lip, Samuel Kwok Piu
Tseung Kwan O, Hong Kong

MEMBER

Tsang, Ying Piu
Tseung Kwan O, Hong Kong

Lee, Hui Ming
Hong Kong, Hong Kong

Kavadias, George
Patras, Greece

Marino, Sabrina
Teddington, UK

Arcidiacono, Giuseppe
Maidstone, UK

Chou, Ho Wai
Tai Wai, Hong Kong

Tang, Ka Ming
Hong Kong

Yeung, Chi Keung
Hong Kong, Hong Kong

Wong, Wai Ping
New Territories, Hong Kong

Hallam, Chris
Warrington, UK

Tang, Wah Yiu Keith
Hong Kong, Hong Kong

Loizou-Christodoulou, Michael
London, United Kingdom

Solanke, Olusola Oladipo
Stevenage, UK

Ho Koon, Chi
Wanchai, Hong Kong

O'Connell, Bartholomew Gerard
Blarney, Ireland

Sloan, Simon
Holywood, United Kingdom

Moore, Erik Christopher Briscoe
Sydney, Australia

ASSOCIATE

Glenn, Simon
Exeter, United Kingdom

LICENTIATE

Aherne, Tony
Cork, Ireland

Croft, Arron
Solihull, UK

Charlesworth, Paul John
Essex, UK

Curran, David
Great Horkesley, UK

Fitzgerald, Daniel
London, UK

Henderson, George
Hull, UK

Human, Francois
Uxbridge, UK

Hunt, Josh
Exeter, UK

Holt, David
Leeds, UK

Howden, Steve
Bexleyheath, UK

Hermanstein, Lance
Norbury, UK

Kerai, Vijay
Harrow, UK

Koshy, Prasanth George
Cambridge, UK

Lopez, Javier
Bournemouth, UK

Lewis, Jak
Oxford, UK

McHale, Brad Richard
Eldwick, UK

Roskell, Paul James
Fulwood, UK

Sherry, Robert
Sandy, UK

Smith, Martin
Bournemouth, UK

Stephens, Paul
Plymouth, UK

Sullivan, Adam
Bristol, UK

Tahir, Rabia
Godalming, UK

Ukereghe, Juran
Thornton Heath, UK

Van Heerden, Johannes
Wickford, UK

Vissariou, Pafsanias-Athanasios
Edinburgh, UK

Watts, Marcos
Newcastle upon Tyne, UK

Yeates-Mayo, William Luke
Cardiff, UK

Yu, Zhongshi
Loughborough, UK

Upcoming webinars to help with applications

CIBSE's latest series of membership webinars aims to help applicants understand the application process for the Licentiate, Associate and Member grades of membership, as well as get to grips with the qualification requirements for both IEng and CEng.

The webinars are designed to help applicants start their Engineering Practice Reports where they are given a detailed description of what the competencies mean and how to interpret them.

There are four webinars available:

- Qualification requirements
- How to start your Engineering Practice Report
- How to prepare for your interview
- LCIBSE EngTech membership and registration.

For details and dates, visit **bit.ly/2xylHMK**

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FEEDBACK


Spanish houses have small windows and external shading

A reader speaks out on data-centre standards; an advert is clarified; and LinkedIn members try to beat the heat

Made in Britain

Your article on data-centre reliability (Tiers for fears, *CIBSE Journal*, July 2017) reads like an advertorial for a private American standard written and promoted by the profit-making Uptime Institute.

We have a perfectly good – and modern – British and European standard that is much more appropriate for data-centre design, construction and management in Europe: BS EN 50600-1:2012 *Information technology. Data centre facilities and infrastructures. General concepts*. This standard doesn't use the word 'tiers' – copyrighted by the Uptime Institute – but four 'classes' of resilience.

Unlike the Uptime tier system, which only looks at power and cooling, BS EN50600 covers power, cooling, building, architectural and location issues, telecommunication cabling and physical security, and fire-safety engineering. Later additions now cover management and energy optimisation.

If some territories don't believe a European standard is appropriate, there is always the equally useful ANSI-TIA942, with its four 'ratings' of data-centre resilience.
Barry Elliott MCIBSE

Editor's reply

The Uptime Institute is one of several organisations to define four levels of data-centre resilience, all of which are based on the same principle of redundancy.

ANSI-TIA942 is an American Telecoms standard and is specifically focused on IT. However, this uses almost exactly the same four 'classes' of resilience in its definition. Many major clients, such as banks, have their own data-centre standards. These are based on one of the existing standards, but tweaked to minimise risk for their specific business.

The article focused on resilience from an M&E perspective, so architectural and location issues, physical security and fire-safety engineering were not discussed.

Loud and unclear

The August issue of *CIBSE Journal* contained an advert that appears to suggest only Safe Electric-registered contractors can provide completion certificates for electrical work that meets all the latest standards. This advert is misleading and incorrect. Safe Electric is the statutory regulatory scheme for electrical contractors in the Republic of Ireland only. It does not operate in the UK.

There are around 45,000 electrical contractors registered with English and Welsh government-approved scheme operators. This allows them to self-certify electrical work instead of getting Building Regulations approval. Certsure is one of these operators and – through its NICEIC and ELECSA brands – represents more than 34,000 registered electrical contractors who are assessed on an annual basis to ensure high standards.
Alan Wells

After the summer heatwave in Europe, CIBSE LinkedIn asks if we can design homes to beat the heat

Chris Gunn
Build like they do in Spain: tiled floors, small windows and external shading.

Simon Wright MCIBSE
We did some modelling based on climate-change data, and the best solution was simple 'dynamic' shading in the form of external occupant-controlled shutters. A good retrofit option too. Residential [construction] – in the UK at least – has moved towards lightweight and highly insulated solutions, which are storing up problems for the future because housing lifespans are significantly longer than many other types of buildings.

Mapping performance over lifetime would be an interesting research subject. What should we be building into our homes now, and how should we plan for retrofit solutions/modification as climate change evolves?

Ashok Dhayal
One can try: lowering window glass g-values; night purging; fixed/movable shading; south-facing glazing; optimum window/wall ratio; evaporative cooling for low humid climate; PV-Trombe wall; and peak lop cooling.

John Littlewood
Even heavyweight buildings can overheat without correct ventilation.

Prokopis Perdikis
Use high solar-reflective performing coatings.

Ian Knight
I'd go for heavyweight buildings with high ceilings, decent external shading for the day, and good passive ventilation systems for night cooling if needed.

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We reserve the right to edit all letters.

Air of authority

With the UK government coming under increasing pressure to tackle air pollution, Hywel Davies reviews the CIBSE guidance on building air quality

European air-quality standards require member states to undertake air-quality assessments and report the results annually. The EU Directive 2008/50/EC on Ambient Air Quality and Cleaner Air for Europe, and the Fourth Daughter Directive (2004/107/EC), are implemented through the Air Quality Standards Regulations 2010 and further legislation in the devolved administrations.

Monitoring has shown that much of the UK has a problem with pollution, and specifically with nitrogen oxide (NO_x) emissions. The latest annual report published for 2015[1] shows that – out of 43 monitoring zones in the UK – just six met the limit for annual mean NO_x levels. By far the worst case is London, but a number of other urban centres are also well above the limit.

As a result, the UK government has been under pressure to produce a plan to reduce NO_x emissions to the limits set in the 2010 regulations. The latest version was published on 26 July[2] to much media comment, and included the proposals to ban the sale of new diesel- and petrol-engine vehicles from 2040.

"Out of 43 monitoring zones in the UK, just six met the limit for annual mean nitrogen dioxide levels"

In the meantime, there has been a flurry of activity in the building services press over standards for indoor air quality (IAQ). The Greater London Authority is consulting on the planning framework for the London Plan, and there have been calls for the creation of an air-quality standard. Given the pollution levels in London, delivering acceptable and healthy air quality inside a building is more of a challenge than it is in Brighton, Blackpool or the Borders – all of which meet the legal limits.

But there is considerable CIBSE guidance available for services engineers delivering projects in urban areas with higher levels of pollution. IAQ is addressed in detail in CIBSE technical guidance, with principal references being Guides A and B, and further guidance in AM10 Natural Ventilation, TM57 Schools, TM21 – on minimising pollution at air intakes – and KS17, which offers an overview of the topic. The new edition of TM40, on health in buildings, will also address air-quality issues.

Guide A Chapter 0 gives the background to health and indoor air quality in building design, while chapter 1 sets out the primary criteria and associated indicative air-supply rates.

Chapter 4 includes the basic ventilation rates, in litres per second per person, for the BS EN 13779 IAQ categories, where IDA 1 is the highest indoor air quality and IDA 4 the lowest. The chapter also recommends ventilation rates for specific spaces in dwellings and offices, and gives references for spaces such as call centres, clean rooms and prison cells.

In addition, it introduces the classic 'pollution concentration equation' for assessing the potential of a space to control levels of transient pollutants, with an example of occupant CO_2 emissions and polluted outdoor air.

Chapter 8 provides the main commentary on IAQ, with typically required fresh-air supply rates for acceptable CO_2 levels. There is guidance on indoor pollutants and their health – and sensory – effects, and links to relevant occupational exposure limits. Table 8.3 shows the influence of poor system practices, such as unclean ductwork, on occupant respiratory symptoms.

The chapter also considers the importance and impact of outdoor air on IAQ, the typical relative pollution of the 'fresh' air we use, and means of moderating the impact of poor outdoor air quality on IAQ. There is a brief discussion of the impact of IAQ on sickness and productivity – a topic that is coming to the fore with the growing interest in wellbeing in buildings.

There is now a page on the CIBSE website[3] that offers a detailed review of all the published, peer-reviewed CIBSE guidance on indoor air quality, as well as recent *CIBSE Journal* articles. The page is an essential read for anyone working on the topic.

While engineers have to design for the prevailing conditions, better outdoor air quality and reduced levels of pollutants will improve the quality of the 'fresh' air we use to ventilate our buildings. It will also reduce the need for measures to remove or control outdoor pollution inside buildings.

For these reasons, it is essential that government takes serious steps to control pollution and meet the current legal standards. In the meantime, *Journal* readers should make full use of the available guidance and standards for indoor air quality.

References:

1 Air Pollution in the UK 2015, September 2015, Department for Environment, Food and Rural Affairs (Defra), **bit.ly/2v4TkZT**

2 UK plan for tackling roadside nitrogen dioxide concentrations, July 2017, Defra and the Department for Transport **bit.ly/2g4uORM**

3 Indoor air quality – an outline of CIBSE information, May 2017, **bit.ly/2ioxQRG**

DR HYWEL DAVIES is technical director at CIBSE **www.cibse.org**

The Grenfell Tower tragedy: key issues for prosecutors

In assessing liability of parties who refurbished Grenfell Tower, prosecutors will look at who had a 'duty to warn' about potentially combustible cladding. Keystone Law's David Beckenham and Jason Kallis explain

The fatal blaze at Grenfell Tower has raised important safety questions. The cladding system may have contributed to the rapid spread of the fire – so where does this leave those involved in its design, manufacture and installation? This will include private companies and consultants, as well as the local authority.

Prosecution cannot be ruled out, so what are the key issues to be considered by the police, the Crown Prosecution Service and, possibly, a jury?

First, the investigation will concentrate on identifying evidence that may support charges of gross negligence manslaughter or corporate manslaughter. The test for gross negligence manslaughter is:

- Was there a duty of care owed by the defendant to the deceased?
- Did a breach of that duty of care lead to the death(s)?
- Did the behaviour of the defendant fall so far below the standard that could reasonably have been expected that it warrants criminal liability?

For corporate manslaughter, it is broadly similar – an organisation is guilty of an offence if the way in which its activities are managed or organised:

- Causes a person's death
- Amounts to a gross breach of a relevant duty of care owed by the organisation to the deceased.

The organisation is guilty of an offence only if the way in which its activities were managed or organised was a substantial element in the breach.

With gross negligence manslaughter, issues will arise should the prosecution identify that no single person's negligence led to the fire; the offence does not allow for the aggregation of people's negligence to be taken into account. The Corporate Manslaughter and Corporate Homicide Act 2007 allows for aggregation of negligence, but does not allow for individual liability.

Was one entity to blame?

On the refurbishment of a high-rise tower, different people or corporations will be responsible for various elements of the design. However, one entity or individual is likely to have had responsibility for the overall design. As lead consultant, architects normally take on this role – but it is not just their scope of service or responsibility that should be scrutinised. It would be more appropriate to assess the probable liability for gross negligence – in this instance, within the realms of what they should do about high-risk fire issues. Who had a duty to warn? In the case of Grenfell, this question can be reduced to who had – and who ought to have had – knowledge of the cladding issue?

Deciphering who had a duty to warn is not easy. Some involved on the project may have been unaware that the cladding was not fire retardant; some – despite knowing – may still be entitled to assume that design would be implemented to prevent the cladding from spreading fire.

Designer's liability and a duty to warn

There is no general duty to warn in English law, but there is a duty to warn where there is danger to human lives (see Akenhead J, in *Cleightonhills v Bembridge Marine*). All the professionals contracted with the council who knew the cladding was potentially combustible are likely to have had a duty to warn, unless circumstances show they could, feasibly, have assumed it would become fire-proofed during installation.

Ordinarily, simply warning an employer of a risk of catastrophic fire is not enough; one must warn vigorously or – where the risk is high – refuse to proceed with the works, and perhaps prevent others from proceeding.

Investigators will need to see the contracts and associated documents, professional appointments and explanations about why decisions were made to determine the potential responsibility of the cladding specialists, contractors, architect, engineers, those checking Building Regulation compliance, or the employer. But a lead designer or consultant may find it difficult to argue they did not have a duty to warn. The assumption that others will be 'designing out' a fire risk is, however, likely to protect the lead consultant. They may be able to vindicate proceeding with the cladding installation if they had been told expressly that it would resist the spread of fire.

In summary, it is possible that the designer, contractor or local authority could be prosecuted for breaching a duty to warn. Whether this constitutes gross negligence manslaughter or corporate manslaughter will, ultimately, be a matter for the jury to decide.

DAVID BECKENHAM is a health and safety lawyer and **JASON KALLIS** is a construction litigation expert, both at Keystone Law

Efficiency drive

Opportunities exist for building services engineers to help property owners meet the MEES, says energy consultant Mitch Layng

The Minimum Energy Efficiency Standards (MEES) will prohibit a landlord from letting a 'substandard property' from 1 April 2018 and from continuing to let one from 1 April 2023. 'Substandard' is defined as failing to meet a minimum energy efficiency standard, set at an Energy Performance Certificate (EPC) rating of E. So an F- or G-rated property – unless exempt or excluded – can be at risk from the MEES regulations.

Evidence suggests that many property owners, and those responsible for letting property, are unaware of the implications of having substandard premises – or, if they are aware, they do not have a strategy to ensure improvements are made or exemptions registered. In a survey by *Property Week* magazine, 32% of all respondents did not know what MEES was and how it would affect their business.

Even where the energy rating of a building is known, there can be an issue with the quality of the EPC, particularly if it was done in the early years – mainly pre-2011. This is because there was a lack of accredited assessors when EPCs were introduced in 2008. Default data was often used, and updating the software in line with current Building Regulations has meant a ratcheting up of standards.

Recent research by Arbnco – which re-ran 3,500 EPCs using current Simplified Building Energy Model (SBEM) software – found that 24% achieved a worse rating than the original EPC, with the proportion of buildings falling into the F and G bands increasing from 14% to 22%. The analysis was conducted on well-managed building stock, so there is potential to see a greater percentage drop in less well managed portfolios.

"There can be an issue with the accuracy of the EPC, particularly if it was done in the early years"

There is always a chance to improve the energy performance of a building when interventions are made – not just the operational performance, but also the asset performance (EPC) – but often these opportunities are missed. When smaller-scale refurbishments and plant replacements are undertaken, like-for-like substitutions are common – but this often results in only a small improvement in the EPC rating, or no improvement at all.

If modelling is done at the design stage to look at improvement options – including cost and return on investment, using more efficient equipment, and using detailed design data, rather than default or insufficient information, to model the EPC – evidence can be provided to ensure an informed decision is made about the best option for replacement. I am sure property owners would rather make improvements at design stage than at a later stage, often at increased cost and disruption.

There is an opportunity for building services engineers to engage with their clients and property owners to ensure the correct actions are taken at the right time.

MITCH LAYNG is lead energy consultant at Layng Energy Solutions

Further reading:

1 Guidance to regulations, **bit.ly/2vUxc3n**
2 Arbnco EPC analyses, **bit.ly/2inIVCP**
3 Property Investor Today, **bit.ly/2ilmjTa**
3 Don't get MEES wrong, *CIBSE Journal*, **bit.ly/2wa9yyf**

BUILDING A NEW SOCIETY

CIBSE's new Society of Digital Engineering aims to give building services professionals the skills to take advantage of fresh opportunities. **Carl Collins** explains

The Society of Digital Engineering (SDE) is a new CIBSE network that aims to make the most of the opportunities offered by the technological revolution sweeping through engineering and construction.

CIBSE and its Digital (formerly BIM) Steering Group have been addressing the many challenges presented by the global drive to digitise construction and engineering. The development of CIBSE Digital Engineering Series (DES) publications, the UK BIM Roadshow, and related training programmes made CIBSE realise there was a pressing need to develop a home for 'digital engineers' in the building services and property sectors.

The Steering Group has been tackling the challenges that building information modelling (BIM) brings by developing tools and software to help categorise information about products and systems in a way that BIM understands. It developed Product Data Templates (PDTs) and – with N G Bailey – BIMHawk software, which is designed to speed up and facilitate PDT production. DES publications that have helped employers and their teams get to grips with the specifics of BIM include pre-qualification questionnaires, Employers' Information Requirements, and BIM Execution Plans.

SDE is relevant for anyone working in the building services supply chain... all levels are welcome

The SDE is relevant for anyone working in the building services supply chain, including engineers, contractors, manufacturers, and facilities and operations management.

It welcomes those involved in design, construction, operation, maintenance, refurbishment and manufacture of building engineering services and related systems, such as façades. Technicians and engineers at all levels of experience and qualification can join. (See panel 'Who should join the SDE?')

Key issues

Hardly a week passes without news of another cyber 'attack', such as the one that struck the NHS in May. The issue of cyber security in building and construction is increasing in importance as use of digital information expands, and this affects asset and facilities management. CIBSE and the SDE will address these issues, and offer a home to engineers who specialise in these areas.

The drive for digital asset information management also creates an opportunity to enhance CIBSE's offer to facilities managers through the FM Group.

Digitisation of construction is an international phenomenon and CIBSE is working with members in Hong Kong, the Gulf, Australia and New Zealand to identify the benefits that the SDE could deliver around the world.

Why join the SDE?

Currently, there is no obvious and recognised 'home' for specialists in digital technologies and processes in building services engineering – or for technicians who may not necessarily seek full corporate membership of CIBSE. Such individuals seek support, guidance and a place to speak to peers. The SDE will offer this, as well as 'professional' progression with structure and credibility, which may lead to MCIBSE and EC Registration at the relevant level (not just CEng).

SDE will also offer a career progression for apprentices and other young digital engineers. Until now, technicians were in danger of not being able to move beyond the level of CAD/BIM manager.

CIBSE has increasingly close contact with many software vendors and resellers, and they are eager to develop closer ties with members of CIBSE and its societies.

Creation of the SDE signals CIBSE's strong commitment to supporting engineers in this field. The Industrial Membership scheme will be designed to ensure active industry engagement with the SDE and its members.

What will the SDE deliver to its members?

- Membership – the CIBSE society model requires that all members are at least CIBSE affiliates. As a member of the SDE, you will receive all the benefits of affiliate membership
- CIBSE benefits that SDE members will receive include:
  - The Knowledge Portal
  - Access to the DES publications
  - Subscription to *CIBSE Journal*
  - CIBSE events: member rates and access to conferences, workshops, and briefings organised by CIBSE
  - CIBSE training and CPD – member reduced rates
- SDE benefits for its members:
  - Regular newsletter featuring software developments, case studies, and news of relevant research
  - SDE social media and collaboration activities – LinkedIn and more
  - Networking events and regional meetings; a Manchester BIM/Digital Group already exists
  - Digital Awards, to be launched at Build2Perform Live in November 2017
  - Certification: e-learning modules and face-to-face training leading to certification and qualifications for membership levels
  - CPD virtual events – webinars and more
- Briefings: regular updates on key developments
- Progression: members will receive the support of the CIBSE membership team to assist them in making professional progress through to 'MSDE' level and beyond, to membership of CIBSE at Student, Licentiate, Associate, Member and Fellow levels
- Competence Criteria for a Digital Professional have been mapped against CIBSE's and the Engineering Council UK's requirements. This is being drafted for full membership – as well as for EngTech and IEng, up to CEng status – ensuring that SDE offers progression through the SDE grades, leading to MCIBSE and EC Registration (not just CEng). **CJ**

WHO SHOULD JOIN THE SDE?'

The Society is intended for engineers and technicians at all levels of experience and qualification involved in digital activities in the building services sector and supply chain, including:

- **Young engineers, for whom digital workflows are 'business as usual' – and who would like to engage, share ideas and set best practice.**
- **Mid-career engineers, who need to engage with digitisation for the rest of their careers, and work alongside tech savvy younger engineers**
- **Senior engineers, who need to manage and understand the role of digital processes.**

The Society will also appeal to those involved in digital engineering activity that falls outside the traditional envelope of building services, including project and facility managers, and building operators.

SPEAKERS' CORNER

With CIBSE's first Build2Perform Live event set for November, we ask speakers what they think needs to change in the industry to improve building performance

Coming to London's Olympia on 21-22 November, Build2Perform Live is CIBSE's new two-day event dedicated to helping built-environment professionals – and the wider supply chain – to improve efficiency and save money through effective building services.

Evolving from the Building Performance Conference and Exhibition, the free event offers more interactive features and multiple seminar streams, as well as continuing professional development (CPD) theatres and exhibitor stands.

We have asked speakers to outline what they think needs to change in the industry to improve performance. They say soft landings or post-occupancy evaluation are essential, as well as better dialogue between stakeholders and the use of simulation and energy models from conceptual design through to the end of a building's life. **CJ**

JANNICK ROTH, senior building performance engineer at WindowMaster

We believe joined-up thinking and a holistic approach throughout design and delivery are key to improved performance. This entails specialists and designers working more closely with builders and contractors to achieve integrated and holistic designs that are cost-effective and high-performing. If specialists are engaged with a trusted voice from the design phase, right through to delivery, buildings are more likely to look and perform as intended – and within budget, without unnecessary value engineering that often compromises design or performance.

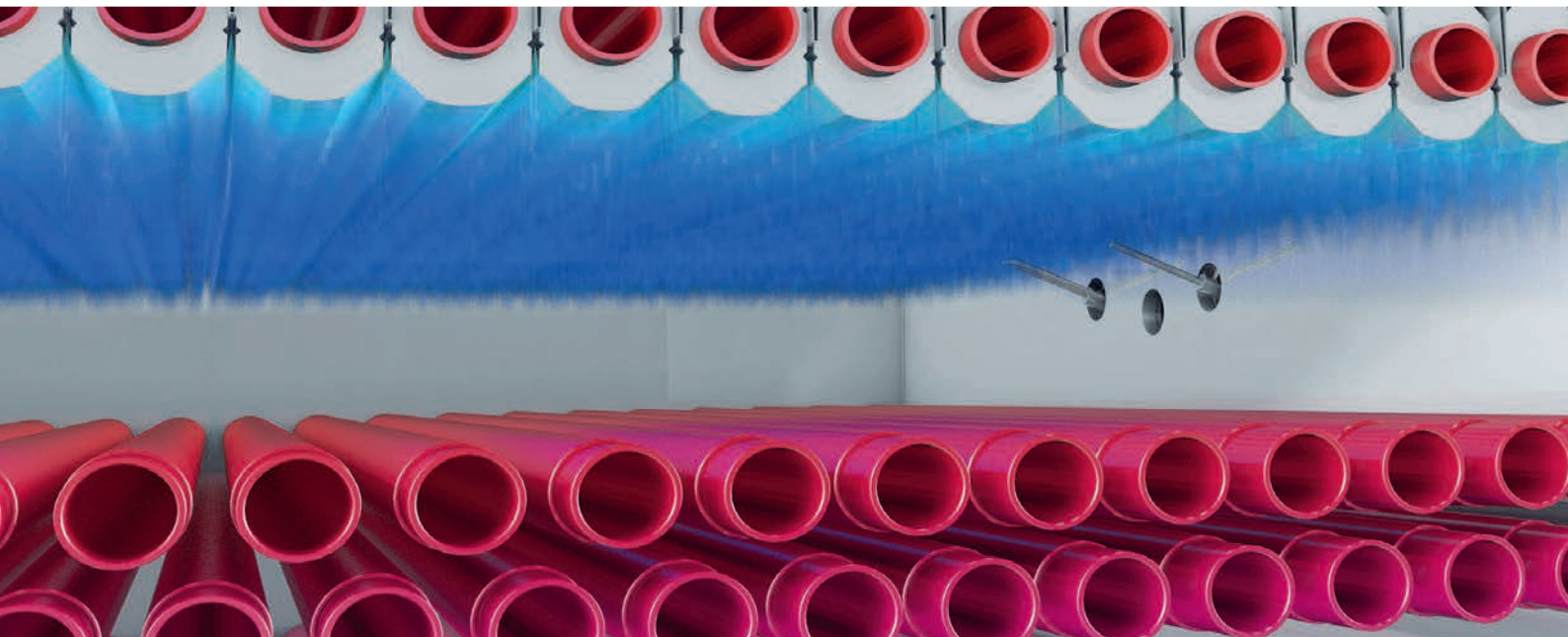
Specialists engaged early can help the project avoid potential pitfalls and ensure more robust cost planning, with clearer specifications that are thoroughly validated and understood. Important design elements that must co-exist, but that are typically assessed independently – such as energy, thermal and acoustic performance, aesthetics, installation practicalities, maintenance and cost – must be considered jointly during the design phase, to ensure that all relevant disciplines have sufficient specialist input. This will give in-depth awareness of interconnecting factors and result in a smoother, more cost-effective building process and a better outcome.

Together, we can move from acceptable to exceptional.

JULIE GODEFROY, head of sustainability development at CIBSE

Performance in operation needs to be viewed as an essential part of the service we provide, not an optional add-on.

Building projects can be really fragmented from developer to occupier, and with a multitude of consultants around the table – often not involved from start to finish – it is easy to pass responsibility to others. We need to encourage enthusiasm, a sense of ownership and an interest in how our projects develop – from early planning stages, throughout construction, and during occupation. This is more likely to happen if engineers remain involved in projects, rather than come in just for specific tasks or at specific stages.



"We should pause, reflect as a team, set a vision, agree goals and define what success means this time round" – Ed Garrod

CIBSE LIVE BUILD2 PERFORM
21-22 November 2017
Olympia, London

ED GARROD, principal at Elementa Consulting

There is no 'one thing'. Building performance is a complex system: many points of failure, many unintended consequences from many well-intentioned decisions made by many people, set against a backdrop of relentless pressures of time, money and resources.

Performance suggests rigour and independence, but – in reality – it is incredibly subjective. Should our buildings perform for their occupants, their owners, for the communities they serve, for our shared environment or future generations – or for a datapoint on a meter reading, a planning permission granted, a sustainability rating verified? Is a net-zero energy building a failure if it is unloved? Success looks different for every project, each with its own unique set of challenges.

We should pause, reflect as a team, set a vision, agree goals, and define what success means this time round.

CARLA BARTHOLOMEW, senior mechanical engineer at Arup

We need to encourage post-occupancy evaluation and soft landings on all our projects – big or small – to provide better industry benchmarks and generation of realistic data comparisons between as-designed and in-use buildings.

We need to engage our clients at initial stages, and promote the benefits of operating their buildings properly. We need to explain how employing designers to take forward their roles on projects beyond building completions will allow them to operate the systems as intended, making them more efficient.

The problem comes when we are not actively promoting this service to clients – or, as is more often the case, where clients have not allowed for it in their budgets. While post-occupancy evaluation and soft landings remain an underused project stage, the question is, who will absorb the additional costs required for this important service, to promote its benefits to both clients and the industry?

SUSIE DIAMOND and ANNIE MARSTON of Inkling


Susie Diamond

Use simulation and the energy model from conceptual design through to the end of life of the building. Once compliance and Breeam have been approved using a model, update that model to the as-built documents, and adjust it for the schedules and thermostats used for the first year of performance. This model can represent the as-designed building, against which the performance can be measured. Rather than changing the model to fit the building, the building can be changed to fit the model/design, and so improve its performance. This model can go on to be used throughout the life-cycle of the building.

CHRIS TWINN, principal at Twinn Sustainability Innovation

Building services must evolve to reflect changing client expectations and value perceptions in a world of reducing money and margins. Simply offering ever more complex and bigger systems does not provide this value – or the claimed performance. As an industry, we need to work more closely with – and trust – our partners and end users. We will quickly find their requirements are not for ever larger and more complex kit.

There are trends not being reflected in services design. For example, smart IT and LED lighting are reducing office cooling loads, and challenging traditional M&E specifications, while electric vehicles are set to remove the presumption of sealed windows to negate street pollution and noise. And when was the last time you included the structural floor slab in your cooling-reduction calculation, thereby avoiding oversized kit? As for residential properties, why specify the 32kW boiler/district heating connection, when 20 years ago it was 12kW? Is it surprising that new 'efficient' homes have a performance gap?

The Australian Nabers scheme is helping the building industry there to cut energy use substantially with simpler systems, with designers guaranteeing end energy use and so meeting client expectations.

WHEN YOU'RE SMILING

A happy society is a successful society, according to **Bjarne Olesen**, who took over as ASHRAE President at a California conference packed with presentations. **Tim Dwyer** reports

New ASHRAE President Bjarne Olesen called on the society to 'extend our community' as he took over from Tim Wentz at the summer conference in Long Beach, California.

During his speech at the Presidential lunch, Olesen – of the Technical University of Denmark – said ASHRAE's proposition 'is made stronger by global diversity', and announced the formation of a new European ASHRAE region. By working with agencies such as the United Nations Environment Programme, Olesen believes ASHRAE can forge technological developments that will improve the lives of three billion people living in poverty in developing economies – and he explicitly said the society's work and agreements with CIBSE were important to these global connections and actions.

He concluded his maiden speech by quoting Danish/American comedian Victor Borge. 'The smile is the shortest distance between two people,' Olesen said, before declaring that – without fun – the society would not enjoy continued success.

The range and number of technical presentations at the conference was astounding. Here are snapshots of just two.

Geothermal heat pumps to achieve net zero

Erin McConahey, of Arup Los Angeles, reported on an ambitious project to create the first 'net zero' public transportation centre using geothermal heat pumps, a photovoltaic (PV) system and an onsite wood-pellet boiler.

The 2,230m², two-storey Olver Transit Center – designed to link future railway and bus networks with offices on the first floor – is located in Greenfield, Massachusetts, with external design temperatures of 28°C in the summer and -14.5°C in winter. The building has carefully placed glazed elements, south and east overhangs, shading and louvres, to make the most of useful solar gain while minimising overheating. To maintain daylighting levels, the optimised glazing layout was accompanied by light tubes into the core first-floor offices. The centre was also configured with a transpired solar collector on the south face, to pre-heat the ventilation system's winter incoming air (up to 8.3°C).

The building's geothermal water-to-water heat pump draws from 22 closed-loop, 123m-deep wells, providing the cooling heat rejection for the air handling unit (AHU), as well as the second-stage pre-heating. Space conditions are maintained by 57 chilled beams and a $5m^3 \cdot s^{-1}$ ventilation system. The AHU incorporates a preheat coil (from heat pump), an enthalpy recovery wheel, a recirculation section (economiser), a heating coil (from biomass) and a cooling coil (from heat pump), with a wraparound heat pipe to enhance the effectiveness of the cooling coil. The 220kW biomass boiler is fuelled by locally sourced wood pellets made from forestry waste, and the 680m² ground-mounted PV array has an estimated annual output of 123MWh.

After one year of operation under a service contractor, the consultants were brought back in because the system was not performing as expected. They discovered that none of the metering was working properly and that some sensors had been poorly located or commissioned. The PVs were also underperforming; the summer operation was as expected, but the unusually intense snow had not been swept off the PVs, although the PV staging was designed for access. This was added to the operational procedures.

The consultants also found that lighting use was greater than expected because the photo cells had not been calibrated properly, so the lights were never fully off. Staff were also leaving external lights on for prolonged periods when not required.

Mechanical energy use was twice what had been predicted, mainly because of control problems. This included users not

> "Olesen believes ASHRAE's proposition is made stronger by global diversity"

MONEY MATTERS

At the opening plenary session of the conference, ASHRAE CEO Jeff Littleton announced that a record US$3m-plus had been contributed to the Society through the research programme and other gifts. He also revealed that 44 scholarships – totalling more than US$180,000 – had been awarded over the past year, to give financial help to young and mid-career engineers.

Convention Centre in Long Beach


New ASHRAE President Bjarne Olesen


Erin McConahey


ASHRAE CEO Jeff Littleton

Delegates took an engineering tour of the *Queen Mary*, permanently moored at Long Beach harbour

understanding how to operate systems and so manually 'adjusting' them by, for example, fixing outdoor air control dampers in the fully open position and lowering the set-point of chilled beams to increase air movement.

After retro-commissioning, the systems operated with 94% of energy being supplied from renewables (PV and biofuels). 'Net zero' will not happen, McConahey noted, unless all parties are committed – but, in any case, high-quality commissioning and proper metering are essential. She recommended the first year be treated as a period of learning, with monthly visits at least, and then regular recommissioning.

Impact of residential HVAC filters on indoor air quality

John Zhang spoke about the control of indoor contaminants. Domestic application of air systems is more common in North America than in many areas of the world but, because of rising temperatures, there is increasing global use of mechanical ventilation.

Zhang considered the typical sources of small particulate matter (PM) in homes, including smoking, air fresheners, scented candles, pets, mould, cooking and flora. With each $10\times\mu\cdot m^{-3}$ increase of PM2.5 contaminants in the air that is consistently breathed, he said, human life is likely to be shortened by more than four months. He did indicate, however, that 'normal' levels in residences were less than $5\times\mu\cdot m^{-3}$.

Zhang noted that 99% of the inhaled particles in residential applications are typically smaller than one micron (PM1) – the very particle sizes that are thought to be particularly harmful to human health. He compared various international filter-testing methods, with particular focus on the contaminants present in a domestic setting. His conclusion was that the ASHRAE 52.2 minimum efficiency reporting value (MERV) tests are a better predictor of filter performance for residential applications than ISO 16890 ones, which tend to underestimate.

Zhang believes that, because of the different operational characteristics of domestic and commercial ventilation systems – velocities, contaminants and frequency of use – there should be a separate filter-rating system for domestic systems. **CJ**

Bjarne Olesen's speech can be viewed at **youtu.be/bsbGDaIKVdA**, and conference sessions can be accessed at **www.ashrae.org** – for which a paid registration is needed.

THE ART OF RESTORATION

Timber-lined ventilation ducts helped spread the fire that destroyed large parts of Glasgow's Mackintosh Building – but those very same ducts have been given a key role in the building services of the refurbished landmark, says **Andy Pearson**

Above: Phase 1 of the restoration focused on making the building watertight

On 23 May 2014, fire spread rapidly through The Glasgow School of Art's (GSA's) hallowed Mackintosh Building, completed by architect Charles Rennie Mackintosh in 1909.

The fire began in the basement of this Scottish art nouveau gem, and quickly moved upwards – through three levels of studios – and outwards, to the first-floor library. Although the blaze was brought under control relatively quickly, significant damage was done to the historic studios and stairways of the grade A-listed building, and the renowned Mackintosh library was destroyed.

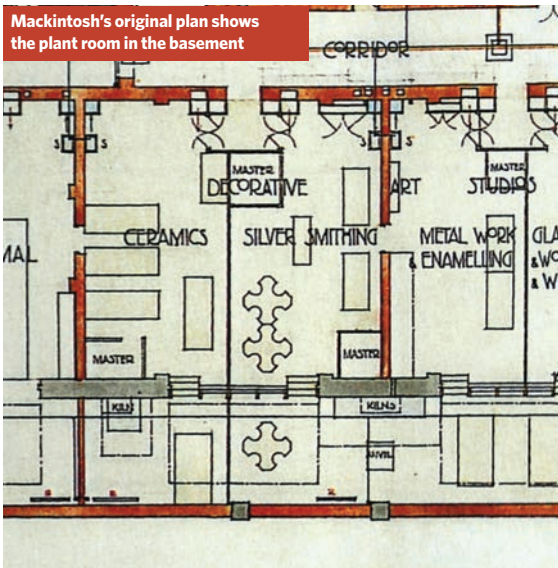
Scottish Fire and Rescue Service's report said the fire started close to a hot projector. The report also found that the design of the building contributed to the spread of fire, as there were a 'number of timber-lined walls and voids, and original ventilation ducts running both vertically and horizontally throughout the building'.

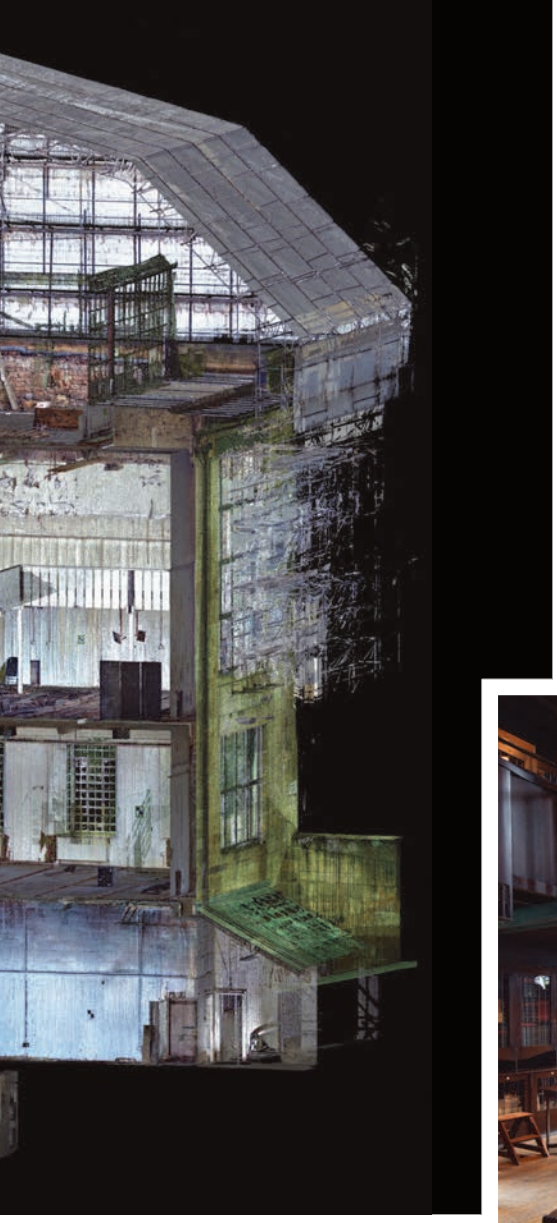
Three years after the blaze, those same timber-lined ventilation ducts form a key element of engineering consultant Harley Haddow's building services strategy for the property's refurbishment. The design team for the restoration is being led by Page\Park Architects, who have worked closely with experts at the GSA researching both original documentation and what the fire has revealed about the design of the building.

PROJECT TEAM

Client: The Glasgow School of Art
Design team lead: Page\Park
Project manager & QS: Gardiner & Theobald
Building services engineer: Harley Haddow
Structural engineers: David Narrow Associates
Lighting design: KSLD
Main contractor: Kier Scotland
Building services contractor: Forth Electrical Services

Mackintosh's original plan shows the plant room in the basement



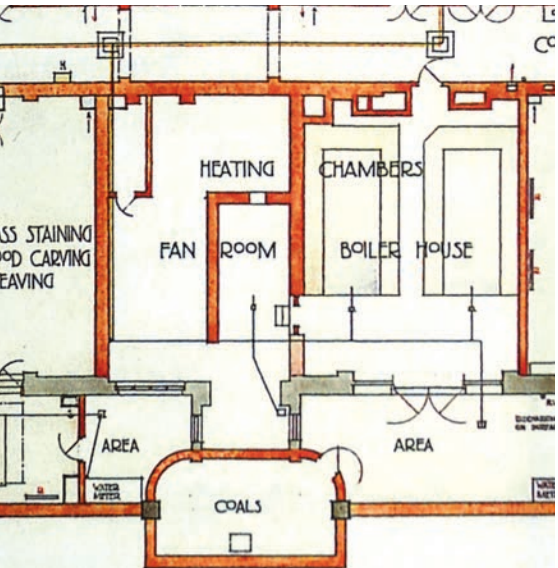


Above: The aftermath of the 2014 blaze at The Glasgow School of Art's Mackintosh Building and, left, the original library

'A key aspect of the project is The Glasgow School of Art's decision to restore the building to Mackintosh's original design while providing an energy efficient, technologically advanced and flexible teaching environment for today's students,' says Mark Napier, a director at Harley Haddow. Napier has drawn on more than a decade of involvement with the Mackintosh Building to develop the design.

Harley Haddow's first experience of 'The Mack' was in 2006, when it worked with Page\Park Architects to remodel part of the building to create a furniture gallery and shop, relocate the reception, install an archive store in the basement, and fit a new piped radiator heating system. Subsequent works in 2008 involved the removal of some of the mezzanine floors that had been added to the studios over the years. Fan convectors – installed in the 1980s – were also stripped out to take the studios back to their original form.

Over the next few years, Harley Haddow's ongoing involvement with The Glasgow School of Art resulted in the consultant doing 'small bits and pieces'. Its next major project was the installation of a fire-suppression system. The GSA needed a solution that was appropriate for a Category A-listed building, so it opted for a high-pressure-mist fire-suppression system to help protect the building. Work on this was not completed at the time of the fire.



Using Mackintosh's original drawings

Afterwards, Harley Haddow returned to the building as advisers to the fire scientists who had been commissioned by the School's insurers to investigate the incident. 'We spent a lot of time helping them to understand how the original ducted warm-air heating solution worked, and how these ducts might have contributed to the spread of fire through the building,' says Napier.

Mackintosh's original drawings showed the building's central spine wall to be perforated by scores of these brick-lined flues rising vertically upwards from the basement. They also depicted a further series of ducts rising from the rooms and studios, and terminating at roof level. 'The drawings were pretty accurate, although not »

» everything was on the drawings, so Harley Haddow had to survey the building,' Napier explains. 'The survey even included dropping plumb lines down some of the ducts to confirm their routes.'

The ductwork system was intended by Mackintosh to heat and ventilate the school with filtered, tempered air, which would avoid the need to clutter the interior with large, unseemly radiators. Fundamental to the system is a brick-built air shaft, which runs below the floor the length of the basement. It is, in effect, a giant air plenum. From the top of this shaft, 'hundreds' of wood and brick-lined flues duct air vertically up through the building.

'Every room has at least one air duct terminating inside of it,' Napier explains. Harley Haddow modelled each and every duct in a 3D Revit model (see Figure 1).

The tempered fresh air is delivered to the rooms by these ducts. The system was designed to supply $36m^3 \cdot s^{-1}$ of outside air, drawn from light wells either side of the main entrance and pushed into the basement air shaft by two large, belt-driven centrifugal fans (which are still in place). When the School of Art was constructed, Glasgow would have been a sooty, industrial city so the system used horsehair to filter the outside air. If needed, the filters could be sprayed with water to create a rudimentary humidification and cooling solution. The cleaned air could then be warmed as it passed over a series of steam coils fed with heat from a coal-fired steam boiler. Records show the tempered fresh-air system was installed in two phases by the Glasgow firm of James Cormack & Sons for the sums of £1,454 and £716.

Ahead of its time

In addition to the ducted air supply from the basement, the rooms feature wooden ducts that rise up through the building to vent air out. These exhaust-air ducts terminate either at roof level or at a louvred section set into the rear wall of the building above the ground-floor central corridor. In many of the rooms, the exhaust ducts are fitted with two grilles, one close to the ceiling and one near to the floor. 'The idea is that, in winter, a damper on the high-level grille is closed to force the warm air down into the room; in summer the top grille is opened to let warm air escape from the room,' says Napier.

This innovative environmental engineering system was, perhaps, ahead of its time. 'There were a lot of letters between the contractor and The Glasgow School of Art about there being too much heat

THERMAL PERFORMANCE

Under the refurbishment, improvements have also been made to the thermal performance of the building's envelope, including double-glazing the large, distinctive, north-facing windows that dominate the Renshaw Street façade. Enhanced thermal performance of the glazing will enable the studios to be heated by radiators alone. Each studio will also be supplied with tempered fresh air ducted from the basement supply duct. 'They will get two air changes per hour, which is enough fresh air for 30 people without the need to open windows,' says Napier.

A digital scan of the Mackintosh before the refurbishment

"The restoration is an opportunity to take the building back to the Mackintosh original conception by removing later additions and modifications to the spaces"

in some rooms and too little in others, especially the library,' adds Napier. There is even a note of the scheme's coal consumption, which averaged 13.5 tons per week while the system was being snagged from 31 January to 5 March 1910. The same note goes on to say: 'We [the GSA] are inferred by the contractor that this is a very moderate consumpt [sic] of coal.'

Regardless of its coal consumption, the system could not be made to work effectively, so was abandoned in 1920 and steam-fed radiators installed in its place. In 1986, these were also supplanted, by a low pressure hot water (LPHW) system of cast-iron radiators and fan convector heaters, and it was this set-up that Harley Haddow's LPHW heating system was designed to replace in 2008. Now, under the restoration works, this scheme is being largely superseded too.

'The 2008 system was installed in a live building, so the GSA is taking full advantage of the restoration project to conceal the pipe routes and remove the radiant panels from the large studios. As the thermal performance of the building's fabric has been improved, some of the radiators are now smaller,' says Napier.

Return of the Mack

The initial focus of the restoration was on repairing the fire-damaged building envelope to make the building watertight. Work to restore and upgrade the building interiors is now taking place. For the GSA, the restoration is an opportunity to take the building back to the Mackintosh original conception by removing later additions and modifications to the spaces. At the same time, the restored building needs to function as a facility for today's students. »

» 'The Glasgow School of Art's philosophy is to bring the building back to its original design, but to make it function as a modern art school,' says Napier, 'which is an interesting brief for the design team because the GSA needs power, data and LED lighting, while – at the same time – respecting Mackintosh's original.'

The School of Art was one of the earliest buildings to feature an electric lighting system. Now, more than 100 years later, the Mackintosh Building is being fitted with a state-of-the-art, LED-based lighting scheme, designed by consultancy KSLD. It is intended to offer flexibility of use within the studio spaces, which can range from fine art to computer labs, and can also be configured as exhibition spaces.

Reusing timber ducts

The GSA's quest to be true to Mackintosh's original conception involves resurrecting the abandoned timber-ducted ventilation system. This time round, though, it will only be used to supply heated fresh air to studios, the library, the Mackintosh Room and lecture theatre – and, rather than relying on two giant centrifugal fans, two air handling units (AHUs) will each deliver $3m^3 \cdot s^{-1}$ of air. The original fans will remain in place, so the AHUs will push air over them and into the basement air duct.

'We'll only be pushing $6m^3 \cdot s^{-1}$ of fresh air into the basement air duct to provide ventilation air for the occupants, not $36m^3 \cdot s^{-1}$ like in the original scheme,' says Napier. All remaining ducts not being used – which Napier describes as 'a lot' – will be closed up.

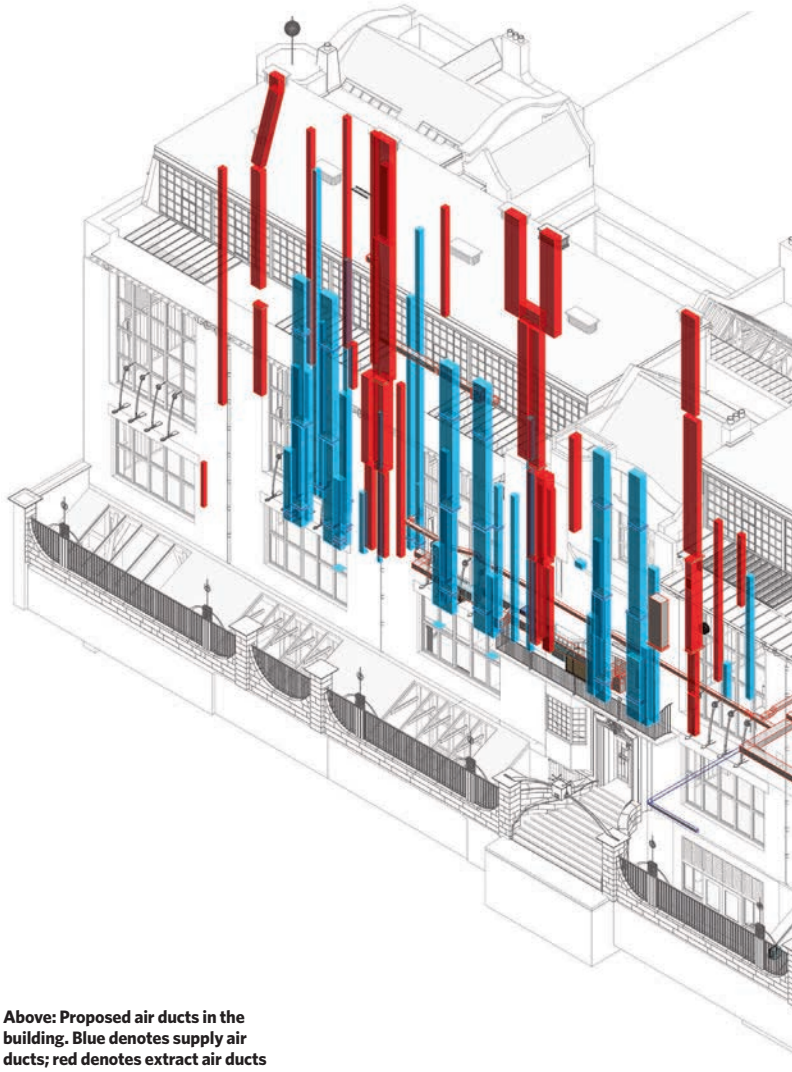
As with Mackintosh's original scheme, the system is full fresh air; unlike the original, however, Harley Haddow's solution will include heat recovery. Heat will be recovered from the exhaust air by connecting the original extract ducts to an existing plenum duct, located above the ground-floor corridor ceiling. This duct is then routed back to the basement, via the old steam-boiler chimney, from where it will pass through the thermal wheel heat recovery units installed in the space previously occupied by the steam heating coils.

Harley Haddow's scheme supplies just enough heated fresh air for ventilation and to assist with space heating. The main heating will be provided by underfloor heating or an LPHW radiator system. In a nod to the original, for example, the entrance foyer will have underfloor heating. With Mackintosh's warm-air ventilation system, the foyer

> "The philosophy was that the floor would be heated from below, by heat given off by the boiler and hot coils"

£2,170

The total cost of the tempered fresh-air system, installed over two phases during the building's original construction in 1909



Above: Proposed air ducts in the building. Blue denotes supply air ducts; red denotes extract air ducts

The library in the west wing of the Glasgow School of Art

was located directly above the basement space containing the steam boiler and heating coils.

'The philosophy was that the floor would be heated from below, by heat given off by the boiler and hot coils,' says Napier. Now, with the boiler no longer in place, a new underfloor heating system will warm the floor instead.

The heating strategy

Underfloor heating will also be installed in the restored library. The original building design had the library heated using the warm-air system alone. However, letters from the School to the original contractor indicate that this solution did not work as intended and radiators were installed to improve comfort, and then the warm-air system was later abandoned.

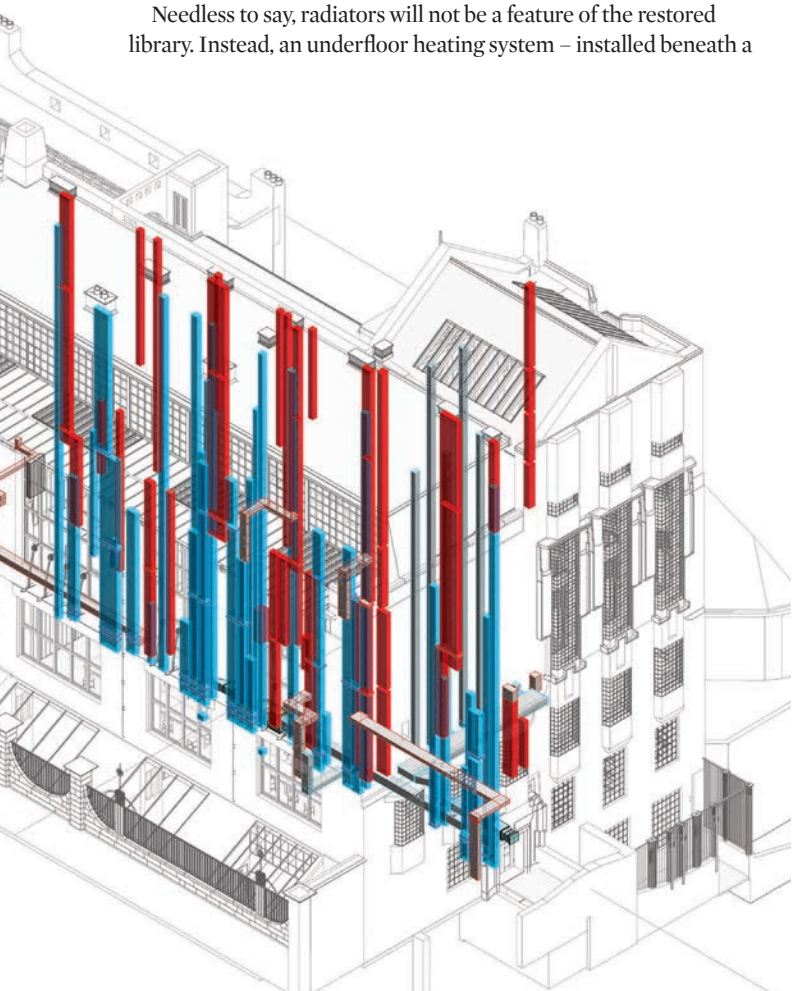
Needless to say, radiators will not be a feature of the restored library. Instead, an underfloor heating system – installed beneath a new floor – will heat the space. Additional warmth will be supplied by a fan heater – a duct mounted fan, low temperature hot water heating coil and air filter assembly – concealed in the basement service shaft, and ducted up to the room using the existing 1910 brick air ducts and grilles that previously served the library. The heat source for the fan heater is from the building's heating system.

A similar solution of underfloor heating and concealed fan heater will be used to heat the Mackintosh Room. This is situated on the east gable, directly opposite the library in the west, and is often referred to as the 'Mack Room'. It was named on Mackintosh's drawings as 'Design Room'.

The quest for originality does not stretch to the use of coal, however. In a much more environmentally friendly solution, heat for the Mackintosh building is now piped from an adjacent building containing gas- and biomass-fired boilers.

Again, Mackintosh's forest of timber ducts are a key part of the refurbishment. 'The timber ducts that run up through the building are now being used as routes for new power and communications cabling, along with pipework for a new mist fire-suppression system,' says Napier.

'And, of course, we'll be fitting the ducts with fire dampers and fire stopping.' CJ



DIGITAL MODELLING

The restoration works are modelled in Level 2 BIM after a cloud-point survey was undertaken of the fire-damaged building by specialists in 3D visualisation in the GSA's School of Simulation and Visualisation. 'BIM was necessary because much of the interior is being rebuilt. We're having to use the model to plan the new integrated, concealed service routes and individual conduit runs,' says Napier.

SMART ABOUT METERING

Good communication helped Carbon2018 and The Crown Estate execute best practice and install a full metering system that meets building users' needs at their new London development. **Joanne Merry** reports

Located off Regent Street, London, is the site of 1 and 2 St James's Market, a joint venture between The Crown Estate and Oxford Properties. It comprises two buildings – with 19,500m² of office accommodation, six flagship stores and seven restaurants – set within revitalised public spaces, including a new square and art pavilion. The project included the installation of a full metering system to comply with Part L of the Building Regulations and to meet the operational requirements of the property after completion. Carbon2018 was commissioned as metering consultants, and the metering strategy review requirements, throughout all stages of the project, were clearly defined at the outset (see Figure 1).

Metering strategy

Step 1: Objectives – Determining the desired outputs

Objectives and desired outputs underpin any successful metering strategy. When setting out the objectives, it was necessary to engage with all stakeholders, including: the design team; the main electrical and mechanical contractor, and appropriate subcontractors; the managing agent; and Carbon2018.

Step 2: Select the metering boundary

It was important to ensure energy use was captured across the whole St James's Market site, including the square's external lighting. The metering was to encompass electricity, gas, heating, cooling and water for the services that fall within the boundary line (see Figure 2).

Steps 3-4: List all energy imported and exported across the boundary, and all energy-using items within the boundary

Each of the two buildings has its own incoming utility supplies and central plant services; from an energy perspective, there is no cross-over between the properties. Both buildings have photovoltaic (PV) solar panels on the roof, and 1 St James's Market has a combined heat and power (CHP) unit, so there is generation of power on site. The capacities of this equipment have been sized to support the buildings'

Stage	Output	Review requirements
Concept	Draft strategy	Landlord (TCE) review of metering strategy
Developed design	Final strategy	Landlord (TCE) /managing agent review metering specialist review of metering strategy
Technical design	Tender specifications	Metering specialist review of metering strategy /tender specifications
Construction	Tech submittals & commissioning procedures	Metering specialist review of meter technical submittals and commissioning procedures
Commissioning	Independent verification	Metering specialist independent verification of metering

Figure 1: Metering strategy review requirements and definition of responsible parties

base-load power, and there will be no export of energy back to the grid. The only energy crossing the boundary is from the incoming gas supply and grid power supply to each block.

A list of the main end-use categories inside the boundary was developed and the typical energy flows through the building identified (see Figure 3). This included inputs and outputs of central plant where transformation of primary energy to secondary energy takes place. Following the energy flows through, it was clear that the CHP adds complexity to the meter requirements, as gas is used on site to generate heat and power, and the quantities of each needed to be tracked.

Step 5: Decide which items to meter

The initial metering strategy was developed as part of the base-build electrical and mechanical design. At this stage, the scope appeared comprehensive, with 90% of the energy for end-use categories metered and heat meters for the floors. The strategy included: electrical meters to record power and lighting; heat meters for low temperature hot water and chilled water energy use; water meters; and oil meters for the standby power capacity offered by the generators. A review was done and further meters added to ensure all objectives were met.

Step 6: Select meters and the automatic meter-reading (AMR) system

Meters approved by the Measuring Instruments Directive (MID) were chosen, as the property will be multi-occupied, so has a requirement for the re-charging of energy costs. Additional considerations were:

> "The CHP adds complexity to the meter requirements, as gas is used on site to generate heat and power"

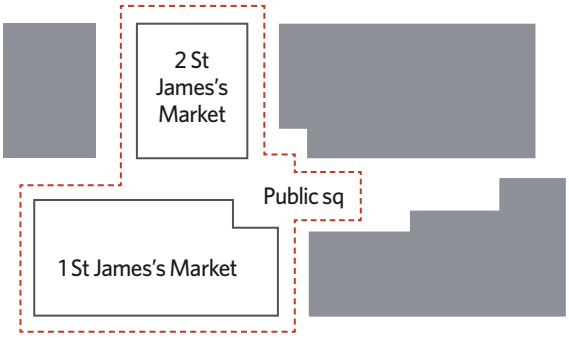


Figure 2: Graphical representation of metering system boundary (*plan not to scale*)

Electricity meters:

- Meters that meet, as a minimum, IEC 62053-21 accuracy class 1, and current transformers (CTs) meeting IEC 61869-2 class 1 accuracy, were selected because of the importance of high accuracy for billing
- The registers provided by different models of electricity meters

Heat meters:

- Inline, ultrasonic-type heat meters were selected because of their accuracy
- Meters were bought as a single package – inclusive of flow part, temperature probes and calculator – to ensure there were no issues with compatibility, and calibration of the calculator, with the other components
- Meters were sized according to flow rate, to ensure they record accurately, as mechanical meters specify minimum and maximum flow-rate thresholds within which they will operate correctly.

The AMR systems had to be able to pick up pulse outputs from the water and gas meters, and Modbus protocol from the electricity and heat meters. A hardwired system was chosen to ensure reliability of communications between the meters and logging equipment.

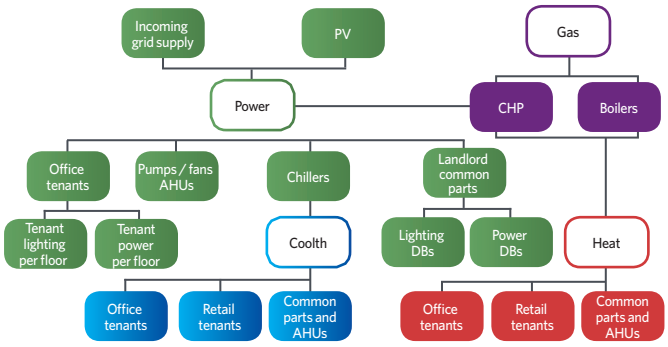
A connection was made to the internal LAN »

METERING BENEFITS

The key outputs that will be derived from the system installed at 1 and 2 St James's Market include: customer billing, with full and transparent backing data for tenants; a monthly energy-performance dashboard, indicating actual building performance against predicted; and exception reports/alarms, to highlight any anomalies and issues, so that these may be acted upon to minimise wastage.

Joanne Merry, technical director for Carbon2018 and metering consultant on the project, said: 'Implementing a best-practice approach that uses the objectives to inform the strategy, incorporates all relevant stakeholders' views, and includes regular reviews/updates throughout the life of the project, has resulted in a system that met the needs of building users and other relevant stakeholders once the site was operational.'

1 St James's Market – energy flows



2 St James's Market – energy flows

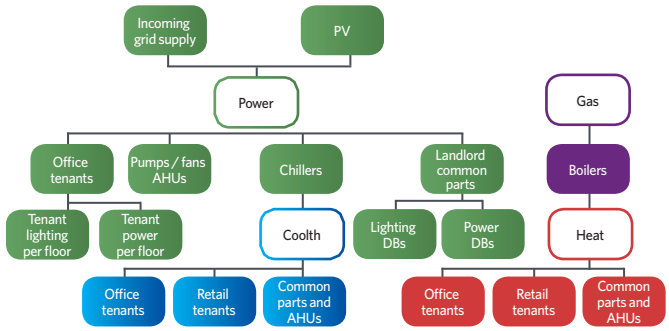


Figure 3: Main building energy flows – 1 and 2 St James's Market

» system, which has a broadband link to enable remote access and export of data. Separate onsite head-ends were supplied, specific to each building. A dashboard function allowed the onsite building manager to analyse and manage energy on a day-to-day basis.

Step 7: Decide on location of meters

The meters on the main office floors were located within the risers, for easy access. They could be found in the same position on each floor, at a height that allows readings to be taken without the need for stepladders. Additional meters – within the plantrooms and electrical switchroom – were also in easily accessible areas. For mechanical meters, consideration was given to orientation, to ensure they are at the most appropriate angle to be read while complying with the installation requirements.

Step 8: Review the metering strategy

A full review was completed at design stage, with input from all stakeholders who would need to use the data output. Several reviews were undertaken during the project, as illustrated in Figure 1. This was important because modifications were made that had a knock-on effect on the metering. The initial review focused on the position of the metering, but – as the project progressed – it was necessary to review the type of meters being used. Technical submissions were analysed and approved to ensure they met the agreed requirements. Commissioning procedures were also examined to ensure they reflected the specific meters installed, and that building users were left with a system that delivered in practice. Agreed changes and updates were clearly documented, with amendments made to the drawings and schedules.

Step 9: Implement and commission the metering

Most manufacturers stipulate that flushing water-based systems during commissioning could damage heat meters, so flushing is typically done with spool pieces installed. These are replaced with meters once flushing is complete and, as a result, meters are often one of the last items to be completed and commissioned. Independent checks were carried out by Carbon2018, to verify that meters had been correctly installed and commissioned, and were in line with the specification developed during the project. Any issues were logged, with an agreed action and timescale, and then rechecked after remedial work. Periodic meter verification will be done, to ensure their accuracy is maintained.

Step 10: Document the strategy

Full documentation relating to the metering system was drawn up for inclusion in the logbook and operation and maintenance (O&M) manuals. This included:

- A full meter schedule
- As-installed schematic drawings, with meters labelled to match the schedule and AMR system
- Floor plans indicating the physical location of the meters and data-collection devices, for ease of ongoing maintenance
- Meter data sheets and technical information
- Commissioning records for each meter. CJ

JOANNE MERRY is technical director at Carbon2018

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Cost Model

Containerised living

Shipping containers are increasingly being repurposed into cost-effective urban homes for the UK's towns and cities. The specialist residential MEP team at **Aecom** considers the potential growth of the market for these recycled homes

Over a short period of time the vocabulary associated with housing has undergone a step change. With the unrelenting upwards march of house prices, and the lack of new, affordable housing and finance available to first time buyers, unfamiliar terminology has crept into the vocabulary of the construction industry. Whether it's tiny living, modular construction or containerised living, the question still remains –how does this solve our need for housing?

Prefabrication and modular are not new ideas; the post war years saw a major push that raised issues of poor performance and quality of construction. More recently the use of modular or flatpack housing has been carried out by a few innovative builders but on a small and often personal scale.

Now we are seeing a fundamental shift in the way people view housing, how that space is designed and constructed, and how it will be used by the owner. First time buyers are looking for a modern approach, living in properties complete with common areas, gyms, rentable office suites, and communal kitchens.

This in turn has reduced the desire for actual living space.

DATA

Number of units: 30
Unit type: Studio
Tenure: Social
GIA: 1,250m²
NIA: 1,040m²

External works for 30-unit studio development

	Cost model
	Total £
Lighting and power to bin store and cycle store	£3,366
External lighting to building and landscaped areas	£16,830
Incoming services for foul water disposal, electrical, communication ducts and infrastructure charges for water and disposal	£89,087
Total external works	**£109,283**

Current situation

This new solution is now providing an affordable, modern and sustainable building method as schemes often utilise unwanted shipping containers. Wenckehof, a 1,000-bed multi-storey container estate in Amsterdam, and the under-construction CPH Village in Copenhagen are prime examples. Both are aimed primarily at young people as a direct response to the lack of affordable housing. CPH set itself the target of supplying 2,500 homes in Copenhagen by 2020, with the first homes due to launch this year.

Quality issues have long been eradicated – today's offerings are credible, with the ability to deliver a product to market by overcoming supply issues from the raw materials to labour. The use of specialist factories, robots and computer numerical control (CNC) machines are now commonplace.

Site wastage is heavily reduced and with 'Just in time' delivery in place, storage onsite is minimised. Off-site production also cuts the need to work in difficult weather conditions, and reduces noise pollution.

Containers, used as temporary housing, can enable a valuable solution for disaster relief in the form of medical clinics and first aid shelters. They may even help address homelessness.

The government is showing an interest, notably in the potential for upping housing delivery and closing the gap between supply and demand. Add to that the prospect of mitigating the industry skills shortage – not to mention an estimated 20-30% decline in skilled labour over the next decade caused by migration and retirement – and it's no wonder containerised construction is a hot prospect.

Services design

To make the most of the limited areas, design is a vital step in creating the most efficient living through ingenious use of space. Services distribution is routed externally for rain and foul water disposal, boosted

cold water and electrical installations.

The containers operate an all-electrical system for both hot water and heating.

The highly insulated containers, along with factory quality detailing, allow the installation of minimal heating requirements – a typical studio's heating requirement is circa 1,000 watts. The largest requirement for electrical power is the generation of hot water so, in order to restrict it, low water use fittings are installed in the kitchen and bathrooms. While 30-minute morning showers may be a thing of the past, it means cheaper utility bills.

Cost model

The cost model is based on a small-scale social development on a brownfield site in London within zone 3. There are 30 studio apartments arranged over three floors, with open walkways, a single open central stair and a single 13-person lift. The fit-out element includes electric underfloor heating, electric hot water generation, MVHR, plumbing installations and electrical installations. The price date for the cost model is second quarter 2017. The model excludes main contractors on costs, risk, VAT, design fees and land acquisition costs. CJ

ABOUT THE AUTHORS

Authors Garry Burdett, Andrew Freeman and Rebecca Turner are part of the specialist MEP cost management team at Aecom engineering services, whose cost-management group specialises in the cost estimating, procurement and cost management of building services installations.

AECOM

Shell and core cost of 30-unit studio development

Shell and Core (GIA 1,250m²)	Cost model	
	Total £	£/m² of GIA
Disposal installations – Rain water: Fusion welded HDPE vertical pipe work to roof and walkways, connection to rain water outlets	£4,860	£3.89/m²
Disposal installations – Foul water disposal: Fusion welded HDPE vertical pipework, associated ventilation stacks, connection to apartments and fire stopping	£15,820	£12.66/m²
Water installations – Incoming main, primary meter, GRP storage tank, booster pump set, electo-magnetic water treatment, stainless steel pipework, tenant sets and meters, valves, insulation, CAT 5 installation	£40,852	£32.68/m²
Space heating and air treatment – Electric heating to plant room	£1,122	£0.90/m²
Electrical installations – LV installations: Primary LV panel, landlord lighting and power cabling and distribution boards, containment, power to lift and mechanical installations	£27,730	£22.18/m²
Tenants' power installations – Ryefield panel installation, cabling and meters	£25,245	£20.20/m²
Lighting – Cabling, light fittings, emergency lighting, photocell, time clock and PIRs	£21,374	£17.10/m²
Power – Power for maintenance and cleaning, cabling, outlets and containment	£3,000	£2.40/m²
Earthing and bonding – Clamps and cabling to metal work	£2,805	£2.24/m²
Lifts – One 13-person lift, 1m/s, standard finishes	£46,000	£36.80/m²
Protective installations – Dry riser: Breaching inlet, pipework and landing valves	£5,834	£4.67/m²
Lightning protection – Air terminals, rooftop network, down conductors and earth pits	£5,610	£4.49/m²
Communication installations – Fire alarms: Break glasses, sounders, detectors and cabling	£5,610	£4.49/m²
Satellite and TV – Rooftop satellite/aerial, cabling, containment splitters and distribution to apartments	£28,583	£22.87/m²
Entry System – Videophone entry panel to main entrance gate and rear entrance gate, CAT 6 cabling and equipment	£25,806	£20.64/m²
Security installations – CCTV to front and rear entrance, externally mounted cameras, cameras to walkways, access control to lift, bike store and bin store	£38,541	£30.83/m²
Controls – Basic controls installation to landlord plant	£16,830	£13.46/m²
Special installations – PV to roof areas	£15,147	£12.11/m²
Builders Work in Connection – Holes, secondary metal work, cat ladders, plinths, etc	£8,264	£6.61/m²
Total Shell and core costs including sub-contractor preliminaries	**£339,033**	**£271.22/m²**

Fit out of 30-unit studio development

Fit out (NIA 1,040m²)	Cost model	
	Total £	£/m² of NIA
Sanitary ware – Close-coupled WC, plastic insert WHB, plastic shower tray, shower screen, bright chrome brassware	£71,588	£68.83/m²
Disposal installations – Solvent welded UPVC pipe work to sanitary white, washing machine and condensate drain to MVHR	£16,110	£15.49/m²
Water installations Plastic pipework for hot and cold water to sanitary ware, kitchen and washing machine, insulation and electric hot water storage cylinder	£95,280	£91.62/m²
Space heating and air treatment Electric underfloor heating to the bedroom, lounge and kitchen area including electric towel rail to bathroom	£42,150	£40.53/m²
Ventilation installation MVHR, plastic ductwork, exhaust / supply grilles and connection to external façade	£80,880	£77.77/m²
Electrical installation Consumer unit, white plastic electrical accessories, twin and earth cabling laid loose on ceiling and within walls, recessed LV downlighters, earthing and bonding	£75,780	£72.87/m²
Communication installations Fire alarm, TV outlet to lounge and bedroom, master telephone point, telephone to lounge, black and white videophone entry	£34,980	£33.63/m²
Builders work in connection – Holes, pattresses and the like	£12,510	£12.03/m²
Total fit-out costs including sub-contractor preliminaries	£429,278	£412.77/m²

	Cost model
	Total £
Total MEP construction costs (Shell core, fit out and external works)	**£877,594**
Total cost per apartment	**£29,253, £702.08/m²**

MAKING THE GRADE

New ventilation guidelines will have a significant impact on the design of schools. **Liza Young** finds out how the requirements on air quality affect three ventilation strategies

New guidelines on air quality in classrooms come into force later this year and are set to redefine ventilation in schools. Building Bulletin 101 (BB101) *Guidelines on ventilation, thermal comfort and indoor air quality in schools* has introduced a new category for ventilation – hybrid – in addition to the current mechanical and natural ventilation definitions.

'Hybrid' applies to systems that may be passive for the majority of the time, but that use fans if environmental conditions don't allow classrooms to meet BB101's temperature and carbon dioxide (CO_2) requirements using unassisted ventilation.

The new guidelines place tougher demands on ventilation strategies, and will have a significant impact on the design, specification and construction of schools in the future.

Air quality and thermal comfort are crucial for any building. On warm days, there are many benefits to natural ventilation – plenty of fresh air and a connection with nature. However, in cooler weather, some ventilation experts say a purely natural system can struggle to supply sufficient fresh air without causing unwelcome cold draughts. Others argue that draughts can be countered using heat recovery within natural systems.

BB101 CHANGES AT A GLANCE

Mechanical systems – which use a fan to drive in airflow – must adhere to a daily average of 1,000ppm CO_2. Natural ventilation systems cannot exceed a daily average of 1,500ppm CO_2.

The degree of excursions has been restricted, too. CO_2 levels can reach 2,000ppm for no more than 20 consecutive minutes in a given day.

The guide has also introduced the concept of adaptive thermal comfort, in line with CIBSE TM52 *The Limits of Thermal Comfort: Avoiding Overheating in European Buildings* – so the temperature threshold can change on a daily basis, depending on external conditions.

In criterion one, BB101 states that the number of hours the predicted operative temperature exceeds the maximum acceptable operative temperature by 1K or more must not exceed 40 occupied hours.

Types of ventilation

BB101 outlines a range of ventilation strategies – from completely natural to totally mechanical. The type of strategy that can be used will be determined by the constraints of the classroom's design.

Traditionally, natural ventilation – where the driving force for the supply of fresh air is wind and buoyancy – has been the standard solution for schools. It involves openable windows, or natural ventilation openings, and chimneys with manually operated dampers. But limited control options – for example, opening or closing windows – mean that, in more extreme weather or occupancy conditions, the space may be unsuitable for this type of ventilation. There are also limitations on the depth of room that can be naturally ventilated using passive means, and – depending on the external environment – there are potential challenges with noise and pollution ingress.

Mechanical ventilation gives a controlled supply and extract airflow, enabling a basic control of room temperature, humidity and air quality. The systems can be designed to allow local regulation – installing a responsive system using automatic or manual controls – and to deliver reasonable thermal comfort via heat exchangers.

A hybrid – or mixed-mode – system introduces outdoor air into a building by mechanical and passive means. These systems employ »

Ventive's system is installed at the Cullum Centre at Salesian School in Chertsey, Surrey

» natural driving forces of the wind and the stack effect, and fans when natural forces alone do not result in the thermal requirements being met.

BB101 points out that there is a wealth of combinations on the spectrum between natural and mechanical ventilation.

The limits

According to the updated guide, mechanical systems – which use a fan to move air – must adhere to a daily average of 1,000ppm CO_2, while their natural-ventilation counterparts cannot exceed 1,500ppm CO_2.

The document has also restricted the degree of excursions – CO_2 levels are allowed to reach 2,000ppm for no more than 20 consecutive minutes in a given day.

The reason for the difference in design maximum target levels for CO_2 is that the variability of natural driving forces is much greater than that of a mechanical ventilation system, according to Annex A of BB101.

Whereas mechanical system fan speeds accelerate rapidly with rising CO_2 levels to stay within the allowable range for indoor air quality (IAQ), natural ventilation is much more variable through the year because of the changing weather conditions.

Colin Biggs, technical director at Nuaire, says the more onerous target for mechanical systems creates a bias towards natural ventilation. 'The issue is that higher CO_2 levels have a short-term effect on academic performance – for example, during a lesson – so the use of average levels is surely not an appropriate measure. But if these higher CO_2 levels are deemed acceptable, why not apply them to mechanical systems as well?'

Biggs says that, in a mechanical system, if the CO_2 levels were allowed to drift to 1,500ppm, the design fresh-flow rate could reduce from 8 $L{\cdot}s^{-1}$ per person to 5 $L{\cdot}s^{-1}$ per person. 'This would translate into a fan-speed reduction and, therefore, an electrical-power reduction of around 70%. Noise levels would also reduce – by around 10dB – as would the capital cost of the system,' he says.

> "System choice should be based on thermal comfort, air quality and energy efficiency, as well as acoustics"

Natural ventilation

Tom Lipinski, technical director at Ventive, says natural ventilation – unlike mechanical systems – has no running or maintenance costs. 'They are not dependent on factors such as regular maintenance and electricity supply,' he says. 'If you combine that with heat recovery – so reducing heating costs in winter – you have the best of both worlds.'

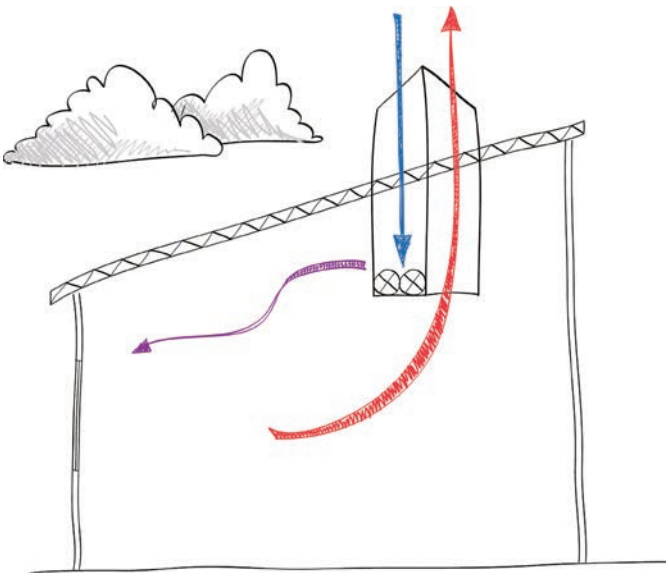
Ventive's system combines traditional stack ventilation on the roof with heat recovery, and façade openings to prevent overheating. It works when the heat exchanger inside the stack captures heat from the stale exhaust air, and uses it to warm up the supply air. Only 60-70% of the heat is extracted so enough buoyancy is left to keep air moving. Lipinski says the two air streams are kept separate, so the stale air does not contaminate the incoming air.

The drawback of natural ventilation systems is draughts in winter, but Lipinski says: 'We don't have that problem, because the incoming air is pre-warmed by the exhaust air.'

BB101 says the elimination of cold draughts in winter and in mid-season is a major design consideration for classroom ventilation systems, because the spaces have relatively low ceilings and high flow rates are required because of occupation density. Many naturally ventilated schools that could achieve the air-change rates in winter fail to do so because teaching staff do not open windows, to avoid draughts.

Lipinski says Ventive's system is constrained in May and June, when wind and buoyancy are limited, and outside temperatures are equal to inside ones. But he says the system can be put into purge-ventilation mode by opening façade louvres.

However, Shaun Fitzgerald, CEO at Breathing Buildings, says a natural system would not have enough driving force on a warm windless day to aid airflow, unless the air has very large areas to travel through – which can make the system expensive. He says system »



Breathing Buildings' system pre-mixes incoming air with interior air

air diffusion

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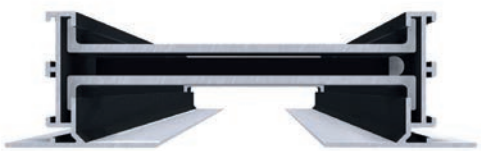

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FlowBar can provide straight lines or curves to blend with other architectural elements and enhance the overall concept of the project.

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Swegon
Air Management

» choice should be based on thermal comfort – in both summer and winter – air quality and energy efficiency, as well as acoustics.

Although a school near a noisy road can be naturally ventilated, the amount of acoustic attenuation needed would make the cost of the system prohibitively high, Fitzgerald says. Road traffic also means air pollution, so façades facing onto busy roads will probably be ventilated using some form of mechanical system that offers filtration. Quieter façades can rely on passive means.

'Different parts of schools might have different challenges, so there is not just one solution,' says Fitzgerald. 'Acoustics might be an issue on one side, architecturally landlocked rooms on another. Or there may be no roof access, so large ducts have to penetrate the building, meaning natural ventilation becomes inordinately expensive. The right answer might be a mixture of systems.'

A hybrid solution

Chris Iddon, design manager at SE Controls, says mechanical and hybrid systems provide enough air to meet IAQ requirements, but are often insufficient for cooling. Windows and louvres, on the other hand, can supply greater air flow to aid summer cooling but, during cold, inclement weather, the airflow can lead to occupant thermal discomfort.

Together with Charalampos Angelopoulos, a research student at Loughborough University, Iddon modelled a generic classroom using computational fluid dynamics (CFD) and analysed under what conditions it could be ventilated with windows without affecting occupant comfort.

In his paper, *Evaluation of thermal comfort in naturally ventilated school classrooms using CFD*, Angelopoulos found that if the external temperature was greater than 8°C – and wind speed was less than 10 $m \cdot s^{-1}$ – windows could be used to provide enough air to meet IAQ requirements and BB101 guidance on occupant comfort. Outside these parameters, some form of mechanical or hybrid solution would be required to temper the air.

Iddon says an ideal system would consist of a hybrid mixing box for background ventilation – ensuring CO_2 levels are kept between 1,000 and 1,500ppm – and windows, to cope with mid-season IAQ and to prevent overheating in summer.

'Windows also provide an important connection with nature, while ensuring occupants can manage their own environment,' says Iddon. 'People are less familiar with mechanical systems, which also have maintenance requirements – including filter changes – presenting a potential risk if they are not kept up to date.'

Iddon says natural ventilation using automated windows/vents is perfect for sports and assembly halls with high ceilings, as well as for transient spaces – such as communal corridors – where draughts are not an issue. Although air and noise pollution can present a challenge in some locations, he can envisage a future in which these are less of a problem. 'By 2040, all new vehicles will be electric, so – if we are designing buildings to last 60 years – we should consider these future scenarios.'

It is useful to have alternative means of bringing air into a space, Iddon adds. 'Roadworks outside, for example, can lead to occupants closing windows.'

Fitzgerald says a mixture of ventilation systems is nearly always used because school kitchens and toilets must have mechanical extract, as must architecturally landlocked rooms. 'A mixture of systems can achieve better air quality and energy efficiency – one shouldn't have to be traded off against the other,' he adds.

Every school has to be dealt with on an individual basis; air quality, thermal comfort, noise and acoustics must be considered – and it must all be done within a tight budget. CJ

VENTIVE CASE STUDY

Six Ventive passive ventilation with heat recovery (PVHR) systems were installed at a Lewisham primary school, and monitored for one year.

According to Ventive, the CO_2 levels in the monitored classrooms remained below 1,000ppm for 55.5% of occupied hours, below 1,500ppm for 85%, and below 2,000ppm for 97.5%.

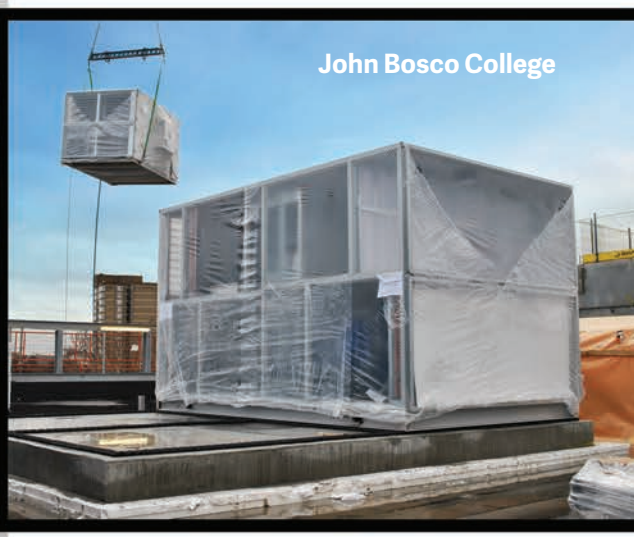
The heat recovery efficiency of the system during the intense part of the study period averaged 94%.

Instances of windows being opened were also recorded, with ventilation rates increasing by an average of 138% when one window was opened, and by up to 280% with two windows open. The calculated volume flow rate increased to 145 $L \cdot s^{-1}$ and 330 $L \cdot s^{-1}$ respectively.

Vivian Dorizas, lead KTP associate at UCL – in partnership with Ventive – is evaluating the impacts of passive ventilation with heat recovery systems on the built environment and its occupants.

Packaged Reverse Cycle Heat Pump Units R410a

EcoAir Box



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THE HISTORY MAN

Professor Alan Short says designers must look to the past to come up with resilient buildings that can withstand climate change. **Alex Smith** meets the architect who has helped revive the art of natural ventilation

Despite creating some of the UK's most acclaimed modern buildings, Professor Alan Short's ambition is not to produce showstopping Stirling Prize winners, but to rediscover the lost art and science of designing low-energy buildings.

In his book *The Recovery of Natural Environments in Architecture*[1], Short makes a compelling case for architecture based on engineering rigour rather than the artistic whims of designers. 'Most architects nowadays don't know where the architecture has come from. People have wilfully forgotten,' says Short. 'The language of classic modernism is completely and deliberately not resilient. It's incredibly lightweight, very glassy, blow-away architecture.'

Such glass-and-steel designs are only made habitable by energy-intensive air conditioning, says Short, who believes designers should look at how natural forces were used to create comfortable conditions before the advent of artificial cooling. Today's architectural idioms, he says, will not be robust enough to withstand the rising temperatures caused by climate change. 'Within 20 years, glass towers will be a liability for whoever owns them. Urban heat islands are developing so fast that, even when air conditioning is overspecified, it will soon be underspecified. There will be a massive energy bill. They will be pariah buildings.'

A recent spate of glass towers in China is making matters worse, says Short, who reports in his book that air conditioning in the mid-2000s accounted for 15% of the country's annual power consumption and up to 40% in the summer. Short, who describes his practice as research-based, is the principal investigator on a joint Chinese/UK initiative[2] to come up with retrofit strategies that would cut energy use for millions of Chinese buildings. 'I'm really interested in solutions you can roll out thousands of times,' he says.

Short argues that architects must look at how their predecessors designed for a wide range of climatic conditions before the invention of 'artificial weather'. His book summarises some of his extensive research on historic naturally ventilated buildings, which aims to re-establish a common thread of learning that – according to Short – was abruptly cut by Willis Carrier's application of mechanical air conditioning in the early 20th century.

His subjects include Dr David Boswell Reid and his ventilation for the temporary Houses of Parliament, and the American surgeon Major John S Billings, whose research on hospitals brought him into contact with Florence Nightingale and her work on hospital wards and cross-ventilation. Arguments are supported by scientific evidence that Short and his collaborators have gathered since the 1980s, when he designed his first naturally ventilated, masonry building for a Maltese brewer. The opportunity to work on the Simonds Farsons Cisk brewery came after Short attended a summer school for young architects in Malta, during a period of political isolation for the country. Import duties of 70% meant relying on resources from the island, and this changed the client's original plan for an air conditioned, industrial shed to a naturally ventilated building made from local, load-bearing limestone. Ventilation stacks 14-metres high helped drive significant airflow through the building, cooling the thermal mass and dissipating heat.

The building was modelled with what was thought to be the first algorithm developed for stack ventilation. It was created by Professor Nick Baker, of the University of Cambridge – an early example of Short collaborating with academics to drive innovation. The model predicted that, during an extreme heatwave, night ventilation would remove the previous day's heat and maintain peak internal temperatures well below external peaks. After completion, Short collected data from the head brewer that proved the success of the design; surface temperatures remained stable at around 23°C as external temperatures exceeded 38°C. It was calculated that the cooling strategy would save the brewery around 70 tonnes of CO_2 annually. 'They brew Carlsberg in that building. It put paid to the lie that you need air conditioning in metal sheds. The M&E industry was very sceptical at the time,' says Short.

After this successful prototype, a string of innovative, naturally

> "My buildings are not more expensive. You shift money into the superstructure and enrich the environment"

Professor Alan Short outside Clare Hall, at the University of Cambridge, where he is a Fellow

ventilated buildings followed in the UK. For the Queen's Building, at De Montfort University in Leicester, Short worked with Max Fordham to design naturally ventilated laboratories – unheard of at the time. His experience at the brewery, meanwhile, had convinced Short it was possible to design naturally ventilated auditoriums – and he did so at the Contact Theatre in Manchester, again in collaboration with Max Fordham.

Short's designs require more collaboration at an early stage, as the form of a building is integral to the ventilation strategy. 'My buildings are more complicated, but they are not more expensive, because less money goes into the M&E budget,' he says. 'You shift the money into the superstructure, and you enrich the environment.' Short estimates that M&E made up 30% of the cost at the Queen's Building, whereas, typically in a laboratory, 50% of the cost would be for services.

The complexity of large, naturally ventilated buildings is a challenge for the UK supply chain, says Short, whose design for University College London's School of Slavonic and East European Studies was the first modern building to use passive down-draught cooling. The design took 18 months to commission because of the difficulty in integrating components with the building management system (BMS). 'Between the BMS and the 300 moving components, there were seven contractors. The separate components may have worked, but the linkages were quite weak,' says Short, who co-authored a paper on the building.[3]

Short says there is an opportunity for manufacturers to supply systems that integrate software and hardware. 'There's a huge amount of money to be made delivering complete systems, with variations for different climates,' he says. 'You could bring together the best subcontractor in each field.'

However, the litigious nature of construction discourages the innovation necessary to improve buildings, he claims. 'The atrophying of the construction industry because of contractual arrangements – and

the appalling penalties for making mistakes – has paralysed everything.'

As professor of architecture at the University of Cambridge, Short has access to some of the world's leading academics in areas such as fluid dynamics. But he laments that there are no graduate research degrees in architecture – as there are in engineering – and he says engineering content on many architectural degrees is rapidly disappearing. 'The best path for a young architect is to be a practitioner and academic, and step between the worlds,' he says.

Short ensures there is plenty of engineering in Cambridge's architecture degrees, while the history of art department, next door, ensures students are open to lessons from the past. 'The divisions between the professions are unhelpful,' he says. 'You need a superskilled team who can understand a lot of things happening at the same time.'

According to Short, designers will have to look beyond building professions to solve one looming threat to human wellbeing – antimicrobial resistance (AMR). 'The world that can deal with AMR is interdisciplinary. New professions are being created that involve biologists and medics,' says Short, who believes a focus on air quality and movement is central to dealing with AMR. 'People have forgotten about air and are happy to leave it to M&E contractors. The Victorians would never have done that – they were terrified of bad air.' **CJ**

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The Contact Theatre, Manchester

DESIGNING RESILIENT HOSPITALS

Professor Alan Short has long been interested in the resilience of hospital buildings and won a Carter Bronze Medal from CIBSE for co-authoring a paper on the resilience of a 1970s maternity hospital in the east of England.

Short says traditional Nightingale wards, with cross-ventilation, are among the most resilient NHS buildings. He co-managed the £50m NHS Energy Efficiency Fund in 2015 with Professor Peter Guthrie, and calls on trusts to consider improvements to building fabric in the next funding round.

Short is collaborating with the Royal College of Surgeons in a study on airborne pathogens, in order to reduce hospital infection. 'Surprisingly, little is known about how pathogens of different mass travel in air,' says Short, who wants to create a safe space for surgery in low-income regions. In the research team is a PhD student who is researching the Connaught Hospital, in Freetown, Sierra Leone, which was at the epicentre of the Ebola epidemic.

FRESH THINKING

Indoor air quality is not easy to measure, but metrics must move beyond mere odour control and towards environments that consider occupant health, says the University of Nottingham's **Benjamin Jones**

In a recent review of 31 green-building certification schemes used around the world, indoor air quality (IAQ) was found to contribute to just 7.5% of the final score on average.[1] As policy-makers strive to reduce the energy demands of buildings by sealing or reducing outdoor air ventilation rates, an unintended consequence could be a reduction in the quality of indoor air, with corresponding negative health effects for occupants. This article summarises the discussions had during an Air Infiltration and Ventilation Centre (AIVC) workshop on IAQ metrics, held in Brussels, Belgium, in March.[2] It identifies the types of contaminants found in buildings today, the mechanisms of exposure to them, and the methods of mitigating their effects. It also explores metrics that could be used to quantify the quality of indoor air.

7,000

The number of different compounds – many of which are harmful – that are emitted by smoking[3]

Problems

Building materials and systems – and activities in buildings – can be sources of contaminants harmful to human health. Some materials used to construct and furnish buildings emit harmful gases and harbour biological organisms. Unvented combustion processes for space and food heating emit gaseous and particulate contaminants, and can be a source of moisture that is a primary driver of biological growth. Human activities – such as cooking and vacuuming – also discharge particulates; cleaning and deodorising products give off gaseous contaminants and particulates; and smoking emits more than 7,000 compounds, many of which are harmful.[3] Pets conceal biological contaminants, and can themselves be allergens. People and pets also emit gaseous bio-effluents that smell, and harbour pathogens that produce disease.

The presence and concentrations of airborne contaminants are often measured without careful consideration of their relevance. Some are inappropriately grouped together; for example, more than one million volatile organic compounds (VOCs) with unknown toxicities exist – yet they are sometimes reported as single values, and referred to as total VOCs (TVOCs).

Carbon dioxide (CO_2) is often used as an indicator of poor IAQ; although it does not negatively affect the health of occupants in the concentrations usually found in buildings, it is a marker of human bio-effluents. Its presence is a function of: occupancy; occupant activity, gender, age and physiology; combustion; and transport from elsewhere. Without an understanding of these variables, indoor CO_2 cannot be used to assess IAQ or ventilation. And it can never be used to indicate the presence of other important indoor contaminants – such as formaldehyde from building materials, the emission of which is unrelated to CO_2 concentration.

However, existing measurements of contaminants – the type and toxicity of which are known – still give cause for concern.[4] They could negatively affect the health of occupants and – when extrapolated to larger building stocks – could adversely affect healthcare systems and economies.

What do we know about IAQ?

Ventilation standards generally agree that indoor air should be perceived as fresh and pleasant by the majority of occupants, so they set a baseline ventilation requirement of around 8 $L \cdot s^{-1}$ per person to dilute bio-effluent odours to an acceptable level for anyone entering an occupied room from relatively clean air.[5] They then attempt to account for other contaminants by increasing the baseline rate to around 10 $L \cdot s^{-1}$ per person, although the increase is not based on specific contaminants.[6]

Ventilation rates in national standards around the world differ by up to four times, and their origins aren't always known or documented.[7] Comparisons of measured ventilation rates against those prescribed by national standards suggest there is also a widespread inability to implement them effectively in many buildings,[8] such as houses[9] and schools.[10]

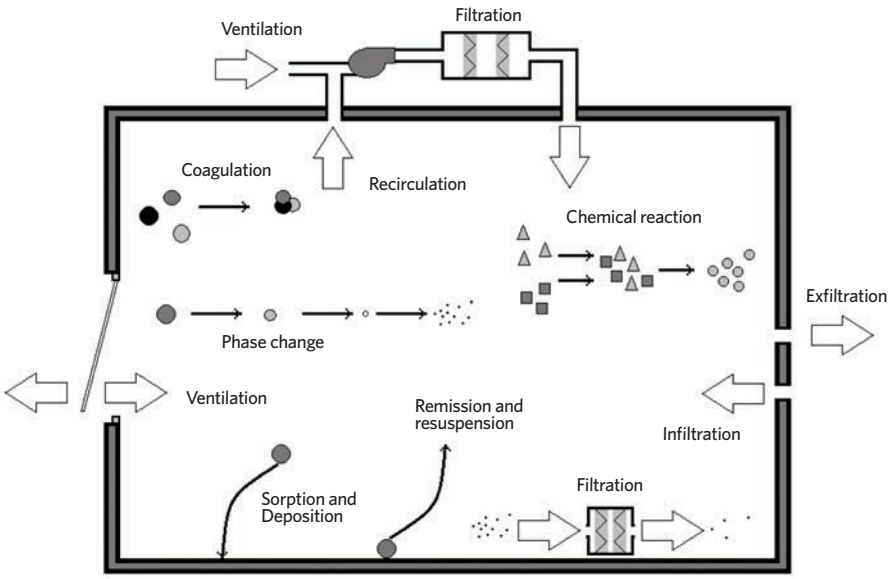

Figure 1: Ventilation mechanisms and pollutant behaviours indoors

The ability of ventilation to mitigate these contaminant exposures is limited. Occupants are exposed to contaminants via: inhalation, dermal absorption (through the skin), and ingestion. Infections – carried by fomites such as skin cells, hair, clothes, bedding and furniture – and are spread by all three. The pumping action of doors, the movement of bedding, and sitting on soft furniture can all resuspend fine particles (see Figure 1), which can be inhaled into the lower respiratory tract. Large droplets produced by breathing, talking, sneezing, and coughing contain mucus, saliva, cells, and infectious agents that are transmitted over distances of less than one metre. Such particles can be inhaled into the upper respiratory tract.[11]

Semi-volatile organic compounds (SVOCs), such as those emitted by dry-cleaned clothing or flame retardants, are absorbed through the skin or by food and ingested.[12] Organic allergens – produced by dust mites, for example – are in bedding, carpets, and soft furnishings, and are inhaled.[13] On its own, ventilation is insufficient, and fails to deliver acceptable IAQ, especially when contaminant sources are not reduced or eliminated.

Practical solutions

By the mid-1800s, pioneer of modern hygiene and environmental science Max Joseph von Pettenkofer identified source control as the most effective step towards acceptable IAQ.[14]

When source control is impossible, local exhaust ventilation – such as a kitchen cooker hood – is effective in removing contaminants before they mix in a space. These devices are imperfect, so diluting well-mixed contaminants using ventilation, or removing them with an air cleaner, is important. Although a useful alternative to ventilation, these devices have energy and financial penalties, as well as performance limitations. There is also evidence that they can re-emit collected particulates, and serve as sites for microbiological growth or chemical reactions that create secondary contaminants, such as ozone, formaldehyde, and other VOCs.[15] There is a pressing need for standardisation and performance data for these devices.

Some contaminants, such as carbon monoxide (CO), are harmful when exposure is acute, so sensors and alarms can be useful for monitoring levels. However, many others require exposures to be chronic before negative health effects occur. Devices indicating the presence of specific contaminants should be used.

IAQ metrics

An air-quality metric should identify when the quality of indoor air is unacceptable, and should be based on its effects on human health and comfort, acknowledging that they may not be immediate.

One method is to ask occupants. The human nose is as sensitive to some gaseous contaminants as chemical analyses; using it indicates occupant preference and ensures people are the focus of an assessment. Perceived air quality (PAQ) is the basis of most ventilation standards and is used to assess indoor odours[16] and IAQ.[17] However, its subjectivity, humans' inability to smell all harmful contaminants, its high dependence on temperature and relative humidity,[18] and the propensity of people to adapt to malodours after only a few minutes,[19] are concerning.

»

"Ventilation rates in national standards around the world differ by up to four times"

Another method is to identify properties of a building that are known to affect IAQ directly – for example, by applying a tick-box approach. Each feature could be weighted according to its hazard and aggregated to produce a single metric. This method could help develop a third-party rating system – similar to many energy-rating schemes – and help people sensitive to specific contaminants when choosing a house.

To obtain a comprehensive picture of the IAQ in a building, we need to measure a range of contaminants. However, their concentrations may be incomparable because of varying health impacts and time scales, and different units – for example, radon ($Bq \cdot m^{-3}$) and particulate matter ($\mu g \cdot m^{-3}$). One approach is to convert the individual contaminant concentrations into sub-indices – which may be a function of their health risks – before they are aggregated into a single index. Although the summing of sub-indices can lead to situations where they are all under individual health thresholds, the final index shows exceedance. Conversely, the averaging of sub-indices can lead to a final index that indicates acceptable IAQ when one or more sub-indices is greater than their individual thresholds. One solution is to use the maximum of all sub-indices as the final index,[20] but this does not indicate overall IAQ. Other methods weight the sub-indices before aggregation.[21]

Exposure limit values (ELV) are used in occupational environments to prevent or reduce risks to health from hazards – such as vibrations[22] – by setting a maximum quantity experienced per person per day. This principle could be applied when measuring the concentrations of a range of contaminants in a building. Here, the ratios of their maximum concentrations to their respective ELV concentrations give a quick indication of risk, where a ratio <<1 might be acceptable, but one approaching or exceeding unity may be problematic.

A problem with IAQ indices and ELVs is that it isn't clear how a change to either metric – say by 10% – would affect occupant health and comfort. An indication of the relationship between exposure and health consequences is required.

The disability adjusted life year (DALY) is a measure of time, where a value of unity is one year of healthy life lost to disease or injury. DALYs are calculated as the sum of years of life lost to premature mortality and morbidity in a population for some negative health effect. Disability is weighted by its effect on people's life in general, accounting for mental illness. In the case of IAQ, the burden of disease is a measure of the difference between the current health status of building occupants and an ideal situation where they all live into old age, free of disease and disability. The DALY has been used by the AIVC[23] to prioritise indoor contaminants found in houses for mitigation (see Figure 2).

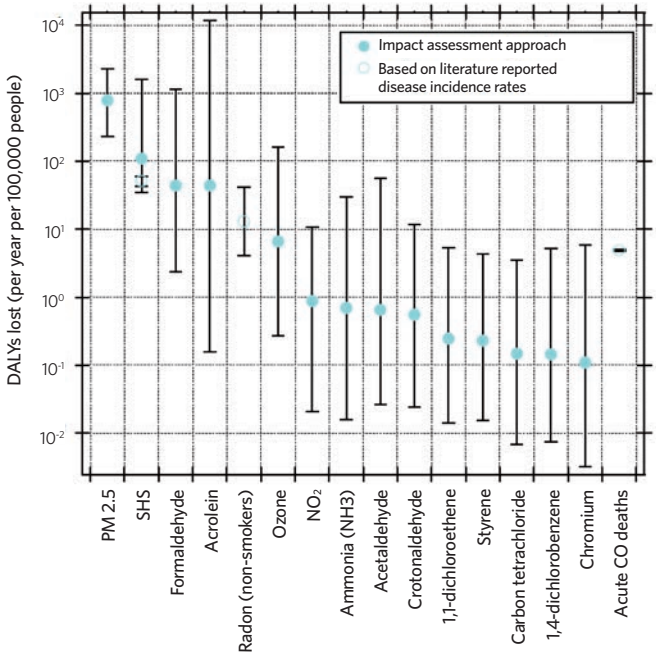

Figure 2: Estimated population averaged annual cost, in DALYs, of chronic air contaminant inhalation in US residences[23]

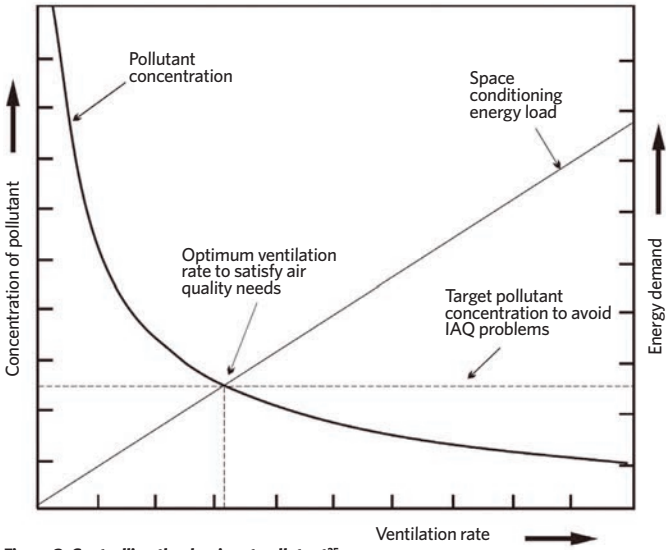

Figure 3: Controlling the dominant pollutant[25]

Next steps

Metrics must be trustworthy because unreliable evidence can be disputed and could lead to litigation. A metric must have robust technical specifications, prescribing the methods of measurement and calculation. It must clearly identify measurement locations, device types, tolerances, calibration intervals, and measurer and analyst competences. This will increase the likelihood that two assessors surveying the same building arrive at the same score.

> "Metrics must be trustworthy because unreliable evidence could lead to litigation"

Metrics should not be a barrier to innovation, so it is important that methods of pollution control are not prescribed. Any remediation measure should consider the need simultaneously to provide acceptable IAQ and energy-use reduction (see Figure 3), so they should only be used when they are effective in achieving both. This requires good sensing and control devices. When non-compliance is identified, pre-defined sanctions must be imposed.

The consideration of IAQ and its effects on occupant health and comfort will lead to a new paradigm in building standards and guidelines, moving them beyond the control of odour towards the provision of indoor environments that consider occupant health. ASHRAE 62.2[24] has begun this transition, and – as other standards join – they will start to have a tangible effect on people, healthcare systems and economies. **CJ**

The author is grateful to **Max Sherman**, **Andrew Persily**, **Iain Walker** and **Rémi Carrié** for their comments on this article.

All references are available to view online at **www.cibsejournal.com**

The 38th AIVC conference will be held on 13-14 September in Nottingham.

DR BENJAMIN JONES is assistant professor at the Faculty of Engineering, University of Nottingham

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Kilma-Therm is remotely monitoring new 2W chiller

Rooftop chillers replaced at Sloane Square John Lewis store

Tight fit for replacement 2MW Klima-Therm chiller

A 2MW chiller, powered by a magnetic-levitating Turbocor compressor, has been installed at a branch of John Lewis, in London, by Klima-Therm and its sister company LH.

Manufacturer Rhoss supplied the technology to the Sloane Square store for a project that replaced two ageing rooftop modular chillers, which had come to the end of their working life. The replacement chillers had to conform to strict planning restrictions on noise and height – to reduce visibility – and fit within a confined space on the roof.

The weight of the units also had to be minimised to ensure safe and manageable crane lifts from one of London's busiest shopping streets.

Klima-Therm's solution needed a specially designed, low-height, chiller-mounting system and highly compact, low-profile chillers – each 9,350mm in length – and was based on three Turbocor compressors arranged in two refrigerant circuits.

Klima-Therm claims the installtion will significantly reduce the client's cooling energy bills over the anticipated 15- to 20-year operational life of the equipment. Klima-Therm said it was remotely monitoring the chillers' performance to optimise energy consumption and occupant comfort.

Andrews' temporary chiller helps keep instruments in tune at UK university

A 50kW chiller coupled to air handling units (AHUs) helped Andrews Sykes hit the right note with a university's music department. The chiller hire specialist was asked to achieve and maintain the perfect temperature in temporary music rooms while the university's main music hall was being renovated.

Fluctuations in temperature can affect musical instruments, decreasing the tension in strings and changing the dimension of pipes in reed instruments – ultimately, altering their sound.

The Andrews 50kW air-cooled water chiller circulates chilled water to each of the AHUs, and warm air from the music rooms is drawn into the lower portion of the units. It passes over the chilled coils, resulting in a drop in temperature, and the cooler air is then gently blown back into the room from the top vents.

The solution gave effective climate control and allowed the university's music courses to continue without disruption.

Energy contract awarded for London's next business district

Vital Energi has been appointed design consultants for the £7.9m design-and-build contract with Multiplex for an energy scheme at the new business district under construction at London's Royal Albert Dock.

Vital will build, operate and maintain the temporary energy centre and district heating and cooling networks that will serve the first phase of the 437,000m^2, mixed-use development, which is set to become London's next business district in a £1.7bn project for Chinese developer ABP.

The temporary energy centre includes two 5MW gas boilers, one 100m^3 insulated thermal store, four 1.2MW air-cooled chillers and a BMS control system. It will supply 50,000m^2 of commercial space via a 2.6km district heating and cooling network, with packaged plate heat exchangers serving each of the buildings connected in phase one.

Cooltherm's new chiller offers 15% increase in EER

The design and development of Circlemiser technology is unique because of its special cylinder condensers and the installation of cascade-flooded evaporators.

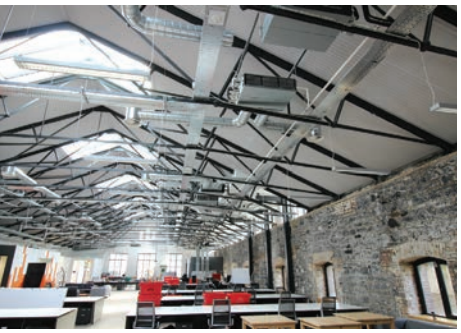
The product range uses microchannel condensers, with the heat-exchange surface increased by 45% compared with traditional condensers.

Geoclima's design makes it possible to increase the heat exchange capacity, reducing condensing temperature for better performance without altering the chiller's footprint.

According to the manufacturer, there is an increase in the energy efficiency rating (EER) of up to 9.5% with one compressor unit, and up to 15% with multi-compressor units, with the highest achievable value of EER 4.35, compared to traditional air-cooled Turbomiser chillers.

The series is available for air-cooled Turbomiser units, with R134a and HFO-1234ze refrigerants.

VRF solution transforms old Dublin warehouse



System recovers 77% of heat, reducing air con load by 20%

A Panasonic variable refrigerant flow (VRF) system has been installed at online fashion brand Zalando's 19th-century warehouse office conversion at Grand Canal Quay, Dublin. The project needed to be completed with minimal changes to the fabric of the building, with fresh air delivered using energy recovery ventilators (ERVs) in the roof space.

FKM Group selected the 3-pipe ECOi MF2 AC system, installed by Crystal Air, because it has a compact design and low noise levels, thanks to a unique two-compartment casing. The upper chamber contains the heat exchanger and the lower one the compressors.

Ducted units have sufficient fan power to drive warm air from the roof to the floor. The ERV recovers 77% of the heat in the outgoing air, reducing the air conditioning load by about 20%. During summer, the system allows purge ventilation at night, while the number of ERVs running can be reduced depending on occupancy. ECO NAVI detectors automatically reduce energy consumption in unoccupied rooms.

Intelligent flow sensor lowers energy costs by up to 50%

A flow sensor that enables ventilation to adapt to actual demand has been developed by VTT Technical Research Centre, of Finland, and Fläkt Woods.

The flow control uses a sensor, based on ultrasound, which enables reliable measurement across the entire speed range, even at low air flow rates.

An ultrasound pulse is transmitted in the radial direction of the air channel and is measured differentially. 'This enables us to eliminate several sources of error and obtain highly accurate measurements,' said VTT's Anu Kärkkäinen, who is leading the research team.

Timo Kaasalainen, product manager at Fläkt Woods, added: 'The overall life-cycle costs of a property fall when the ventilation works precisely and is demand-controlled.' Such ventilation reduces energy costs by 45–50%, he said.

The product will be launched this month, on the Finnish and Swedish markets first.

Gilberts' hybrid system goes up on the roof

Mixing damper combines fresh air with warm exhaust air, extracting its heat

Building on its hybrid system that uses internal heat to warm incoming air through wall façade louvres, Gilberts Blackpool has developed a roof-based system.

MFS Vertical (MFS-V) incorporates two Fusion MFS128 units placed vertically into a rooftop penthouse turret, with a shaft area of up to 1,500mm^2, ensuring effective 'stand-alone' ventilation of the space below.

By routing the ventilation through the roof, internal spaces that have no external façade can still be ventilated, be it through natural or hybrid principles. The concept has been put into practice at eight schools being built in the Midlands, which have enclosed, single-storey, sunken-garden 'break out' spaces over classrooms, surrounded by a two-storey building. The single-storey enclosed classrooms can still use the MFS strategy employed in the areas with an external façade by using the vertical units sited in the sunken gardens.

According to the manufacturer, one roof unit can ventilate a standard 32-person classroom, achieving the 8 L·s^{-1} per person of fresh air required by Building Bulletin 101 (BB101) and Priority School Building Programme guidelines. The standard vertical unit includes a mixing damper to allow the fresh air to mix with the warm exhaust air. A wholly natural version – without the mixing damper – is also available. The unit's operational noise is less than 30 dBA at 1 metre, and they are able to absorb external noise to keep within Building Bulletin 93 (BB93) *Acoustic design of schools – performance standards* criteria.

Read our BB101 school ventilation feature on page 45.

Zoo and Elta launch destratification solution

Zoo Fans, in partnership with Elta Fans, has launched a destratification solution that evens temperatures from floor-to-ceiling.

The firms said the fan improves air circulation and thermal comfort, so lowering the cost of buildings with high ceilings. They also claimed the solution offered a typical payback period of one- to-three years.

By bringing a directed column of warm air down to floor level, the fan destratifies the space and reduces the temperature differential to as low as 1°C overall, according to the firms. They said HVAC systems can then be used less often and the requirement for ducting is reduced.

The product is available for open ceiling, drop ceiling and spot cooling requirements, with a range of supporting controllers.

Richard Johnston, national business development manager at Elta Group Building Services, said: 'The concept behind the fan is that it uses reduced levels of energy, resulting in a need for fewer units than comparable destratification systems; lowering installation and operating costs.'

OPPORTUNITY NO_x

There is now one global testing procedure and classification system for particle air filters – which should have a positive impact on urban air quality and people's health, as **Peter Dyment** reports

Diesel emissions are Group 1 carcinogens, for which there is 'no safe level of exposure' for humans

Air pollution in our cities caused by traffic emissions poses a threat to human health. Medical and scientific experts report that the PM1 fraction of airborne fine-combustion particulate matter (PM) – together with the associated nitrogen dioxide (NO_2) – is the most hazardous. PM1 particles come, principally, from diesel-vehicle emissions and other combustion of fossil fuels.

The World Health Organization has classified diesel emissions as Group 1 carcinogens – the most toxic – adding that there is 'no safe level of exposure' for humans. A recent report from the Royal College of Physicians, *Every breath we take*, has also identified the threat to health of nitrogen dioxide – so ISO 10121-2:2013 gives a test method for NO_2 removal filters; 90% efficiency is achievable.

PM1 particles can be absorbed into the bloodstream via the lungs. Particles below 10 micron (µm) in diameter are invisible to the human eye. The opportunity to select and use filters with a particulate matter removal efficiency (ePMx, as defined in 3.1.6 of the new standard) of ePM1 will result in improved indoor air quality (IAQ) and a reduced risk to health.

The diagrams in Figure 1 show that the peak mass distribution of the toxic PM1 range (84%) penetrate the furthest. Those above PM1 have a much-reduced (28%) ability to penetrate a person's lung alveoli and the bloodstream.

So ISO 16890:2016 ePM1-rated filters used to a high efficiency are recommended, to clean incoming supply air in city buildings and make it clean enough to breathe without risk to health.

Testing procedure

ISO 16890:2016 – published in December 2016 – is the new testing procedure and classification system for particle air filters used in general ventilation systems. The decision to release it was backed by all voting ISO countries, as the air-filtration industry had previously lacked a global standard. ASHRAE 52.2 dominated in the Americas, while EN 779:2012 – which will be withdrawn from the UK in June 2018 – prevailed in Europe. In Asia and the Middle East, both standards were used side by side, along with those from individual countries such as Japan and China.

How is the standard constructed?

It has four parts:

- Technical specifications, requirements and the classification system
- Measurement of fractional efficiency
- Determination of dust arrestance and airflow resistance versus the mass of test dust
- The conditioning method to determine the minimum fractional test efficiency.

Efficiency is tested with three different particle sizes within the 0.3µm to 10µm range, and the results are related directly to performance against PM1, PM2.5 and PM10.

A new, fine ISO dust is used for dust loading, which indicates the life of a filter and development of pressure loss. A mandatory and rigorous »

PM1 particles can be absorbed into a person's bloodstream via the lungs

» discharging method is employed, using an IPA vapour. Filters must achieve a minimum 50% efficiency to qualify for ePM1 and ePM2.5 classifications. Overall, there are 49 filter classifications in four groups – ePM1, ePM2.5, ePM10 and ISO Coarse. Only one classification is allowed on a product label.

Advantages

One of the most significant advantages is that the new test procedure requires filter efficiency to be measured against the fine-particle fraction PM1 – particles of one micron and smaller. This test must be done when the filter is new and unused, and it is repeated when any electrostatic charge – which could artificially enhance performance in the laboratory – has been removed from the filter. In real-life applications, electrostatic charges are lost and there is no addition to filter performance. Both the new result and the discharge result must exceed 50% minimum efficiency for the filter to be rated ePM1.

For city locations or polluted areas, ePM2.5- and ePM10-rated filters should only be used as pre-filters. The tolerance of classification efficiency is much tighter at 5% than EN779:2012.

> "The standard recognises that air filters positively influence air quality – and, so, human health. It is also better aligned with real-world air pollution"

Who benefits?

Definitely building HVAC system specifiers and end users. The standard recognises that air filters positively influence air quality – and, so, human health. ISO 16890:2016 is also more intuitive, being better aligned with real-world air pollution. For example, an ePM1 85% filter removes 85% of particles in the tested range of 0.3µm to 10µm. The public is now better informed about air-quality issues and has access to low-cost air-monitoring technology.

Global impact

Because it is applicable worldwide, there is now one test for all filter providers. This will eliminate confusion and invalid attempts to cross-reference results from different test methods. It will also remove a barrier to trade. Consider the real world of HVAC projects today; in major construction projects – such as international airports – it is not unusual for the design engineers, constructors and the airport itself all to be in different countries.

Future outlook

For the first time, there are global HVAC air-filter standards, giving laboratory-tested efficiency performance that is close to real life for PM1 particle filters and molecular gas filters. When coupled to the Eurovent A+ energy-rating system for low-energy air filters, they should make it easier to compare fully correlated and costed solutions.

New building IAQ standards and guidance will also be aligned to these air-filter test standards. **CJ**

PETER DYMENT is a technical manager at Camfil

Figure 1: How PM1 particles make deep-lung penetration

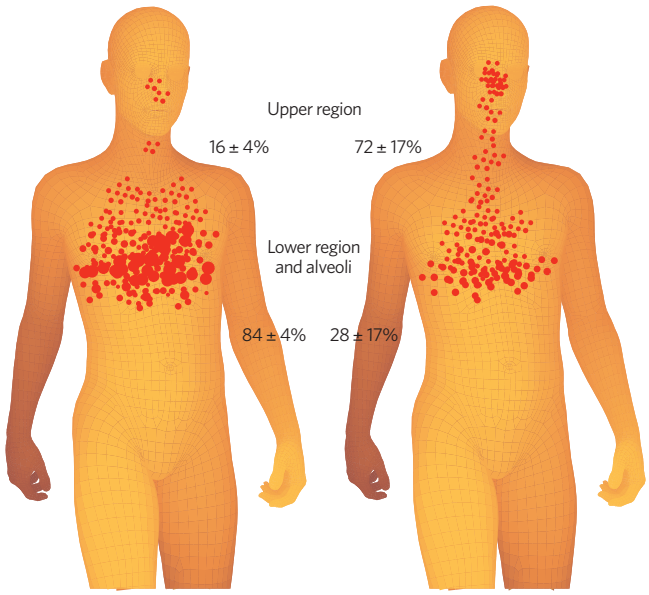
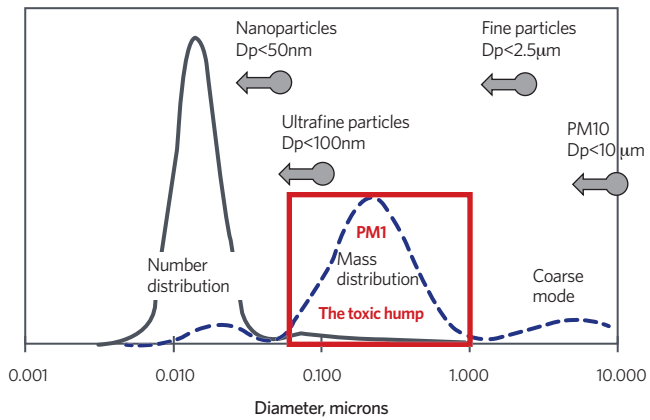


Diagram of penetration of different particle sizes into our respiratory system based on upper-body scan following inhalation of tracer labelled particles

Source: Camfil medical health report

Figure 2: Diesel particulate size distribution



Source: Dieselnet.com – bit.ly/2wEwClj

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Assessing life-cycle costs of delivering domestic hot water in commercial applications

This module expands on previous CPDs, with a more extensive example of how net present value analysis can be undertaken to calculate the life-cycle cost of heating and domestic hot water systems

In the UK, the traditional method of providing potable hot water – known as 'domestic hot water' (DHW) – to taps and appliances in commercial applications has been to use storage calorifiers (cylinders with integral coil heat exchangers) heated from a primary low temperature hot water (LTHW) circuit fired by natural gas or oil boilers. Robust alternative and hybrid systems, with varying energy sources, are increasingly available, but to determine the most effective solution requires a credible assessment of their comparative life-cycle cost and carbon emissions. This CPD article will build on the October 2016 CPD module – which explained the net present value (NPV) technique and applied it to a simple DHW system – with a more extensive example of how such an analysis can be undertaken. It will consider six options for the supply of heat for space heating and domestic hot water for a notional development of two adjacent student residences, housing 643 occupants.

As reflected in the most recent CIBSE Guide B1[1], the demand for DHW varies greatly depending on building type, but also differs considerably between buildings of the same type. So prediction of DHW consumption and the sizing of DHW systems is a challenging engineering task. However, as buildings become more energy efficient in terms of HVAC and lighting, so the energy consumption of DHW systems increases in significance, and the optimum choice and design of DHW systems becomes ever more important. By applying net present value techniques with simple financial models – together with carbon-impact models – systems can be evaluated and compared, to determine which is the most effective. The sensitivity of the models to the input data – such as assumed hot water demand and fuel costs – can be readily tested to ensure that there is a reasonable degree of confidence in the overall outcome.

As reflected in the findings of a 2011 study of practical water use in 'sustainable' homes, 'there was evidence of occupants exhibiting water-use behaviour associated with practical limitations of low-flow taps: that is, the practice of filling kettles and other kitchen utensils from bath taps'[2] – which reinforces the need to consider carefully the assumed input data used in water usage models.

A comparison undertaken by an independent consultant for a continuous-flow hot-water heater manufacturer considered different heating and hot-water supply scenarios for two student accommodation blocks, with a total of 643 occupants, to give comparative 20-year NPV costs and equivalent carbon emissions.

Based on data from the Plumbing Engineering Services Design Guide[3], a daily DHW usage profile was created (shown in Figure 1), which equates to a daily usage rate of 70l per person that – in energy terms – is approximately 1,733kWh, based on a 55K temperature rise between the incoming cold water and the heated water. The DHW demand was adjusted seasonally to account for typical student occupancy profiles, while the incoming cold-water temperature was assumed to follow the average ground temperature at a depth of 1.5m. The annual »

» demand for DHW was thereby determined as 536MWh per year, before allowing for storage and distribution losses.

The predicted peak hot-water demand was based on all occupants having a shower within a one-hour period, so each consuming 40l of water – thermostatically mixed from cold and hot water at point of use to 40°C – that equates to a peak instantaneous DHW demand of 4.3L·s^{-1} (15,480l per hour) at 60°C.

The demand for space heating was determined using a dynamic thermal model of the two student accommodation blocks, and the resulting annual heating-load profile is shown in Figure 2, which equates to 445MWh per year, excluding storage and distribution losses. The simulation applied the CIBSE Test Reference Year (TRY) for London – as described at **www.cibse.org/weatherdata** – and the building model was created to meet the requirements of the England and Wales Building Regulations Approved Document Part L 2013 for carbon emissions targets and the performance of thermal elements and fittings. Each bedroom has 8l·s^{-1} of extract ventilation, with 50% of the ventilation make-up air modelled as coming directly from outdoors – via window trickle vents – with the remainder from the adjacent unheated corridors.

A base-case system was established, with two calorifiers providing a total of 37% of the hourly peak load (one 2,900l DHW calorifier in each building), storing water at 65°C with approximately 15kWh daily standing losses. The remainder of the DHW was generated from heat supplied directly from the boiler primary circuit through plate heat exchangers. The recirculating DHW distribution circuit was modelled as returning water at 55°C.

To meet this DHW load, together with a peak space-heating demand of 330kW, the base system comprised a set of modular boilers – located together in one plantroom – delivering a total heat output of 1.44MW (six modules each providing 240kW) with a primary flow of 80°C and return of 50°C. Distribution pipework, insulated to meet the requirements of the UK Building Regulations, had total heat 'losses' of 23kW for the DHW pipework – based on 60°C water and ambient temperature of 20°C – and 31kW for space-heating pipework (based on 65°C water and an ambient temperature of 20°C). The heat loss from the pipework was seasonally adjusted for water and ambient temperatures.

Five system configurations were compared to the base case:

1. **Gas boiler LTHW heating + gas continuous flow DHW (no DHW storage)** DHW demand met by 18 natural gas-fired continuous-flow water heaters, similar to those shown in Figure 3. The main boiler plant was reduced in size, as it is serving only the space heating (that is, 0.40MW instead of 1.44MW) and there is no storage requirement for DHW.

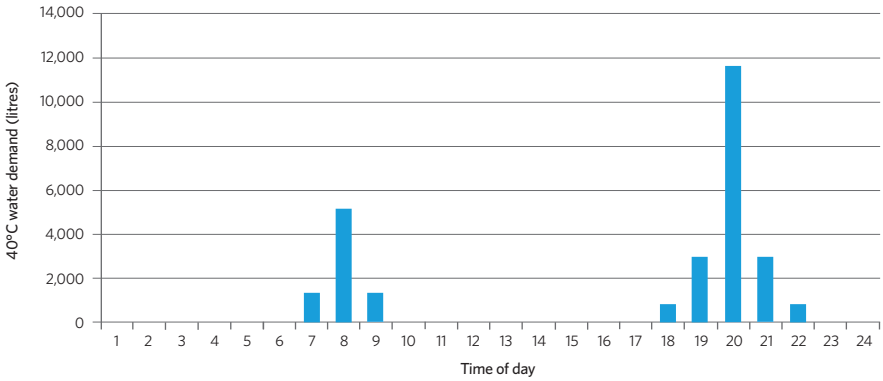

Figure 1: Typical term-time hourly hot water requirement (at mixed temperature of 40°C) (Source: Aecom/Rinnai research report[4])

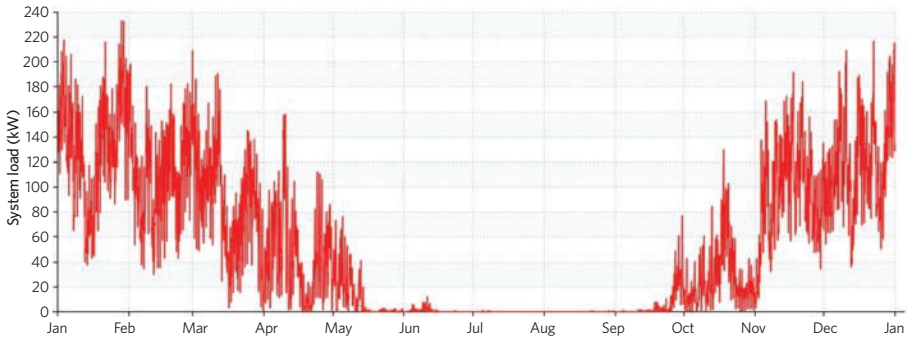

Figure 2: Simulated annual heating profile for student accommodation (Source: Aecom/Rinnai research report[4])

Figure 3: Example of application of gas-fired continuous-flow hot-water heaters (Source: Rinnai UK)

2a. **Electric space heating + electric DHW (+ DHW storage)** Both space heating and hot water are generated using electric resistance heating. As rooms have electric panel heaters, there is no LTHW distribution pipework. DHW is generated by calorifiers with immersion heaters, so requires 100% storage to meet peak demand, which equates to around 15,500l, with approximately 27kWh daily standing losses.

2b. **Electric space heating + gas continuous flow DHW (no DHW storage)** As per configuration 2a, but where the DHW is provided by 18 natural gas-fired continuous-flow water heaters, with no requirement for storage.

3a. **Air source heat pump (ASHP) heating + ASHP DHW (+ DHW storage)** Both space heating and DHW are generated using air source heat pumps. Because of the limited capacity of ASHPs, 100% DHW storage is required. The analysis is based on multiple commercial modular ASHPs, each with an output of approximately 45kW. The LTHW flow temperature and the temperature differential are lower – depending on the ambient temperature, the flow will be between 55°C and 35°C, and the flow/return temperature differential will be 10K. Hence, the flow rate is doubled, compared to the base case, and the pipe diameters are increased by 50%, which also affects pumping energy, distribution-pipe costs and heat losses.

3b. **ASHP heating + gas continuous flow DHW (no DHW storage)** As per configuration 3a, but where the DHW is provided by 18 natural gas-fired continuous-flow water heaters, with no requirement for storage.

Each of the systems was designed, modelled and costed. Separating the space heating and DHW allows each system to operate more efficiently. In both the base case and option 1, there are modulating condensing boilers with weather compensation – but whenever there is simultaneous requirement for space heating and DHW, the base case boilers will not operate as efficiently, as the DHW heat exchangers result in higher return-water temperatures to the boilers. The seasonal efficiency of the base-case boilers supplying both heating and DHW is around 89%, compared with the standard seasonal efficiency of the space-heating boilers of around 91%.

The complete ASHP solution (option 3a) has a seasonal coefficient of performance (COP) of around 2.4, compared with 3.1 in option 3b, where the heat pumps are providing only space heating. In this case, the reduction in efficiency is the result of the reduction in COP as the heat pump's condenser temperature is increased to produce hot water.

The capital costs of the continuous-flow water-heating systems are favourable, mainly because of the saving in the cost of the storage cylinders. They also maintain a seasonal efficiency of around 95%, as they are optimised and controlled to maintain high-efficiency hot-water generation.

The distribution pipework requires a significant capital cost, so the options with electric panel heating have significantly lower capital costs, as there is no need for LTHW pipework. The annual heat losses in the distribution pipework show that the heat loss through the space-heating pipes is between 22% and 25%, while for DHW pipework it varies from 35% to 39%. This would indicate that further savings could be achieved through the approach of distributed – instead of centralised – generation, both in terms of energy and in the capital costs resulting from the omission of distribution pipework.

Using the resulting data (the grey-shaded section) from Table 1, a life-cycle comparison was undertaken for a period of 20 years, based on the expected system service life before any replacement. The NPV calculation was based on a discount rate of 3.5% and an inflation rate of 2% for maintenance costs. (See *CIBSE Journal* October 2016 CPD for an explanation of the NPV method.) The analysis applied projected retail fuel costs and equivalent carbon emissions factors (CO_{2e}) for electricity, based on UK government data.[5] Although the equivalent carbon-emission factors for gas would also vary over time, no reliable projections were found at the time of carrying out the analysis, so it has been assumed to be constant at 0.184 $kgCO_{2e}{\cdot}kWh^{-1}$, which is taken from the UK government greenhouse gas (GHG) conversion factors for company reporting.

The yellow-shaded section from Table 1 summarises the comparison in terms of 20-year life-cycle cost and operational CO_{2e} emissions. The system with the gas boiler LTHW heating and gas-fired continuous-flow DHW (option 1) has the lowest cost. The operational CO_{2e} emissions over 20 years indicate significant differences between gas- and electric-based heat sources, with the all-heat-pump solutions generating around a third of the CO_{2e} of the base case.

Figure 4 illustrates the discounting effect on capital and operational costs that, in this particular case, indicates that the systems need to be considered for at least five to 10 years before the life-cycle trend is clearly set.

The analysis that is reported in this article indicates that – to establish a reasonable understanding of the total impact of the different systems – some form of whole-life assessment is required to provide a more informed input into the final selection.

Turn to page 70 for further reading and references.

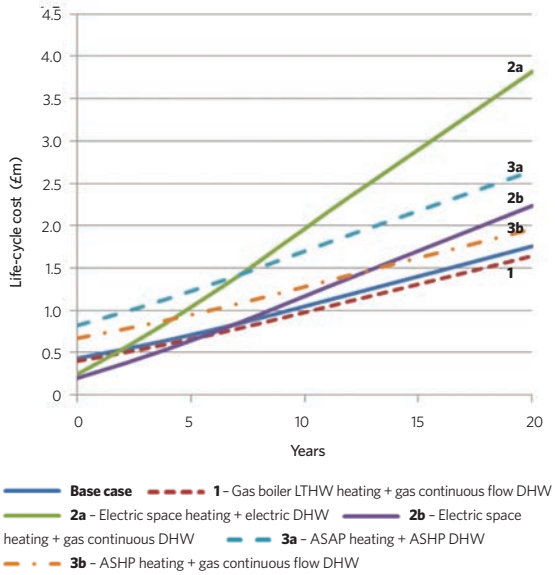

Figure 4: Zero to 20-year NPV of the base case and five options (Source: Aecom/Rinnai research report[4])

	Input to NPV calculation					20-year NPV	20-year tonnes CO_{2e}
	Natural gas (MWh per year)	Electricity (MWh per year)	Initial capital costs	Annual fuel costs	Annual maintenance costs		
Baseline	1,503	15	£432k	£50k	£875	£1.4m	5.4k
1 Gas boiler LTHW heating + gas continuous flow DHW	1,415	13	£399k	£47k	£850	£1.3m	5.1k
2a Electric space heating + electric DHW	0	1,178	£242k	£148k	£300	£2.8m	3.9k
2b Electric space heating + gas continuous flow DHW	759	450	£198k	£82k	£850	£1.6m	4.3k
3a ASHP heating + ASHP DHW	0	609	£850k	£74k	£1,575	£2.1m	2.0k
3b ASHP heating + gas continuous flow DHW	760	210	£699k	£49k	£2,125	£1.6m	3.4k

Table 1: Energy, costs and emissions for the various configurations (red indicates highest and green the lowest in the respective column) (Source: Aecom/Rinnai research report[4])

» Module 115

September 2017

1. Which CIBSE Guide is referred to for advice on DHW demand?

- ☐ A A1
- ☐ B B1
- ☐ C C1
- ☐ D D1
- ☐ E E1

2. What temperature was the DHW return water in the model?

- ☐ A 40°C
- ☐ B 45°C
- ☐ C 50°C
- ☐ D 55°C
- ☐ E 60°C

3. Which modelled systems were assumed as not needing DHW storage?

- ☐ A Systems 1, 2a and 3a
- ☐ B Systems 1, 2a and 3b
- ☐ C Systems 1, 2b and 3b
- ☐ D Systems 3a and 3b
- ☐ E Systems 2a and 2b

4. Which system had the lowest modelled CO_{2e} emissions over 20 years?

- ☐ A Gas boiler LTHW heating + gas continuous flow DHW
- ☐ B Electric space heating + electric DHW
- ☐ C Electric space heating + gas continuous flow DHW
- ☐ D ASHP heating + ASHP DHW
- ☐ E ASHP heating + gas continuous flow DHW

5. Considering the NPV costs in Figure 4 (for this particular scenario), approximately how many years' operation does it take for the 'Gas boiler LTHW heating + gas continuous flow DHW' system to become the lowest cost solution?

- ☐ A 1 year
- ☐ B 4 years
- ☐ C 7 years
- ☐ D 10 years
- ☐ E 13 years

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Further reading:

The comparison of the systems in this article is based on the output of the independent study undertaken by Aecom on behalf of Rinnai. For more information on the full report, email **info@rinnaiuk.com**.

References:

1 CIBSE Guide B1 *Heating*, CIBSE, 2016, p.120.
2 *Water consumption in sustainable new homes*, NHBC Foundation, 2011.
3 *Plumbing Engineering Services Design Guide*, Institute of Plumbing, 2002.
4 *Life-cycle comparison of heating systems – Task 2 – Student accommodation case study*, Aecom/Rinnai UK, June 2017.
5 Data available at **www.gov.uk/government/publications/crc-conversion-factors** – accessed 1 August 2017.

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PRODUCTS & SERVICES

Grundfos combats legionella effectively with disinfection

Effective water disinfection is very important in all buildings. The Oxiperm Pro is a bespoke chlorine dioxide generator from Grundfos that has WRAS-approved components. Chlorine dioxide is vital in providing clean water to a variety of potentially susceptible applications including hotels, sports and leisure facilities, and hospitals.

Chlorine dioxide is a powerful disinfection selection, and has bactericidal, viricidal, sporicidal and algicidal properties. The Oxiperm Pro generator offers many features and benefits:

- It removes both legionella and biofilm
- It has no effect on water taste and smell
- It has a low life-cycle cost compared to sterilisation by hot water
- It does not produce bromates or THM (toxic and cancer promoters)
- It is water pH adaptable
- It has a long-term effect.

The Oxiperm Pro is a compact robust system which is easy to install, operate and maintain. Up to 90% of operating costs in energy reduction can be saved compared to sterilisation by hot water method.

Call 01525 850 000, email grundfosuk@grundfos.com or visit www.grundfos.co.uk

Condair opens new Hamburg factory

Global humidifier specialist, the Condair Group, has recently opened its newly-built production, logistics and sales facility in Hamburg, Germany, marking a milestone in the company's development. The 13,000m² building centralises Condair's European manufacturing operations, previously carried out in four regions across the continent.

Situated next to Hamburg airport, the new Condair facility is also close to the motorway and harbour, and its design incorporates the latest in energy saving building services technology.

Visit www.condair.co.uk

Underfloor air conditioning fits the bill at 8 Waterloo Place

8 Waterloo Place, at St James, London, has recently undergone a full refurbishment.

AET Flexible Space is delighted to have supplied a CAM-C direct expansion underfloor air conditioning system for this prestigious refurbishment, comprising 8 CAM-C 35 downflow units, Daikin heat pumps and approximately 108 TU4-EC Fantiles.

Both client and architect requested a clean finish with no services at high-level – and the AET Flexible Space CAM-C direct expansion system fitted the brief.

Call 01342 310 400 or email aet@flexiblespace.com

Dunham-Bush LST radiators deliver safety and warmth to luxury care home

More than 200 Dunham-Bush system low surface temperature radiators – fitted with SAV/Danfoss PT 40 flow and pressure monitoring thermostatic valves – have been installed at Manor Grange luxury care home in Corstorphine, Edinburgh, which cares for people with dementia and Alzheimer's disease.

The Dunham-Bush LST radiators' design provides the installer with a quick and simple installation process and the end user with a cosmetically desirable product with easy access for maintenance.

Email info@dunham-bush.co.uk

Atag Commercial's XL series excels in a range of applications

Atag Commercial's XL series range of highly efficient gas-fired boilers not only offers impressive levels of performance, high quality and reliable engineering, but it is also complemented by an extensive selection of modular installation and cascade options.

XL boilers are quick and simple to install, with multiple boiler sizes and configurations possible, including options for wall-mounted in-line installations. No matter what size a plant room is, a suitable boiler configuration is available.

Visit www.atagcommercial.co.uk

Lochinvar launches app-based smart boiler control

Boiler and water heater manufacturer Lochinvar has launched a 'smart' app-based controller for its Herald range of gas-fired condensing boilers.

The Con-X-us system enables users to connect their smart devices, including phones and tablets, to the on-board boiler controls so they can monitor and adjust the system operation and heating parameters from anywhere in the world.

Con-X-us is an ancillary option, which can either be ordered and fitted to the boiler before despatch, or retrofitted on site. The app is free to download and is suitable for iPhone or Android devices. There are no ongoing costs and it gives full control over the boiler with email or text alerts keeping users connected and updated 24/7.

Operation of the device is via touch screen technology or by typing in specific information to remotely adjust set points, outdoor reset curves, pump controls and other functions. Colour-coded status alerts indicate if the boiler needs servicing.

Visit www.lochinvar.co.uk

Sylvania leads the Retro revolution

Sylvania has expanded its range of ToLEDo Retro lamps to give architects, specifiers, installers and consumers even more choice. The successful lamp collection replicates the look and feel of traditional incandescent and halogen lights and is one of the largest selections available on the market.

The improved range includes new dimmable and non-dimmable versions in a range of lamp shapes. The new ToLEDo Retro dimmable V2 lamps now share the same construction design as the non-dimmable range.

Visit www.feilosylvania.com

Gripple develops its pipework solutions product range

Gripple has added products and developed others in its piping range for greater breadth, depth and strength – for easier and quicker heating installation.

Notable improvements are in Gripple's universal clamp range for the suspension of pipe from 15mm copper to 6" steel, replacing more than 13 different pipe ring sizes with one product.

A new acoustic universal clamp has been developed for projects where noise reduction is a key criterion, as well as a new wall bracket.

Call 0114 2288 713 or visit www.gripple.com

Nicotra Gebhardt introduces innovative RQM hybrid fan

Fan manufacturer Nicotra Gebhardt has launched a new compact fan with unrivalled energy efficiency.

The RQM 'MultiEvo' beats the traditional plug fan on energy efficiency, thanks to the optimisation of all key components, including a hollow section 'aero-foil' backward curve impeller, a permanent magnet (PM) internal rotor motor rated at IE5 efficiency, and integrated electronic controls. The compactly designed RQM can be fitted at multiple access points for ease of maintenance and is ideal for both new-build and refurbishment/retrofit applications.

The company's 'MultiEvo' technology has delivered a range of directly driven hybrid centrifugal fans with multiple discharge outlets and static system efficiencies of up to 78%. Its multi-spiral technology combines the compact design of plug fans with the effectiveness and reliability of traditionally 'housed' fans that offer static pressure increase and energy efficiency. The RQM reaches 8-15% higher energy efficiencies than traditional plug fans.

Call 01709 780760 or email g.llewellyn@nicotra-gebhardt.com

Panasonic UK sponsors RAC Cooling Industry Awards

Panasonic UK is delighted to announce that it will be the category sponsor for RAC Contractor of the Year at the 2017 RAC Cooling Awards.

These awards have been one of the most prominent and respected awards for the past 13 years, and this year's event will bring together 500 members of the industry.

Panasonic will be sponsoring the award for RAC Contractor of the Year, which rewards firms that provide exemplary service.

Visit www.aircon.panasonic.eu

Size matters: get the right size hot water heating unit and system to fit the site

New from Rinnai, UK provider of continuous flow hot water heating, is a Site Sizing Service designed to give the right amount of hot water delivery to meet existing and planned needs.

The new service initiative from Rinnai – available over email, iPhone and site visit – is designed to give contractors and users the right mix of products and system to fit the needs of the site, rather than a 'one-size-fits-all approach' seen with traditional hot water heating systems.

'Every site is different, as all installers know, and the tradition of oversizing a system "just in case" is a very costly way for a site to have hot water on demand,' said Rinnai head of operations Chris Goggin. 'The very basis of our product concept is that the end-user only pays for the fuel to heat water at the point of use.'

Visit www.rinnaiuk.com

Out of sight, but not out of mind

Architects are often confronted with the seemingly impossible problem of ensuring indoor air quality meets acceptable standards, but without using ventilation equipment that spoils the building's interior design. Dan Jones (pictured, left), of Air Diffusion, believes he has the answer.

'One of the biggest issues confronting the industry is the battle to maintain good air quality inside buildings without using equipment that is unsightly or noisy. Yet, due to growing problems from urban pollution, building owners and operators are increasingly concerned about the impact of airborne contaminants on tenants and staff. As a result, adequate ventilation is a major preoccupation for design teams – so being able to balance healthy conditions with a discreet design is something of a 'Holy Grail'.

'At Air Diffusion, we are seeing a dramatic increase in demand for our FlowBar range of high capacity linear slot diffusers. These are designed to combine a very high air-handling capacity with maximum flexibility and subtlety. They are suitable for either ceiling or sidewall applications fitting discreetly into a stylish interior and blending into a design to provide both practical and aesthetic benefits.' Integral pattern controllers are between 300 and 600mm in length, allowing the airstream to be directed left and right for horizontal and vertical airflow. Standard slot sizes are 25mm, 38mm and 51mm with single section lengths available up to 2,400mm.

Call 01746 761 921, email sales@air-diffusion.co.uk or visit www.air-diffusion.co.uk

Tooling range extended by Pegler Yorkshire

Pegler Yorkshire, UK manufacturer of Vsh XPress fittings has expanded its range of tools to meet the demands of the marketplace.

The XPress Press Power Tools range offers a variety of tooling to support press-fit installations from 12mm to 168.3mm and sprinkler systems. In addition, the range includes the popular combined package of AC0203 with 15-35mm jaws in a single case. The improved range of press tools provide greater performance, while being lighter and easier to handle.

Call 0844 243 4400 or visit www.pegleryorkshire.co.uk

EOGB brings Baltur's most powerful burner to the UK

Italian burner manufacturer Baltur has announced the launch of its most powerful packaged monoblock gas burner ever developed, available exclusively in the UK through EOGB Energy Products.

The TBG 2000 ME modulating burner has a maximum thermal output of 20MW and offers a turndown ratio (range between maximum and minimum output) of 1:7, which is one of the best performances recorded in an industrial application.

Additional benefits include easy maintenance, a compact and lightweight frame, better control, low electrical consumption, and reduced noise emissions.

EOGB has been Baltur's sole UK distributor since 2000 and stocks the entire range of oil, gas and dual-fuel burners for commercial and industrial applications alongside its own XSeries domestic oil burner range and new low NO_x modulating burner – Sapphire.

Visit www.eogb.co.uk

Coolair showcases stylish new R32 air conditioning

One of the UK's air conditioning providers has just installed the latest wall-mounted system in its Cheshire offices to showcase the future to its customers.

Coolair Equipment has chosen the new M Series MSZ-LN R32 air conditioning for its Dunkinfield office to highlight the change in refrigerants now being offered to UK customers and the significant advantages this can bring.

'The existing split heat pump system in our manager's office had come to the end of its life, so we chose the perfect replacement with this stylish unit which also shows off the full benefits of the new refrigerant in a fantastic stylish unit,' said Steve Valentine, regional director at Coolair Equipment.

The M-Series MSZ-LN wall mounted split system is the first in Mitsubishi Electric's UK line-up to use R32 refrigerant which has a low global warming potential (GWP) of 675 – less than one third of popular refrigerant R410A.

For details on the range of R32 models available, visit www.timeforR32.co.uk/pr225

Matched heating to match stringent environmental criteria

Hoval boilers fitted with Riello dual fuel low NO_x burners were selected by Skanska for the new Papworth Hospital in Cambridgeshire. The precise matching of boilers and burners will ensure optimum energy efficiency with low NO_x emissions.

The new hospital is being constructed on the Cambridge Biomedical campus, using building information modelling (BIM) techniques, and a key offer was the ability of Hoval and Riello to supply BIM-compatible product information for incorporation into the model.

Call 01480 432 144, email info@rielloburners.co.uk or visit www.rielloburners.co.uk

Fusing efficient ventilation

Effective, compliant ventilation of multi-occupancy rooms is simplified with an innovative concept from Gilberts of Blackpool.

The air movement specialist's Mistrale Fusion (MFS) Terminal delivers optimum air control for less than £5/room/annum. The initial single-sided through-structure unit provides a one box, stand-alone solution, with no additional ductwork or plant. The Mistrale MFS is the first in a new series that revolutionises energy-efficient ventilation in non-domestic buildings, mixing internal and external air for internal space ventilation.

Call 01253 766 911 or email info@gilbertsblackpool.com

Safety standard-compliant connections open up new applications for smart lighting system

The latest DALI sensor package from lighting specialists Helvar is fully IEC 60669-2-5 compliant thanks to the use of WAGO Push in cage clamp pluggable connections. The standard guarantees safe operation within manufacturer's instructions, and allows Helvar's lighting system to be specified for a wider range of projects and applications.

IEC 60669-2-5 applies to the safety and reliability of home and building electrical system (HBES) switches and associated electronic extension units. The standard covers specifications such as mechanical strength, rating, electrical safety protections and resistance to ageing, heat and rust.

iDim Orbit detects movement using passive infrared (PIR) technology, providing reliable performance across a range of applications. One sensor can detect occupancy within a 7m diameter area, or five can be used together to deliver up to 15m coverage at 2.8m height. This makes the system highly suitable for classrooms and offices, where lighting can be easily adapted.

Call 01788 568 008, email paul.witherington@wago.com, or visit http://global.wago.com/uk

Thermal energy storage (TES) ›

Phase change materials (PCM) store and release thermal energy during the process of melting and freezing, and the latest range of PCM solutions between -100ºC and +885 ºC offers new application opportunities.

For example, the excess capacity of existing +7ºC water chillers can be stored in +10ºC PCM containers overnight using lower ambient and lower electricity costs. This efficient and lower cost stored energy tops up the day peak loads saving considerable running costs.

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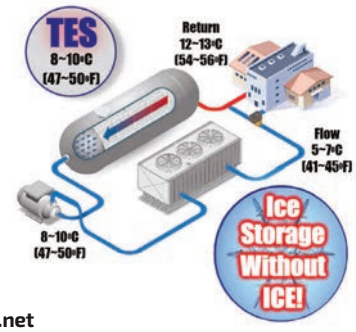
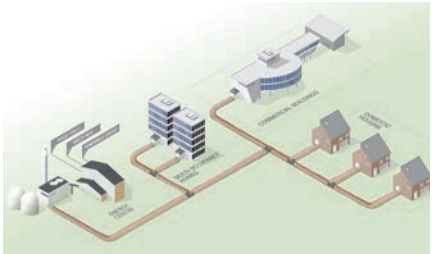


Book now for the free Rehau district heating workshop in Edinburgh ⌄

Rehau's free district heating workshops will be heading to Dynamic Earth in Edinburgh on Wednesday 4 October to offer consultants, contractors, local authorities, developers and housing associations the chance to find out more about the benefits and practicalities of district heating.

Attendees will hear presentations from a line-up of industry experts and take part in breakout sessions to discuss topics in more depth. The presentations will be followed by breakout sessions and a practical case study.

Email Julia.hepburn@rehau.com or visit www.rehau.co.uk/districtheating



‹ Warmafloor gives Vantage Point luxury living advantage

Warmafloor's acoustic batten floor system has been used to optimise living space and minimise noise transfer in the renovated 17-storey Archway Tower, London.

The system delivers high standard sound insulation to transform the former office block into luxury apartments.

Warmafloor's Inteliq smart control systems technology has also been fitted.

Able to interface with heat pumps, solar panels, energy exchangers and underfloor heating, Inteliq optimises energy efficiency to minimise running costs.

Visit www.warmafloor.co.uk

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Brainstorming at The Cornwall Energy Island Project, and (inset) Gavin Thompson

Micro management

Decentralised generation and local distribution could be key to securing the UK's future energy needs, says BuroHappold director Gavin Thompson

BuroHappold teamed up with the Eden Project, to try to answer the question: 'What if Cornwall became self-sufficient in energy?' The Cornwall Energy Island Project was created, and a mass of data was produced from a two-day workshop attended by some of the UK's brightest energy and environment minds. This is now being mined to produce reports, plans and actions that Cornwall can use to improve its economy and achieve energy independence. BuroHappold director Gavin Thompson was involved in the project, and will be talking at Build2Perform Live in November. Here, he discusses future power generation in the UK.

Q How will UK's national energy policy have to change if the country is to meet its Paris target?

A Our Climate Change Act is the envy of many a nation with serious intentions to guard against further climate change. However, while the emissions goals are clear, the energy policy to achieve these is not. The situation is further complicated by the rate of change in technology, the lead time in procuring large-scale energy infrastructure, growing fuel-supply insecurity, and an uneasiness around nuclear.

Our energy policy needs to take a longer view and consider a legacy of flexible infrastructure. In many ways, this makes a case for a patchwork of decentralised generation and local distribution, supported by stable funding for the improved application of demand management and storage.

Q What will be the main sources of energy in the UK?

A Take a look on the internet at real-time power generation in France; you will see the majority of it is from nuclear, with much of the rest from hydro. Arguably, they are already carbon-free. This is the legacy of poor national coal reserves and a strong, long-lasting policy to solve this through nuclear. Click on a dashboard for the UK and you will see a mix of power generation, including gas, nuclear, wind, photovoltaic (PV) and biomass, as well as imports from France and Holland – which is a result of a short-term, market-led approach.

Peak power demand is in decline, thanks, in part, to energy-efficient lighting and a general decline in heavy industry. The future trajectory will be affected by heat pumps and electric vehicles (EVs), but our understanding of by how much remains imprecise. Our nuclear future remains uncertain as existing plant is decommissioned and the procurement of its replacement looks ponderous. While we have successfully weaned ourselves off coal, it has been at the expense of our gas use. It seems wrong to burn gas in central generating plant with no use for heat when that same gas can be readily transported deep into the heart of our cities to produce heat and power.

I see a renewable future – with rapid EV adoption – coupled with a wise use of gas.

Q What role will be played by decentralised energy networks?

A Our key energy consumers are transport, power, industry and heat. Power generation, through the rapid uptake in renewables over the past 10 years, is already being decentralised. Of the four consumers, heat – particularly space heating – remains the most significant.

A fabric-first approach is sensible: reduce demand and then reduce the carbon associated with providing heat. However, our ability to retrofit insulation and improve airtightness in our building stock – most of which will still be with us in 2050 – remains constrained. Heat networks offer a 50- to 60-year legacy. Heat can be consumed without disruption, while heat sources can change – either in real time (after tariffs) or through technical evolution – as we reduce carbon towards 2050.

Q What place is there for combined heat and power district heating?

A Combined heat and power (CHP) private-wire power sales are a key ingredient in the commercial viability of heat networks. With UK networks feeding just 3% of the country's heat demand, it is clear we have some way to go – and CHP will be a vital ingredient in funding network penetration for a least the next 10-15 years.

Load factor has always been a 'live or die' factor in the success of CHP; however, it is interesting to see manufacturers of large-scale, gas-fired, reciprocating generating plant eyeing the peaking market with renewable as lead.

Q Is the UK workforce skilled enough to integrate new technologies?

A I would say yes! Our creativity and resourcefulness are unconstrained by precedent. We must adapt and understand how what we design makes money – we must be true techno-economic engineers. We must also step up and out of the shadows, and be prepared to influence policy at city, regional and national levels.

GAVIN THOMPSON MCIBSE is a director at BuroHappold

Register to see Gavin Thompson at Build2Perform Live at **www.build2perform.co.uk**

EVENTS

NATIONAL EVENTS AND CONFERENCES

Build2Perform Live
21-22 November, London
This free two-day interactive conference offers multiple seminar streams encompassing an entire floor of London's Olympia Exhibition Centre.
www.cibse.org/b2plive

CPD TRAINING

For details, visit **www.cibse.org/training** or call **020 8772 3640**

Mechanical services explained
12-14 September, London

Energy efficiency building regulations: Part L
15 September, London

Fire safety management & use of buildings BS9999
15 September, London

Building services overview
20 September, London

Sanitary and rainwater design
20 September, London

Earthing and bonding systems
21 September, London

Low and zero carbon energy technologies
22 September, London

Gas safety regulations (designing for compliance)
26 September, London

Introduction to ground and water source heat pump schemes. Day 1 (CP2)
27 September, London

Implementing ground and water source heat pump schemes. Day 2 (CP2)
28 September, London

Power systems harmonics
29 September, London

Introduction to Heat Networks Code of Practice (CP1)
3 October, London

Electrical distribution design
4 October, London

ENERGY ASSESSOR TRAINING

For more information visit www.cibse.org/training or call **020 8772 3616**

LCC building design and EPC
18-19 September, London

Air conditioning inspection
19 September, Manchester

LCC building operations and DEC
26-28 September, London

Heat networks code of practice
27-28 September, London

Energy Saving Opportunity Scheme (ESOS)
3 October, London

CIBSE GROUPS, SOCIETIES AND REGIONS

For more information about these events visit: **www.cibse.org/events**

South West: The future of building services engineering
4 September, Bristol
How technology is changing the design, construction and maintenance of building services.

ANZ NSW: Fire and smoke control in buildings
5 September, Sydney
New draft standard on fire and smoke control in buildings, open for consultation.

ILEVE: Technical day and AGM
6 September, London
ILEVE technical day on ventilation extract and stack arrangements for local exhaust ventilation systems.

HCNW: Legionella and other pathogens
7 September, London
David Harper explores the practical and design imperatives of legionella.

First International Museum Lighting Conference
11 September, London
Current research into museum lighting.

Yorkshire: Energy Works visit
11 September, Hull
Visit to the Hull's new Energy Works Centre.

South West: Peninsular summer social, boat cruise
13 September, Plymouth
Enjoy three hours' sailing across Plymouth Sound.

East Anglia: Annual dinner
15 September, Cambridge
Three course meal, and guest speaker.

Scotland: Power quality problems – causes, effects and solutions
18 September, Glasgow
How improving energy efficiency can introduce power quality problems.

SLL and North West: Architectural and media façades based on LG6
19 September, Manchester
Design possibilities with architectural façade lighting and dynamic lighting in architectural design.

SLL and East Midlands: Reflux training
19 September, Kegworth
Reflux Desktop training with Richard Hayes, of 42 Partners.

Society of Façade Engineering: AGM and technical evening
19 September, London
AGM followed by technical presentation.

Daylight Group: Daylight within planning guidance in London
20 September, London
How daylight planning guidance should be applied.

SoPHE: Design and application of HIU systems
20 September, Manchester
Presentation by Oventrop's Chris Doherty.

SLL: Uchronia, meaning 'no time' from Utopia or the Greek, Ou-topos
21 September, London
With speakers Dr Helga Schmid, Dr Andrea Darling and Inessa Demidova.

CIBSE report writing workshop
25 September, London
Help with Engineering Practice Report written for Associate and Member applications.

HCNE: Membership briefing session
26 September, Cornhill
Focus on Associate and Member grade applications, and registration with the Engineering Council.

North East: Comfort, energy, storage and wellbeing
26 September, Newcastle upon Tyne
Ant Wilson, Aecom, will review 'what makes a comfortable environment'.

HCNW: Power quality
26 September, High Wycombe
Joint event with IET Buckinghamshire, with speaker David Bradley, of Socomec.

South West: Designing and understanding local extract ventilation – Part 3
27 September, Bristol
With Adrian Sims, ILEVE vice-chair.

Yorkshire: Drax Power Station tour
28 September, Yorkshire

HIGHLIGHT

Helga Schmid and **Inessa Demidova** will talk at the SLL Uchronia event, on 21 September

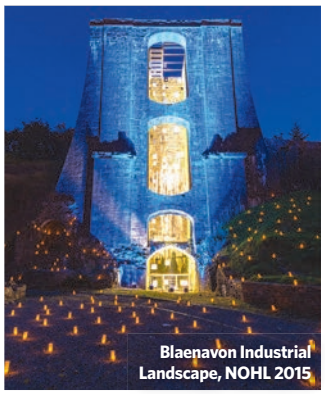
Night of Heritage Light 3

29 September, Oxford

This year, the Society of Light and Lighting (SLL) and CIBSE will be celebrating the third instalment of Night of Heritage Light (NOHL) in Oxford, in conjunction with the Curiosity Carnival.

Designed to showcase the talents of local SLL members, the wider lighting community and the research expertise residing in Oxford, teams of dedicated lighting designers will shine a 'new light' on seven buildings of historic – and research – importance in Oxford.

As part of SLL's aims to inspire future generations of designers, the STEM focused 'Pockets of Light' schools competition will challenge students to come up with lighting schemes, with the winning design from each school being installed by lighting professionals at the Bodleian Library quad. For details, visit **www.cibse.org/sll**



Blaenavon Industrial Landscape, NOHL 2015

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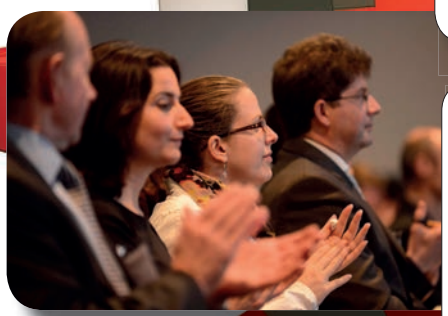

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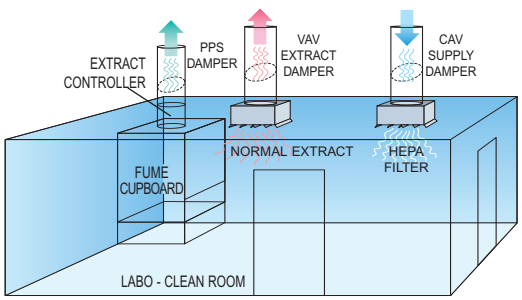

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