CIBSE JOURNAL

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September 2019 www.cibsejournal.com

OUT OF THE SHADOWS

Piers Heath on how environmental engineering came to be at the heart of integrated design at Foster + Partners

HOW TO BE A PASSIVHAUS CONSULTANT

DIGITAL ENGINEERS' ONE-DAY CHALLENGE

RESEARCHING IAQ AND PRODUCTIVITY

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On equal footing

Piers Heath may head up Foster + Partners environmental engineering team, but his favourite subject at school was always art. This has stood Heath in good stead, as having an appreciation of aesthetics is important with high-profile clients such as Apple tending to have the highest of design values.

Engineers are integrated into design teams in all Foster + Partner's projects and, as Heath says, if a client wants diffusers to be hidden you can't just present a catalogue– you need to engineer a solution to make sure they are truly hidden.

Touring the campus in Battersea, there's a strong sense that engineers share equal billing with architects. Engineering expertise is evident everywhere, from the sophisticated models taking up every inch of spare surface, to the experimentation visible in workshops housing 3D printers and laser-cutting machines.

It was encouraging to hear that Heath is leading a project to implement soft landings and post-occupancy evaluations in every Foster + Partners project wherever they're designing around the world. So, even if the practice only delivers 50% of the project, the design intent should still be realised in the finished building.

An event at Foster + Partners organised by the CIBSE ASHRAE Group will see senior MEP engineer Andrew Jackson and architect Matthew Heywood discuss the development of integrated design for buildings and systems. The event is on 18 September, 6-7pm and ticket and webinar details are on page 40.

This month, in a special arrangement with *ASHRAE Journal*, we are publishing an article that looks at all the research around the impact of indoor air quality on productivity. This is accompanied by an article from CIBSE technical manager Julie Godefroy on the gaps in current understanding around the links between environmental factors and health and wellbeing (see page 70).

Godefroy has also reviewed Fionn Stevenson's new book on building performance, *Housing Fit for Purpose*. Stevenson's extensive research of real projects makes it essential reading for anyone who wants to understand why buildings fail to deliver on their design promise. One copy should perhaps be sent to the government.

In Godefroy's research for the article, she discovered that the findings from Innovate UK's important Building Performance Evaluation programme were no longer accessible. Thankfully, this valuable data is currently been transferred to the Usable Buildings website as we write (**www.usablebuildings.co.uk**).

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Hywel Davies
The challenges faced as the UK strives for a decarbonised grid and an end to fossil fuel burning

Liza Young
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'No deal' Brexit would cost £12bn, say industry groups

Trade bodies claim market uncertainty affecting businesses

A number of industry bodies have joined forces to warn the government that a 'no deal' Brexit would cost the UK economy £12bn.

The Association for Consultancy and Engineering (ACE), Build UK, the Construction Products Association, the Civil Engineering Contractors Association and the Federation of Master Builders have written to the Prime Minister, Boris Johnson, to say a smooth Brexit would lead to a rise in construction output of more than £1.2bn by the end of next year.

A disorderly departure from the EU, however, could lead to a fall of £10.5bn over the same period, they claim, 'with the greatest impacts felt on the housebuilding and commercial sectors'.

The trade bodies state that the 'continuing inability of policy-makers to agree a way forward has left our members struggling to overcome the market uncertainty impacting their businesses'. They quote data from ONS and Markit/CIPS surveys, which 'make clear the worsening erosion in recent construction activity'. The letter continued: 'The immediate effect of leaving without a deal in place is not knowing the cost of the materials and goods that construction projects rely on, or if they will arrive on sites across the four nations to keep projects of all shapes and sizes on track.

'With the impact of the previous financial crisis not forgotten in an industry that experienced countless business failures, plant closings and nearly half a million job losses, the resilience of our industry has its limits. We trust that the government and parliamentarians will agree the arrangements for trading with the EU as a matter of urgency.'

Without a deal costs of materials will be unknown

'Standard of new homes will fall after EU exit...'

Builders are cutting recruitment and using more sub-contract labour because of the uncertainty caused by Brexit, according to the Federation of Master Builders (FMB), which says this could lead to 'reputation-damaging mistakes' and affect the quality of new housing.

In its latest quarterly survey of members, the FMB found a drop in employment for the first time in more than five years, with 21% of companies saying they had laid off staff since the previous quarter. This is despite 27% reporting an increase in business during the same period.

The survey also found that housebuilders were encountering problems recruiting skilled workers and the FMB said contractors were 'less likely to build to the right standard'.

'Years of Brexit uncertainty have resulted in construction bosses starting to change how they employ their workforce,' said FMB chief executive Brian Berry. 'To ensure their firms are ready for any economic shockwaves later this year, employers are reducing their number of direct employees and relying more on sub-contractors, who are easier to shed if work dries up.'

He added that apprenticeship training had also 'taken a hit'.

...but output grows, says RICS survey

Surveyors reported an unexpected rise in construction workloads during the second quarter of the year, as clients decided to shrug off the uncertainty created by Brexit.

The latest RICS Construction and Infrastructure Market Survey reported that 16% more surveyors had experienced an increase in construction workloads than had seen a fall – despite growing fears of a 'no deal' exit from the EU.

'After a prolonged period of delays and underinvestment, businesses now appear to be fed up and are proceeding cautiously with new hiring and intentions to invest,' said RICS senior economist Jeffrey Matsu.

'While much of this is likely to be backfilling or maintaining existing capacity, the requirements of larger projects – such as Hinkley Point C and HS2 – are constraining growth opportunities elsewhere. With the range of possible outcomes related to Brexit as wide as ever, we expect to see continued volatility in the construction output data, but foresee workload activity stabilising.'

There was modest growth in commercial and public non-housing activity, but the RICS said it expected the private housing and infrastructure sectors to be more resilient over the year, with – respectively – 27% and 25% rises in surveyors expecting activity to increase rather than fall.

It said investment in training and equipment would also improve over the year, as its market confidence indicator – which includes workload, employment and profit-margin expectations – grew by 21% in quarter two, compared with 13% in the first three months of the year.

IN BRIEF

Ventilation hygiene scheme launched

The Building Engineering Services Association (Besa) has launched a competent person scheme for ventilation hygiene.

It said building owners, operators and insurers were increasingly concerned about the fire risks posed by poorly cleaned and maintained systems – particularly grease-extract systems in commercial kitchens.

The 'Ventilation Hygiene Elite' scheme is based on Besa's specification and guide to good practice TR19. It involves regular audits of contractors' work and a managed database of post-clean reports that can be used as an auditable trail by clients and insurers.

Aecom goes wild in the country

Aecom has opened a 'natural capital laboratory' on a 100-acre site near Loch Ness in the Scottish Highlands.

The engineering firm is working with landowners and conservation charity The Lifescape Project to bring back native forest and reintroduce locally extinct species.

Over the next five years, Aecom will design and test experimental techniques to quantify, measure and communicate environmental and social change, using drones, artificial intelligence, virtual reality, and space satellites.

The project aims to regenerate tree cover to bring back ancient Caledonian forest, with estimates suggesting that replanting the whole site would store around 550 tonnes of CO_2 annually.

Castle secures £6m of work on uni project

Castle Building Services (CBS) has been awarded a £6m package of M&E work from Bowmer & Kirkland, as part of a £32m project at the University of Central Lancashire.

CBS has started design and BIM work in preparation for construction on the four-storey, highly glazed building, which will provide a new reception area, informal learning spaces and a student wellbeing support centre.

The project, designed by architect Hawkins\Brown, starts in May and is part of a £200m investment by the university to transform its Preston campus.

CCC wants overheating to be part of zero carbon push

Revisions to Parts L and F would include consultation on overheating in homes

The Committee on Climate Change (CCC) has called for the issue of overheating in new and existing buildings to be addressed as part of the government's strategy for decarbonisation and improving safety.

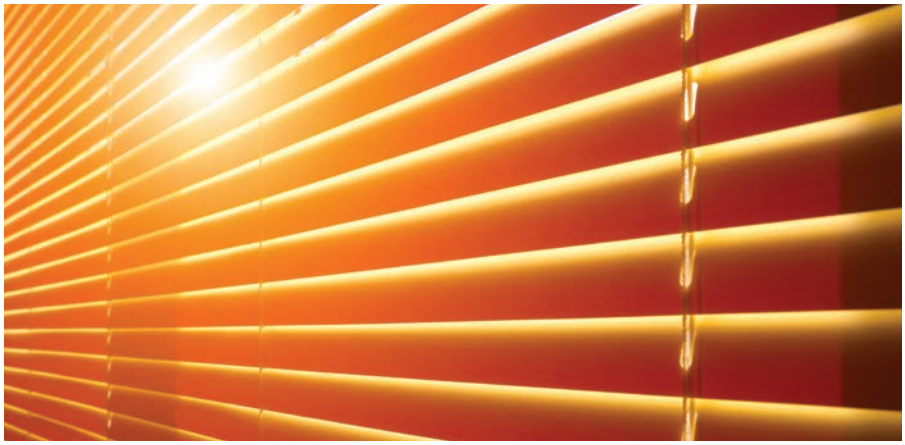
It said an 'overheating plan' should anticipate the implications of both 2°C and 4°C increases in average global temperature and be integrated into policy for decarbonising heating. It added that at least 20% of UK housing stock was prone to overheating, even during 'relatively cool summers'.

The CCC's latest report identifies threats from overheating to occupant health and wellbeing in prisons, schools and the NHS, as well as in homes. It also condemns the current Building Regulations as 'inadequate' on this issue because they are primarily focused on reducing the energy used by air conditioning systems. Revisions to Parts L and F of the Building Regulations – which are planned by the Ministry of Housing, Communities and Local Government for later this year – would include a consultation on methods for curbing the risk of overheating in homes that should lead to a vital change in policy, said the CCC.

It advised that scaling up residential retrofit programmes is an opportunity to address overheating risks, while prioritising 'passive cooling measures' will reduce the requirement for active cooling, such as air conditioning.

'The risk of overheating in terms of minimising risks to health and safety of occupants should be enshrined into regulations for new-build homes and retrofits,' the CCC report said.

'This should be considered alongside an integrated review of energy efficiency and ventilation, and be included in the government's planned Future Homes Standard.'



£36m up for grabs in R&D competition

The government is offering up to £36m in funding via two competitions for collaborative R&D and demonstrator projects aimed at improving construction productivity and quality.

Both competitions focus on modern methods of construction, digital and whole-asset performance. UK Research and Innovation is offering the funding through the Industrial Strategy Challenge Fund's Transforming Construction Challenge.

In the first competition, 'Transforming UK construction – collaborative R&D', up to £10m will be invested in projects that 'go beyond the state-of-the-art in improving productivity, quality and performance of the UK construction sector'.

Successful applicants must be UK-based and include at least one micro, small or medium-sized enterprise in the project team.

The second competition – 'Transforming UK construction demonstrator projects' – invites applications for a share of up to £26m for practical demonstrator projects in modern methods of construction, digital and whole-life asset performance. The aim is to invest in up to 10 'world-leading practical demonstrators… [that] must establish improvements in productivity, quality and performance of the UK construction sector'.

Applications can be made via the Innovate UK website and the deadline is midday on 30 October.

Scheme switches from gas to heat pump to meet GLA rules

ChapmanBDSP changes energy strategy to take account of new carbon factors

A regeneration scheme in Barnet has won planning approval after engineering consultant ChapmanBDSP changed the energy strategy to meet new carbon factors adopted by the Greater London Authority (GLA).

Air source heat pump (ASHP) technology, rather than a gas-fired combined heat and power plant, will now provide energy for 844 new homes and civic spaces at the former Pentavia Retail Park in north London, designed by architect AFK for Meadow Residential.

The factors, adopted by the GLA in January 2019, are based on the SAP 10 calculations that will be used in the next revision of Building Regulations. SAP 10 takes account of the rapid decarbonisation of the National Grid, and reduces the carbon emission factor for electricity from 0.519 $kgCO_2/kWh$ to 0.233 $kgCO_2/kWh$.

ChapmanBDSP associate Joanna Conceicao said: 'It's changed the energy strategy completely. Gas could still be used, but you would have to work a lot harder on the façade performance.'

Permission for the development was refused by the local council in 2018. Plans were later changed and resubmitted, but the redesign had to take account of the new carbon factors.

ChapmanBDSP tested six energy strategies, including those based on direct electric, air source heat pumps and gas.

The design strategy will be ASHP-led – either a communal ASHP with individual top-up electric immersion heaters for hot water, or a communal ASHP with individual air-to-water heat pumps.

Under the new carbon factors, the two strategies offer a 53% and 62% reduction in carbon emissions respectively when compared with the 2013 notional building emission rate. Conceicao said: 'Using the original carbon factors and a CHP-led strategy, there was a 44% reduction – but, with the updated figures, this was only 4%. We're now developing a bigger matrix, looking at the pros and cons of each strategy. Whenever we get a new project, we can immediately analyse the options.'

Zahawi is minister for construction

Nadhim Zahawi has been appointed parliamentary under-secretary of state at the Department for Business, Energy and Industrial Strategy, with responsibility for construction. He was previously parliamentary under-secretary of state at the Department for Education and has been the Conservative MP for Stratford-upon-Avon since May 2010.

In his new role, Zahawi will be responsible for delivery of the Industrial Strategy and the sector deals for aerospace, automotive, life sciences, professional services, nuclear, infrastructure and construction, rail supply chain, defence, maritime, supply chains, national security and investment, local growth and regulatory reform.

Heat pumps still strong in Europe

Sales of heat pumps fell by more than 3% worldwide last year, but Europe continued to show strong growth of almost 13%, according to BSRIA's latest market analysis.

More than three million units were sold worldwide last year – a 3.3% fall in volume terms, according to the study. The economic slowdown in China was seen as the main reason for the dip. In Europe, sales of heat pumps accelerated in 2018, reaching almost 650,000 units – a rise of 12.9% compared with the previous year. This makes the market worth €5.1bn (£4.6bn).

Air source units maintained strong growth rates, with split systems increasing at the fastest pace of 19.1%. Air source units designed to produce sanitary hot water were also on the rise in 2018.

IN BRIEF

Wind comfort for City

Britain's first planning rules for wind restrictions have been created by the governing body for the Square Mile.

The City of London Corporation has worked with wind engineers to set limits for acceptable wind speeds created by tall buildings. Developers constructing buildings higher than 25m will be required to show they will not cause problematic gusts at street level.

The code states that average wind speeds should be restricted to 18mph for pedestrian areas. Wind speed in areas where people stand – such as at bus stops – should not exceed an average of 13mph. In areas with outdoor seating, average speeds should not exceed 6mph.

New homes to be given £600m boost

The Chancellor, Sajid Javid, has promised to release more than £600m from his Housing Infrastructure Fund to support the delivery of 50,000 new homes – plus five new road and rail projects – in London, central Bedfordshire and Essex.

More than half of the money is going to Essex County Council for highways and rail improvements.

'I want to see more homes built in the places people want to live, so more people realise the dream of home ownership,' said Javid. 'But we need the roads, rail links and schools to support the families living in those homes, which is why I set up a fund to put in place the infrastructure to unlock new homes in these areas.'

So far, it has provided £1.3bn to help deliver up to 76,500 homes.

Project scales up solar storage heating

Caplin Solar is introducing its Earth Energy Bank storage technology, and photovoltaic thermal panels and heat pumps in 47 homes, as part of a commercial project.

Designed to generate more energy than is used in a home, the technology will be used at the Priors Hall Park development in Northamptonshire.

Project sponsor Electric Corby has received €750,000 (£684,195) in EU funding to evaluate potential benefits of transforming buildings through the combined use of heat pumps, thermal storage and photovoltaic thermal panels.

BPN calls for 'once in a lifetime' regulations change

Owners should measure CO_2 emissions of existing buildings, says network

An industry network has urged the government to seize a 'once in a lifetime' opportunity to reshape Building Regulations and link building safety to environmental performance.

In a letter to the Committee on Climate Change (CCC), the Building Performance Network (BPN) set out the connection between fire safety, carbon performance, protecting vulnerable people in their homes, and health and wellbeing.

BPN said there was a 'unique opportunity' to intervene in the government's consultation on the Building Regulations, and it urged the CCC to use its position as the government's adviser to ensure the regulations were reformed to take account of in-use carbon emissions and energy use.

Building owners should measure annual carbon emissions, says BPN

The network, which is managed by CIBSE, represents a broad range of stakeholders with an understanding of carbon emissions from buildings. Despite increasing complexity in the modelling of proposed buildings over the past two decades, 'carbon emissions from new buildings are not falling nearly fast enough to meet our national carbon reduction targets', the letter stated.

It added that 'performance gaps' could not be checked under Building Regulations because they have 'no locus beyond the completion and handover of the building'. The Building Act currently prevents moves to assess actual carbon performance because it limits the scope of Building Regulations beyond practical completion.

However, the Act 'will almost certainly require changes' to deliver the proposed radical overhaul of the regulation of buildings and fire safety set out in the *Building a Safer Future* consultation, the BPN said. It proposed new rules compelling building owners to measure annual carbon emissions as part of the health and safety strategy for existing buildings.

'Where the safety case suggests refurbishment work is needed, the opportunity to consider improving the energy and emissions performance of the building should be addressed,' the letter stated.

Ideal claims all high-rise boiler replacements breach regulations

Manufacturer Ideal Boilers says boiler replacements in high-rise buildings no longer comply with Building Regulations. The company's chief technical officer, Elaine Lancaster, has written to several local authorities to express concern that an amendment to the regulations – created in response to the Grenfell Tower fire – has effectively outlawed the flues supplied with all boilers used in buildings above 18 metres.

The amendment, introduced last December, bans the use of combustible materials on the external walls of high-rise residential buildings. Lancaster explained that most boiler manufacturers provide a flue comprising a steel-painted outer air duct and internal polypropylene plastic duct.

'As the inner flue material is classed as a combustible material, according to the standard, this type of flue can no longer be fitted to achieve compliance with Building Regulations,' wrote Lancaster.

A review being carried out by the Ministry of Housing, Communities and Local Government could take up to nine months, and Lancaster said it was unclear whether this would deliver a 'stay of execution or a permanent exemption' for this type of flue. Developing a new flue would be unnecessary and costly for the whole industry, she added.

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Girls overtake boys in A level science

For the first time, more girls took A levels in science subjects than boys this year, according to exam boards in England. Just over 50% of entrants were female, while the proportion of both genders taking science, technology, engineering and maths (STEM) subjects rose to an all-time high of 21% of A-level entries – up from 19.2% last year.

The number of girls taking A level sciences has risen by 10% since 2012, with biology the most popular choice. More girls than boys took chemistry, but boys accounted for 77% of students who studied physics. Maths and computing are also dominated by male students.

Engineering T level set up

Building services engineering will be offered as a T level from September 2021. Students who achieve the top grade will have the equivalent of three A*s at A level.

The two-year qualifications start in England next September and, by 2023, 16 to 19-year-olds will be able to take T levels in 25 subjects. They will be a mix of classroom learning and 'on the job' experience, including a work placement of at least 315 hours.

40 consultancies declare a climate emergency

Signatories have agreed to move towards zero carbon construction

More than 40 building services engineering consultancies have signed a climate emergency declaration and pledged to cut the environmental harm caused by engineering activities.

Signatories – including Aecom, Arup, Atkins, BDP, Buro Happold, Cundall, Elementa, Hilson Moran, Hoare Lea, InTandem, Max Fordham and WSP – said the declaration was a 'significant moment' for the construction industry, as well as structural, civil and building services engineering firms and clients.

'The research and technology exists for us to accelerate transformation now,' said BuroHappold partner Mike Cook. 'What has been lacking is collective will in government and industry. We urgently need current best practice to become normal practice. We are committing to strengthen our working practices and to create complete engineering outcomes that deliver more positive impacts on the world around us.'

The declaration comes after 17 Stirling Prize-winning architects signed the first pledge on behalf of their sector. They have agreed to set new priorities and develop better ways of working, improve the sharing of information and best practice, and move towards zero carbon construction in support of the government's 2050 net zero target.

'We have passed the point where we can afford to sit on the fence and wait for others,' said a Hoare Lea statement. 'We have to set the pace of change.'

To sign the declaration, visit **www.buildingservicesengineersdeclare.com**

IN BRIEF

Technical Symposium final call for papers

The deadline is approaching for abstracts of 250 words for the 2020 CIBSE Technical Symposium, with the final date 16 September.

Next year's event, titled 'Engineering buildings, systems and environments for effective operation', will take place in Glasgow on 16-17 April. It will explore how mitigating and adapting for a changing climate will reshape the engineering of the built environment and the systems that make our buildings habitable.

The symposium offers an opportunity to share key insights from your research and present best-practice case studies to a well-informed and engaged audience, and to develop networks.

Submissions are encouraged from young and experienced industry practitioners, researchers and building users, and should be in the form of research papers, posters, technical reviews, case studies or opinion presentations. They should be based on recent or current research or application, or examine actual or potential impact on the built environment.

For more information, visit **bit.ly/CJSept19symp**

Update your contact details

To ensure you continue to receive your CIBSE membership benefits, CIBSE needs to hold your correct contact details. Whether you are changing employer, moving house or getting a new email address, remember to keep us updated. Email **membership@cibse.org** or log into your **MyCIBSE** account online.

Inclusivity survey

CIBSE would like to thank everyone who took part in its inclusivity survey, which was completed by 917 respondents. The data is currently being analysed and the results will be published next month. For details, or to get involved in the work of the Inclusivity Panel, contact **inclusivity@cibse.org**

Put forward a project for SFE Façade of the Year

Competition showcases the importance of façades in modern architecture

The Society of Façade Engineering's (SFE) 2019 Façade of the Year competition is now open for entries.

The awards recognise and reward excellence in façade design, engineering and application, and aim to raise awareness of the importance of façades in modern architecture.

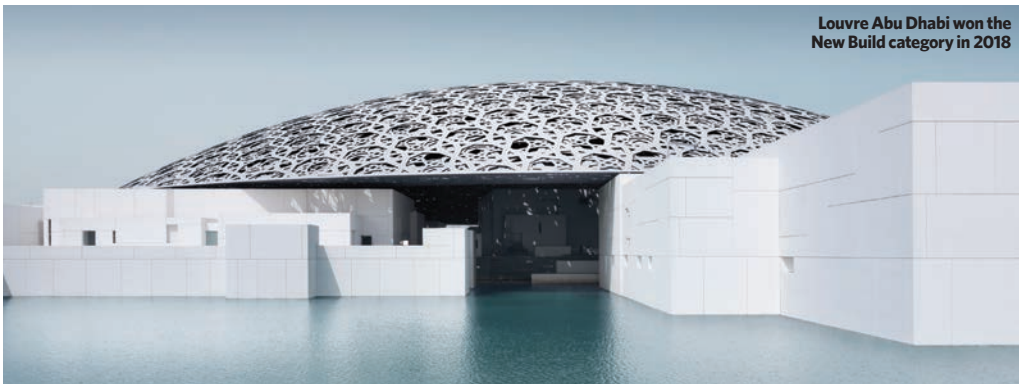
The competition is created, managed and judged by some of the world's leading exponents of façade engineering design.

Entries are invited in three categories – Innovation, Refurbishment and New Build – for any façade contract completed, practically, between 1 January 2017 and 31 December 2018, and that has not previously been entered in an SFE competition.

Entries should include a clear demonstration of excellence in technical design and/or research that has made a significant contribution to the discipline of façade engineering. This may be in the form of technical advances, innovations or advanced engineering systems.

The winners will be announced at the Glass Supper, held at the Guildhall, London on 10 December.

- For more information and to enter, visit **www.sfecompetition.org**



Louvre Abu Dhabi won the New Build category in 2018

Plan your route to success at a membership application session

Nada Issa MCIBSE CEng attended a session last year

If you are looking to apply for professional membership next year, CIBSE's membership application workshops offer support and advice from CIBSE interviewers.

The workshops aim to ensure participants leave with five of the 17 required evidence examples written, and that they gain an understanding of the submission and interview process. It can take an average of four months to put together the report and application documents for Associate and Member grades.

Nada Issa, who attended a session last year and went on to achieve MCIBSE CEng, said: 'The workshop was extremely helpful in understanding the competencies. It was insightful to hear the guidance given by the interviewers on each of the competencies and useful to discuss examples with other professionals. It is very easy to misinterpret the criteria for each competency, and it was reassuring to have the interviewers there, to ask them specific questions.'

Other attendees praised the interactive nature of the workshops and the opportunity to find out about other support offered by CIBSE, such as membership report reviews.

The autumn workshops schedule is now available to book, to help you meet the 1 February deadline. Visit **www.cibse.org/workshop**

Building Performance Awards 2019 Engineer of the Year winner Clara Bagenal George

Not long left to enter BPA Awards 2020

Project of the Year Retrofit category is new for next year

The deadline to enter the CIBSE Building Performance Awards (BPA) 2020 is 13 September.

There are 14 award categories to enter – for free – including Engineer of the Year, which was first awarded this year to Clara Bagenal George, and has proved hugely popular.

New for 2020 are the Project of the Year Retrofit award, and the Product and Innovation categories for Thermal Comfort and Wellbeing.

The BPA awards showcase the highest achievements in building performance across the construction and property industries.

They are the only awards in the built environment sector that are judged on actual, in-use performance rather than projections or designed performance.

The 2020 event will focus on all aspects of a project, product or innovation, looking for the delivery of safe, healthy, functional and sustainable buildings that operate efficiently and meet users' needs.

For the full list of categories and to download entry forms, visit **www.cibse.org/bpa**

Keynote speaker announced for Build2Perform Live

Baroness Brown of Cambridge, vice-chair of the Committee on Climate Change and chair of the Adaptation Committee, has been announced as the keynote speaker for day one of CIBSE's Build2Perform Live.

Baroness Brown's keynote session is titled 'Reaching Net Zero'. She will be discussing how we meet the UK's 2050 zero emissions target and how we can deliver a sustainable built environment.

The full programme for the free event – which takes place at Olympia, in Kensington, London, on 26 and 27 November – is now available. It includes sessions covering: heat pumps; smart buildings; UN Sustainable Development Goals; emergency lighting; review of building regulations; indoor air quality; assessing overheating risk; and new climate projections.

● For the full programme and to register, visit **www.build2perform.co.uk**


Baroness Brown of Cambridge

£1,000 up for grabs in simulation awards

The CIBSE Building Simulation Group (BSG) Awards 2019 are open for entries, with a winning prize of £1,000 up for grabs.

The awards focus on the use of building simulation in projects, and aims to encourage innovation in building simulation techniques. Entries should provide information on a project that has a simulation or modelling aspect, giving details about why simulation and modelling were important.

All entries will be reviewed by a panel of experts, who will select six entrants to present their papers at Build2Perform Live in November, where they will be judged and the winner announced.

The BSG supports and encourages the application of advanced building simulation tools for building and system design, and aims to drive best practices in building simulation.

The deadline for entries is 27 September. For full details and a link to the entry page, visit **bit.ly/CJSept19BSG**

SoPHE to present at Healthcare Estates Conference

The Society of Public Health Engineers (SoPHE) will give two presentations at the Healthcare Estates Conference and Exhibition at Manchester Central on 8-9 October 2019.

Steve Vaughan will present 'The SoPHE/CIPHE Plumbing Centre of Excellence Initiative' at 2.30pm-3pm on 8 October, while Dr Richard Beattie's topic will be 'From engineering design to water-quality compliance of domestic services' at 12.30pm-1pm on 9 October.

The theme of the two-day event focuses on 'Fund, Design, Build, Manage and Maintain', and incorporates presentations, exhibitor stands and a formal awards dinner. In addition, SoPHE and CIBSE will host a stand at the event to promote membership opportunities and highlight what the organisations can offer.

Other speakers at the conference include Simon Corben, director and head of profession NHS estates and facilities, and Alasdair Coates, Engineering Council CEO.

More than 240 companies will exhibit their latest products and services, while 75 speakers will give presentations during four conference streams.

For details and to register, visit **www.healthcare-estates.com**

Nearer to zero

The Climate Change Act has been amended to change our target to net-zero carbon UK emissions by 2050. With most of the 2050 building stock already in place, Hywel Davies considers what this might mean in practice

Theresa May has left the UK one clear legacy – the Climate Change Act 2008 (2050 Target Amendment) Order 2019[1], which amended the target set by the Act to net-zero emissions by 2050. According to the recent 2019 Progress Report by the Committee on Climate Change, and the Business, Energy and Industrial Strategy (BEIS) Select Committee report on energy efficiency, we are nowhere near on course to deliver.

After the power cut on 9 August, the risk of greater reliance on the electricity network is clear, while a recent Mori poll[2] suggests concern about climate change is higher than ever.

Meeting the ambition for the UK to have net-zero carbon emissions by 2050 will require a major change in the way we generate and deliver energy. We will inevitably see greater levels of localised generation, to which the National Grid and distribution networks must adapt. We will also need to accommodate the switch to electric vehicles – with the changing patterns of electricity demand and the potential for energy storage that implies – as well as the requirement to deliver the charging infrastructure.

"We do not know what the future holds for the gas grid, but we can design systems to be adaptable"

At this stage, we do not know what the future holds for the gas grid. This creates uncertainty, but we know that buildings will need heating, and we can design systems to be adaptable to heat sources other than burning methane.

Significant changes in the way we build, service and manage our buildings will also be required. That means CIBSE needs to provide new guidance and update existing guidance on a significant scale.

Almost every building that is constructed from now on will exist in 2050, so – from the outset – we must think about minimising the emissions from each. They may not be net zero when built, but they need to have energy efficient fabric and be adaptable, ready for the installation of low or zero carbon services systems in future. We need guidance on doing this, for a range of building types.

There also needs to be greater focus on the operation of buildings. The net zero target is real, not just a calculation. A building is net zero if it operates as a net zero building, not if a compliance calculation says it would under certain assumed conditions. So we have to understand how much energy buildings really use in practice, and how to reduce it while delivering an environment that is safe, comfortable and healthy, well lit, and conducive to the activities taking place within it.

We need to design buildings to perform, deliver them to perform, and then achieve that performance week to week and year after year. That is a challenge, and needs further guidance, benchmarks and tools so that it can be done in a realistic and cost-effective way.

Heat pumps will inevitably play a significant role. Early experience has not been an unqualified success. If they are not sized and installed appropriately, there is a real risk that at periods of peak heating demand, in deep mid-winter, supplementary heating is needed from an overstretched Grid. So we need further guidance and training to introduce knowledge and skills to our workforce. If heat pumps are going to be a realistic alternative to the traditional gas boiler, we have a lot of work to do there.

As the electricity Grid is decarbonised, demand for all electric buildings will grow. Again, we need guidance, ideally working with those who will install, operate and maintain these systems.

And we have a significant building stock of 29 million homes and commercial buildings that all need to be refurbished and retrofitted over the next 30 years. That is going to need further guidance, to reduce the risk that we reduce their emissions but create condensation and moisture-related problems that affect the building and, more importantly, the health of the occupants.

None of these changes is particularly difficult in theory, but the practicalities of delivering them effectively, at huge scale and reasonable costs, are significant. We need to develop our knowledge, skills training and guidance, throughout the life-cycle of our buildings – and that is a challenge for CIBSE and its membership.

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

References:

1 The Climate Change Act 2008 (2050 Target amendment) Order 2019 **bit.ly/2TXAOvw**

2 ipsos Mori poll on climate change, August 2019 **bit.ly/2NsOtvh**

Build2Perform Live: a look ahead

Decarbonisation is one of the main themes at CIBSE's buiding performance exhibition on 26 and 27 November

A keynote on 'Reaching net zero' by Barnoness Brown of Cambridge will open this year's CIBSE Build2Perform Live conference (see page 15).

The deputy chair of the Committee on Climate Change will be joined at Olympia London on 26 and 27 November 2019, by other speakers discussing the challenges of moving to net-zero carbon by 2050.

Hywel Davies will present a review of the Building Regulations Part L and Part F. He will be joined by Peter Rankin, principal building services engineer at the Ministry of Housing, Communities and Local Government, to discuss the imminent changes to the regulations governing ventilation and energy use.

Other relevant sessions include:

Hydrogen applications: What are the technical deployment, safety and acceptance issues for replacing natural gas with hydrogen in domestic and non-domestic buildings?

- Mark Crowther, technical director, Kiwa Gastec
- Chris Manson-Whitton, director, Progressive Energy

Heat pumps: Specification, integration and whole-life impact: Explore the consequences of heat pumps becoming more prevalent for heating, hot water and cooling applications in buildings across all scales.

- Dave Pearson, director at Star Renewable Energy
- Steve Wisby, partner at Hoare Lea
- Louise Hamot, sustainability consultant at Elementa Consulting

Heating and cooling in a low carbon future: Consider how decarbonisation can be balanced with guarantee of supply, flexibility towards future markets, and changing thermal demands.

- Duncan Josh, principal energy engineer at Atkins
- Aaron Gillich, associate professor at London Southbank University
- Rebecca Sweeney, head of commercial programmes at Energy Systems Catapult
- Dr Laetitia Mottet, University of Cambridge and Imperial College London

Demand management: Explore effective strategies to manage the peak load on the electrical Grid from heat pumps, direct electric heating and domestic transport.

- Federico Seguro, energy engineer at Troup Bywater + Anders
- Daniel Neasham, MEP development project manager, Europe at Lendlease

Saving the world together

One of the planet's worst engineering disasters gives us hope for the future, says CIBSE Patrons' chair **David Fitzpatrick**

Thirty-three years ago, a massive explosion at the Chernobyl nuclear reactor led to an estimated 6,000 cases of thyroid cancer in Russia, Ukraine and Belarus, and left hundreds of miles of countryside unfit for human or animal life. HBO's latest TV blockbuster depicted this in chilling detail. Yet, from this horrific episode has sprung an amazing story of building services engineering inspiration, ingenuity and teamwork.

In 2016, the site was finally prepared for decommissioning with the construction of a vast dome – more than 100m high, 265m long and 160m wide – that was slid, on rails, over the reactor, to seal it off from the outside world. The Chernobyl New Safe Confinement (HSC) is big enough to contain St Paul's Cathedral and is the largest man-made object ever to be moved on land. Even more amazing, though, is that it needs to remain viable for 100 years. This is possible thanks to the design, manufacture and installation of a specialised HVAC system that reduces the potential for the spread of hazardous dust particles and protects the structure from corrosion by maintaining relative humidity at a constant level.

This is, clearly, an extraordinary project – but the fundamental principles that underpinned its success must be adopted more widely. The HSC is a multi-country, multidisciplinary project involving thousands of people and a wide range of expertise, all focused on a single outcome: delivering a vital structure that meets the very highest quality standards over an extended operating life.

Our industry is expected to take a leading role in combating climate change, which will require the ultimate in long-term vision and collaboration. Yet, currently, too many of our supply chains are dysfunctional and our financial models incentivise short-termism. Many top-quality, specialist engineering firms are being forced out of business because they have not been paid fairly and on time. This hampers their efforts to recruit apprentices, invest in new technologies and improve their productivity – and, if they disappear, we have lost their crucial expertise forever.

After the collapse of Carillion, an investigation into construction payment showed that 60% of subcontractors were forced to write off some level of debt every year and that the sector lost £2.8bn in unpaid invoices annually – with the government among the worst offenders.

If you value the person and the work they do for you, surely the least you can do is pay them what they are due. Our industry has gained a reputation for trying to find ways to not pay people, rather than seeking to provide the best possible value for money. Are we not thoroughly fed up of this?

The HSC could not have been built without a team – and you can't have a team without trust. If you don't pay people what they deserve, when they deserve it, how can you expect them to trust you?

- **The Society of CIBSE Patrons is celebrating its 40th anniversary at London's Tower Bridge on 20 November. For more information about this and all the Society's activities, email: cbrown@cibse.org**

Making occupants the focus of building performance

Housing would be vastly improved if more was done to feed back lessons learned from building performance, says Fionn Stevenson, in a new book based on years of her own pioneering research. **Julie Godefroy** finds lots of practical advice for raising standards

Building performance evaluation (BPE) has been applied and promoted for years, mostly by the Usable Buildings Trust and through the development of the Building Use Studies (BUS) surveys and Soft Landings. The focus, however, has often been on the non-domestic sector, rather than housing.

Professor Fionn Stevenson's latest book, *Housing fit for purpose: performance, feedback and learning*, addresses this and offers a wide range of lessons from housing BPE, and detailed and practical advice on how to apply it. It should prove particularly useful now, amid increasing attention from professional institutions and policy-makers on the operational performance of buildings, including energy, comfort, and health – for example, the upcoming updated RIBA Plan of Work on performance.

Lessons from BPE

Stevenson's book is full of BPE lessons, case studies and anecdotes, often based on her decades of experience, such as her pioneering studies of overheating in Scotland. Some are specific to housing and others – such as the importance of commissioning, occupant inductions and simple user guides – will be familiar to other sectors.

Stevenson often sees 'excessive faith in technology', in systems that are overly complex or when designers dismiss evidence that a system is not performing well, claiming that 'occupants must be interfering with it'. She has many examples of overcomplexity in relation to controls, ventilation systems, and 'smart homes' in general. Occupants are more likely to engage with controls that are simple, well explained and useful.

Stevenson finds that passive design generally works better than active technology, and is preferred by occupants. It does, however, need attention, because some features may not work or be used as intended. For example, thermal mass may not improve thermal conditions if – for reasons such as outside noise or midges – occupants leave windows closed at night. Another classic BPE observation is to find plug-in electric heaters, or living room doors open onto unheated 'sun spaces' or 'winter gardens', thereby increasing energy consumption.

As a result, practices that have integrated BPE into their organisation by systematically applying it, sharing lessons internally, and feeding them into their projects, have often become leading-edge low-energy and sustainability practices – as is the case for many CIBSE Awards winners.

Stevenson also makes interesting points about the idea and terminology around 'optimised performance' – and, particularly, who the buildings are optimised for. She argues convincingly that, in making buildings flexible and resilient, it is important to cater for different occupants and their varied lifestyles, backgrounds, comfort preferences and so on. This is something also recommended in CIBSE guidance

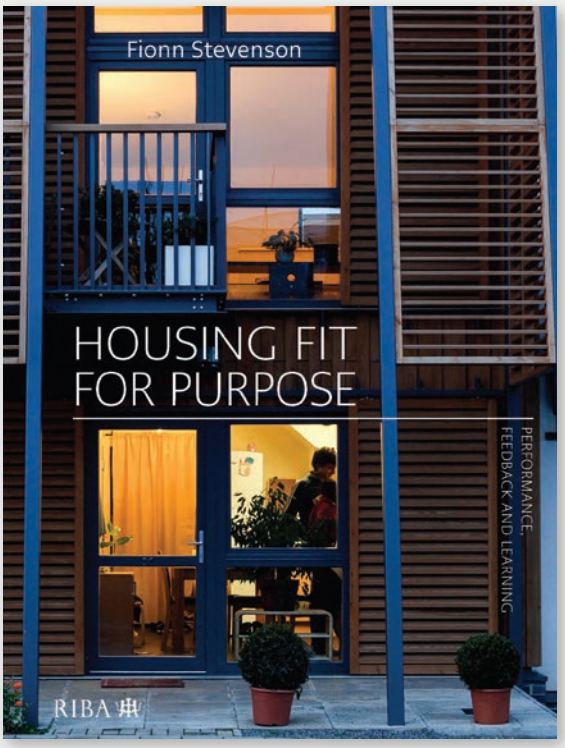
Guidance on BPE methods

There is a wide range of BPE methods, which vary in complexity, costs, duration, and levels of skills and experience required – both for the assessment of physical performance and user experience. Stevenson defines them as 'light touch', 'diagnostic' and 'forensic BPE'. Extensive methods should not be applied without good reason, she says, and a light-touch exercise – such as site visits and occupant interviews – can be very useful.

Beyond individual buildings, there is much value in longitudinal studies, going back to the same building over the years, and studying several homes of the same type. This will help assess new construction practices or innovative systems.

Stevenson insists on the value of interdisciplinary studies, ideally involving several disciplines or through an experienced BPE professional. Too often, she finds that BPE only considers building performance from one angle – typically the technical one. She recommends investigating more deeply how the physical performance – for example, temperature, energy consumption – relates to the occupants' experience, ways of life and socio-cultural context. **CJ**

***Housing fit for purpose: performance, feedback and learning* by Fionn Stevenson, RIBA Publishing**



The 2012-16 Innovate UK BPE programme was one of the largest publicly funded BPE programmes. The outputs are no longer available on the Digital Catapult website, but are being transferred to the Usable Building Trust's website at **usablebuildings.co.uk**

Intelligent insight

New research on intelligent buildings features papers from academics and practitioners. **Derek Clements-Croome** reports

CIBSE Intelligent Buildings Group, in association with the CIB Commission W098, presented its research 'roadmap', *Intelligent and responsive buildings*, at the CIB World Congress in Hong Kong in June. The publication explains the concept of intelligent buildings through a series of papers on technology, health and wellbeing, and infrastructure.

An intelligent building responds to the requirements of occupants, organisations and society. Its energy and water consumption are sustainable, and it is low polluting when it comes to emissions and waste, healthy in terms of wellbeing, and functional according to user needs.

Our designs affect people's physical, mental and social wellbeing. The environment is one of the most significant factors in absenteeism and presenteeism, which cost the UK around £100bn a year. So the intelligent building must be a healthy place to live and work.

Buildings should be able to take advantage of opportunities offered by robotics, quantum computing, the Internet of Things, smart materials, nanotechnology, and artificial intelligence. The ultimate objective should be simplicity rather than complexity, and this is best achieved by naturally responsive architecture.

At every stage in planning, design, construction, commissioning and post-occupancy evaluation, decisions have to be made that offer continuity from one stage to the next. Success depends on stakeholders collaborating as an integrated team and using interventions by other disciplines outside buildings and architecture. The roadmap is about change as reflected in society, as well as the advancements in technology that we create.

- Read the research at **bit.ly/CJSept19CIB**
- **DEREK CLEMENTS-CROOME** is chair of the CIBSE Intelligent Buildings Group and co-cordinator for CIB Commission W098

THE PAPERS FEATURED ARE:

Future of intelligent buildings: a critical debate on key performance indicators, Amirhosein Ghaffarianhoseini, Derek Clements-Croome, Ali Ghaffarianhoseini, Husam AlWaer, John Tookey
Health and wellbeing-oriented indoor built environments for future intelligent buildings, Quan Jin, Holger Wallbaum
Technology-aware workplaces, Matthew Marson
Daylight in intelligent sustainable architecture, Juergen Koch
Intelligent infrastructure, Mark Worall
Sustainable urban transportation in intelligent cities: air quality in underground built environment, Xingxing Zhang
Keeping abreast with technology, Eva D'Souza
Digital futures, Peter McDermott
Upskilling for technology-enhanced collaborative working, Tong Yang and Rosangela Tenorio
Wellbeing homes, Pete Halsall
Bioelectromagnetic design, Isaac Jamieson

"Insanity is doing the same thing over and over again and expecting different results."

– Einstein

Careful management of the Grid should help to popularise EVs

Driving force

Build2Perform speaker **Luke Osborne**, of the ECA, explains what can boost UK electric vehicle uptake

At this year's Build2Perform, Luke Osborne will speak at the electric vehicles (EVs) session on 26 November, between 3.45pm and 4.30pm. The session will consider what is required to deliver high-quality EV charging infrastructure, including market demand and interactions with buildings, and the potential of smart charging solutions, such as vehicle-to-building and vehicle-to-grid (V2G). For details, visit **www.build2perform.co.uk** and read our feature on battery storage and microgrids at **bit.ly/CJSept19ajax**

Will the Grid be able to handle the growing number of EVs?

Despite conflicting reports, it is anticipated that, with careful management, the Grid will be able to accommodate the projected growth of EVs. All new charge points installed in the UK must have smart controls. These will enable load control to be employed via a local control or the distribution network operator (DNO). Average daily journeys are around 30 miles and, with some EV ranges reaching the 300-mile mark, most drivers will only need to charge every few days.

What will have to be done to accommodate EVs on the Grid?

The growth of EVs and the electrification of heating will require additional electricity generation. As our energy mix becomes more decarbonised, however, we will see a shift to renewable generation, which – by its nature – is intermittent.

V2G connections will solve two 'problems' at once – additional storage during times of over-generation and additional capacity when there is increased demand. Static buildings connected to electrical energy storage systems (batteries) will also help balance the system. As prices fall, manufacturers are bringing more options to the market. Time-of-use tariffs (ToU) will help the consumer be more proactive or become a participant in the system, through financial rewards and penalties. Grid upgrades are likely in areas where multiple ultrafast charging points are needed – for example, at motorway service stations.

How will it affect building services engineers' designs for buildings?

They will need to incorporate EV charge points and, ideally, V2G (if the concept is proven) in their designs. Diversity will not be allowed for EV charge points, although load control will be permitted. This will enable the maximum amount of power to be delivered for the circuit design, regardless of the number of vehicles being charged, by 'smartly' controlling which vehicle receives charge at a particular time, thereby remaining within the circuit's limitations and preventing overload. Specific vehicles can be prioritised, if needed.

Under proposed legislation, all new homes will have to have car charging points [outlined in a public consultation on changing Building Regulations in England]. It is feasible that three-phase electricity connections will be considered, allowing a balance across the phases for EV charging for heat pumps and to facilitate fast charging (7kW-22kW) or rapid charging (43kW).

How do we ensure buildings have adequate infrastructure?

The building's load profile will need to be assessed to ensure there is capacity for EV charge points to be added. Limited capacity could be solved by limiting the charging output to vehicles, allowing them to remain within the supply limitations. If the maximum demand for the whole customer connection – including EV charge point ≤13.8kVA per phase or, if the aggregate maximum AC output of EV charge points is ≤30% of the maximum import capacity, the EV charge point connection can be made and the DNO notified afterwards. If the EV charge points exceed this, then prior consultation with the DNO will be needed through an application to connect (see **bit.ly/CJSep19EV**).

What happens to dead batteries?

EV batteries can be repurposed as static batteries for buildings. There is also a healthy lithium-ion battery recycling market, with nearly all the materials recoverable and made available for reuse. South Korea and China are leading on this.

What can encourage uptake of EVs?

We are rapidly seeing the deployment of charge points and there is support, through OLEV, for the installation of EV charge points for domestic and commercial customers. Vehicle manufacturers are also beginning to offer a variety of cars, and demand is now outstripping supply, especially in the fleet sector.

The message is clear: EVs are the future. The government has committed £37m towards wireless, solar and mass-charging infrastructure. And, from April 2021, the benefit in kind tax rate on company car EVs will drop to zero for the year.

LUKE OSBORNE is energy and emerging technologies solutions adviser at the Electrical Contractors' Association (ECA)

Tackling overheating

Changes to Building Regulations offer a chance to reduce overheating risks, according to speakers at a CIBSE seminar last month

Building Regulations governing ventilation and energy should be integrated more closely to help designers mitigate the risks of overheating in buildings. That was the key message at the CIBSE seminar 'Avoiding overheating', which took place in London the day before the UK experienced its highest-ever recorded temperature. At the event, sponsored by IES, CIBSE head of research Anastasia Mylona and technical manager Julie Godefroy discussed the factors affecting overheating and looked at the current regulatory framework for dealing with the issue. They also summarised the guidance available to minimise overheating.

'We are focusing efforts on the revisions to Approved Documents F and L, and are working with the government to make sure they understand the issue,' said Mylona. 'Engineers rely on regulations to get the evidence to convince clients to invest [in reducing risks of overheating].'

Mylona said the risks of overheating were increasing; higher building densities were contributing to urban heat islands and the average floor space in new UK dwellings was 76m^2 compared with 109.2m^2 in Germany. Other factors noted were large areas of glazing, the drive to insulate and make buildings airtight, and inadequate ventilation and poor installations.

City centre locations – where noise and pollution prevent occupants from opening windows – were at higher risk, as were buildings on community heating schemes, added Mylona.

The regulatory framework, methods and tools to avoid overheating were summarised, including CIBSE technical memoranda TM52 *The limits of thermal comfort: avoiding overheating in European buildings* and TM59 *Design methodology for the assessment of overheating risk in homes,* both of which are included in the GLA's draft London Plan. A domestic overheating checklist in the GLA Energy Assessment Guidance was drawn up at the same time as the London Plan. 'It is possible to pass TM59 in central London,' said Mylona. 'It's onerous – especially with single-aspect flats – but with thermal mass, good ventilation, shading and reduced glazing, it is possible'.

Godefroy addressed changes in SAP 10, which will be introduced with new Approved Document L. Assumed air-change rates are lower and there are questions around whether window openings might be inhibited by noise or security issues. Fully open is now the equivalent to the previous 'open half the time', said Godefroy, who warned that SAP shouldn't be relied upon to ensure designs provide thermal comfort.

The seminar also highlighted the Good Homes Alliance's new Early Stage Overheating Risk Tool, which assesses overheating risks in residential schemes at the pre-detail stages of design. Other methodologies mentioned were the Passive House Planning Package overheating assessment, BB101 for schools, and the Home Quality Mark.

"If you always do what you've always done, you'll always get what you've always got."

– Ford

ROLE MODELS

The CIBSE HVAC Systems and Building Simulation groups explored advanced building systems modelling during a discussion at Hoare Lea in July. Aecom's **Mary-Ann Clarke** reports from the event


Darren Coppins


Ant Wilson


Robert Cohen

Three industry experts shared their views on the benefits and limitations of modelling at a recent event organised by the CIBSE HVAC Systems and Building Simulation groups. Ant Wilson, formerly of Aecom, argued that modelling has limitations because human behaviour is inherently unpredictable, while Verco technical director Robert Cohen said clients can reap the benefit of modelling if buildings are simulated at every stage of construction and performance data is fed back to designers so they can improve subsequent simulations. Built Physics director Darren Coppins' concern was that there was little consideration of how plant responds to the building load in models.

Ant Wilson was first to the podium and started by asking the audience: 'Why do we model?' There are a number of reasons, and Wilson highlighted the following: informing the design, ensuring compliance, creating thermal comfort, and predicting energy and carbon performance.

He said, within the building industry, we have been modelling since the 1960s, when solar simulation was used to produce an array of results, one of which might be right, but the rest of which were likely to be wrong.

Moving towards nearly-zero energy building, building performance modelling has become an inseparable part of building and plant design, but Wilson questioned the quality of the models we create.

He suggested that accuracy of results had more to do with the competency of the modeller than the software used. He added that the more accurate the data you put in, the more accurate the result you will get out.

He looked at the ideal scenario – a perfect model, created by a competent modeller, with accurate data. So why do our buildings still not perform as predicted?

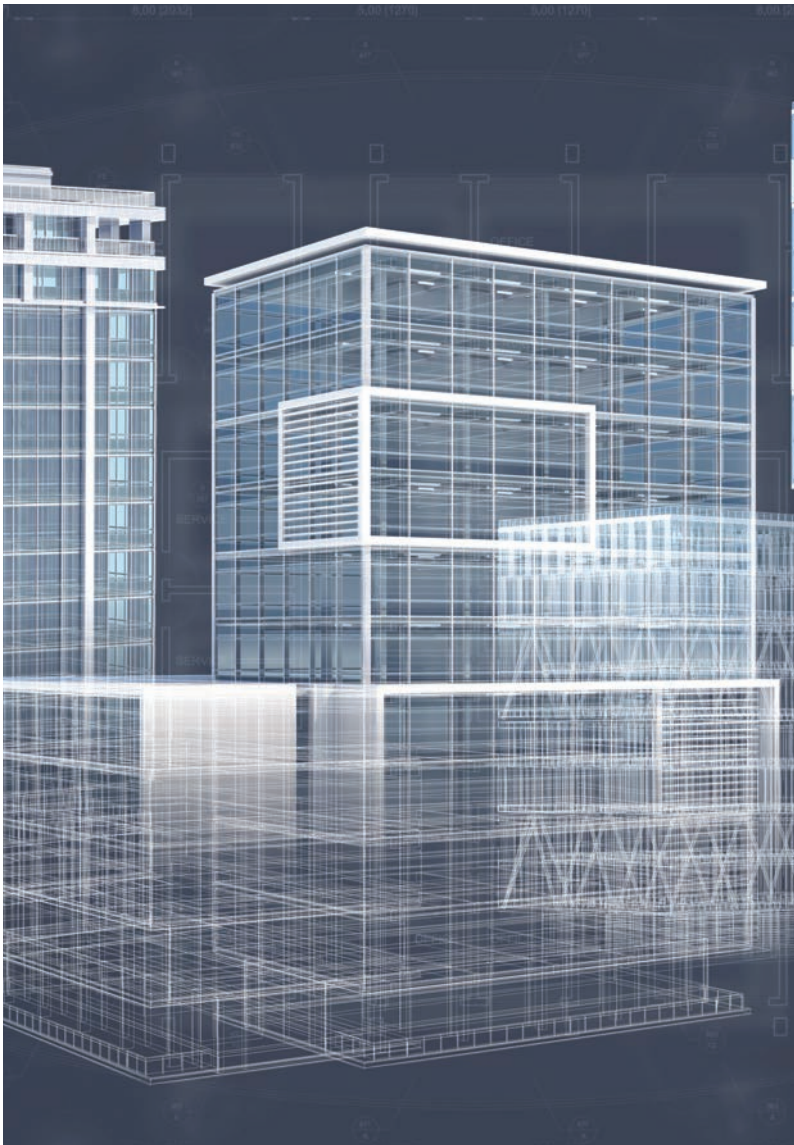
Wilson likened the problem to car emissions, and why the amount of fuel used by different makes and models was so different from the manufacturers' official figures.

He suggested that it was, in fact, the driver – and the way they drove the car – who had control of the car's emissions. Wilson then questioned whether we operate buildings in the predicted way they have been modelled. Perhaps not, he said, and this might be because the models are unable to predict human behaviour.

Measure to improve

Cohen felt passionately that we might learn 'a thing or two' from Australia. Could this be the answer to how to close the performance gap between model and building?

By following the process in a Nabers Commitment Agreement, Australian teams can now routinely achieve in-use operational energy performance ratings in line with the predictions of the design stage models, he said. He demonstrated how, since 2002, by delineating, measuring and disclosing base building operational energy performance, new Australian office buildings were reducing their annual energy use year on year. The least efficient new office building now has half the energy intensity of its peer in 2002, while the most efficient is five times less energy intensive. It is striking that equivalent



data for the UK is not available but, in 2012, a BBP study suggested London's average energy intensity for office buildings was similar to Melbourne's average in 2002.

But what are the factors behind this market transformation? Cohen highlighted two: the market – including occupiers, investors, developers and supply chain – asks for, and values, performance; and the use of commitment agreements to design for performance by setting targets, undertaking advanced simulation modelling, fine-tuning, verifying and then disclosing achieved performance, leading to lessons learned.

If the building is simulated at every stage of the project, from concept through to user occupation, the energy performance can be more accurately checked. Cohen concluded that performance feedback to the original designers was imperative to ensure improvement in their next design. He said to improve performance, we must measure performance.

> "Accuracy of results has more to do with the competency of the modeller than the software used"

Coppins rounded off the presentations by examining HVAC system modelling, asking what it is and why it is important.

Most larger commercial buildings in the UK have some form of energy intensive HVAC system, he said. Currently, the majority of modelling only uses simple formulae for plant efficiency; however, the actual performance can be significantly more complex.

One of his concerns was that we model thermal loads in detail with little consideration for how plant responds to the building load.

By simulating HVAC systems, we gain a greater understanding of energy consumption. For example, if the controls philosophy and plant items are specifically modelled, then outputted data can be used to understand the suitability of the plant, and can offer more realistic building loads, helping to reduce plant sizes and systems.

Coppins said there might be an answer to the performance gap, but conceded there are still many factors impacting our ability to predict energy use. He showed examples of building services that had just 'gone wrong' in construction, illustrating that human error is a major factor in the discrepancy between prediction and performance.

All three speakers felt that modelling gives a valuable insight into the behaviour of a building, but the results are highly dependent on the competencies and commitments from all those entwined in the building process to understand, learn, implement and take responsibility. **CJ**

- The next HVAC Systems event, Low carbon heating – how to meet the challenge, will be held on 23 October. For details, visit **www.cibse.org/Networks/Groups/HVAC-Systems**

- **MARY-ANN CLARKE** is regional director at Aecom

Schneider Electric shows specifiers tender-loving care

New specifier tool takes the hassle out of tendering

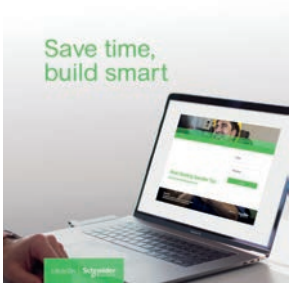
Schneider Electric has launched a new specification tool for M&E consulting engineers. The free online tool aims to make the process of generating specification for tenders quicker, simpler and much easier. It provides an intuitive platform for users to create and store their specifications, and instantly access all the information they need on solutions and digital architectures.

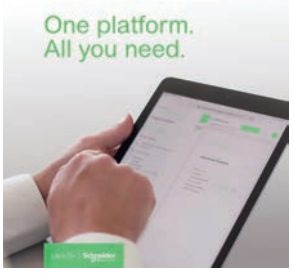
When a company embarks on a new project – such as the construction of an office building – they will issue a design scope, inviting consultants to propose and design the building's electrical and mechanical infrastructure. Submissions must be detailed, outlining everything from the building's energy management system through to individual circuit breakers. The process is difficult and time-consuming, and often fails to secure new business for the consultant. In a highly competitive market where speed is critical, this is time consultant engineers cannot afford to waste.

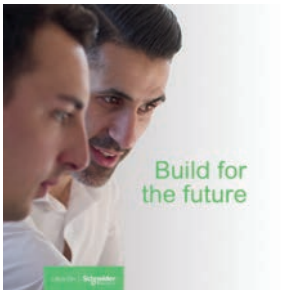
Schneider Electric's specification tool enables consultants to create tender blueprints quickly and easily. Available through the company's Specifier/Consultant mySchnieder Partner Portal, the platform allows users to create specifications from scratch or pre-existing templates.

The platform provides simple functionality, letting specifiers take product information from a vast library of industry solutions and quickly drop it into their tender templates. Product, standards and solution documentation is constantly updated, giving users one easy place for the most up-to-date information on all current design needs.

To access this tool, simply register/log in to the mySchneider Specifier portal at; schneider-electric.co.uk/specifiers







SERVICING THE CIRCULAR ECONOMY

How can engineers accelerate the transition to a circular economy? Arup's **Harry Popplewell** and **Richard Boyd**, UCL's **Ben Stubbs** and CIBSE FM Group's **David Stevens**, set the scene

A circular economy presents engineers with an opportunity to improve system performance, decrease whole-life cost and reduce the environmental impact of their buildings.

Following the recent recommendations by the Committee on Climate Change for net zero greenhouse gas emission for the UK by 2050, CIBSE has set out its own climate action plan, detailing activities that work collectively towards reducing carbon emissions and preparing for the future impacts of climate change. See **bit.ly/CJSept19plan**

What is a circular economy?

The traditional resource consumption model is linear, where resources are extracted from natural systems to make products. These are often thrown away once they have served their purpose, without the full value of their component materials being realised.

A circular economy aims to move away from this, by designing out waste, maximising value, improving maintenance and returning materials into the cycle at the end of their lives. A transition to a circular economy aims to decouple business growth from resource consumption, providing the coherent strategy cities, organisations and projects need to achieve both economic and environmental goals (Figure 1). It should be noted, therefore, that 'circular economy 'is not simply a way of rephrasing 'sustainable development'. It is a shift in the way we do business, which can offer direct value to adopters through improved system operation and maintenance, novel financial opportunities and performance-driven contracts.

The circular economy has been gaining momentum across the built environment, a sector responsible for huge amounts of waste: physical waste through construction and demolition, energy waste through system operation, and space waste through inefficient use (Figure 2).

In addition to the contribution of buildings to climate change through carbon emissions, CIBSE TM56 describes how the production of building services components also results in the direct destruction of ecosystems, the release of toxic by-products, and increasing water stress through process demands.

Arup has been working with colleagues around the world, exploring the ideas of a circular economy for more than five years. These efforts have intensified since 2016, when Arup became the global knowledge partner for the built environment of the Ellen MacArthur Foundation, a leading proponent of circular economy thinking.

Through the partnership, Arup and the foundation have been considering how circular economy principles might operate in the particular circumstances of the built environment.

Circular design principles

More recently, Arup has been working with UCL Estates and the Bartlett School of Planning to create circular design principles for MEP »

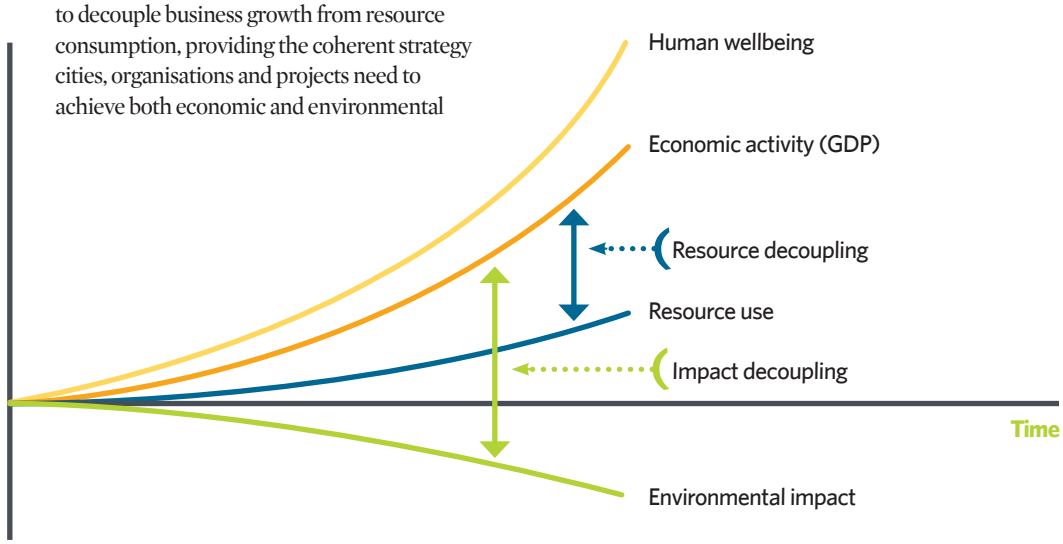


Figure 1: Source: UNEP

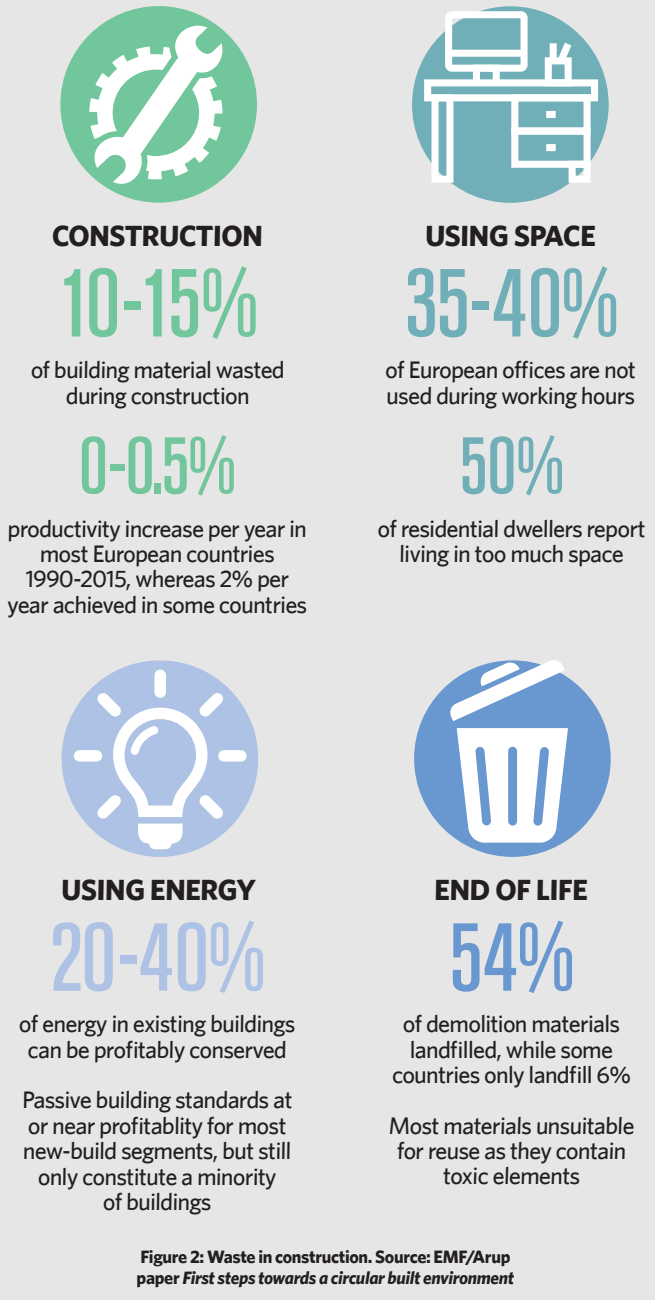


Figure 2: Waste in construction. Source: EMF/Arup paper *First steps towards a circular built environment*

» systems, specifically those of Marshgate 1, UCL's new 35,000m² building in Stratford, East London.

Supported by Schneider Electric, and with input from Aecom life-cycle cost consultants, the work sought to use circular principles to address the key challenges faced by UCL relating to its MEP systems.

These challenges included the need to avoid the early obsolescence of installations, by future-proofing designs, addressing the performance gap that often arises between design and installation, and overcoming the barrier of upfront cost being a greater driver for design decisions than the total cost of a system over its life.

Another aspiration of UCL was to incorporate sustainability measures that would go 'beyond Breeam', while addressing the key operational challenges. The project hoped to indicate the cost and whole-life carbon benefits of applying circular principles.

Technology now enables key circular economy principles, such as the sharing of information, tracking material flows, real-time usage data and straightforward collaboration. In short, digital technology has unlocked the potential of the circular economy in the built environment.

The circular economy building blocks and levers defined by the Ellen MacArthur Foundation were used to create five scenarios, each focusing on a different aspect, tailored to achieve the aims set out by UCL (see panel, 'Circular framework').

There are several key considerations to be made for each scenario, along with opportunities and current barriers to implementation. In the case of the UCL Marshgate building, there were reductions in whole-life cost and carbon across the board, demonstrating the business case for a building services circular economy. Each project is unique and shall lend itself to a different combination of approaches. Appropriate consideration of the maintenance strategy must be included during the design stages to support whichever approach is taken.

Application of these principles shows that design and operations engineers should look together at the circular economy from beyond a component recycling and reuse level. It is equally vital to design out waste to ensure the value of materials are maximised throughout their lives.

The application of these scenarios enables the sector to systematically offer more value to building operators by reducing costs and improving system performance, while improving environmental outcomes.

The outcomes of this research form the basis of a CIBSE technical guidance document, set for publication at the end of the summer, setting out each scenario, key considerations, opportunities, barriers and key enablers. **CJ**

HARRY POPPLEWELL is a mechanical engineer at Arup's buildings London team; **RICHARD BOYD** is a senior engineer at Arup's advanced digital engineering team; **BEN STUBBS** is senior sustainability manager at UCL Estates; and **DAVID STEVENS** is assistant director at UCL Estates and vice-chair, CIBSE FM group

CIRCULAR FRAMEWORK

These five approaches provide a framework that can be applied to any construction, refurbishment or strategic maintenance project to incorporate circular economy principles.

The universal scenario is a response to architect Stewart Brand's theory that simple, flexible buildings get better with time, while complicated, inflexible buildings get worse. A universal building can accommodate several functions, allowing the building to be upgraded or change function in response to changing owner and occupant demands. Flexible buildings maintain their value for longer, or depreciate slower, than inflexible buildings, keeping the materials in the building at their highest possible value for as long as possible.

The joint venture approach aims to align the drivers of each stakeholder within a project by placing them under a single financial umbrella, where payment is dependent on system performance. The result is that designers become more invested in the building's operation, while greater input is taken from facilities managers and potential occupants during design, reducing the risk of a performance gap.

The concept of passive buildings has been around for a long time. This approach minimises the use of active systems, replacing them with passive processes, such as natural ventilation and daylighting. Resource consumption is therefore designed out.

The aim of the recover scenario is to minimise the reliance of the building on external resource flows, particularly water and energy. Capturing the value of waste flows, such as low-grade heat and wastewater, are also prioritised. The consumption of virgin resources is thus minimised.

The pre-loved scenario is about how to incorporate secondhand equipment into buildings to create a market demand model for pre-used equipment, adding value to what is currently a waste flow.

QUALITY AS STANDARD

CIBSE award-winning low energy design consultancy Warm has its roots in Passivhaus, and even put into practice its low-energy expertise by refurbishing its offices to the EnerPHit standard. **Andy Pearson** reports

'Warm is quite a bit different from other consultancies,' says Sally Godber, director at the design firm. 'We're value driven; we're interested in anything that improves energy and comfort performance.'

It is an approach that has proved to be very successful: Warm has an enviable reputation as a leading low-energy design consultancy and Passivhaus specialist, having been involved in almost every non-domestic Passivhaus project in the UK, in addition to many major large-scale residential Passivhaus developments.

Alongside its consultancy services, Warm also certifies Passivhaus projects, offers training courses, and carries out post-occupancy monitoring of such projects. And, if you thought Warm could not be any more Passivhaus, it has even refurbished its Plymouth office to meet the EnerPHit standard.

It was Warm's unswerving commitment to low-energy design that helped the practice win Building Performance Consultancy of the Year (up to 100 employees) at the CIBSE Building Performance Awards 2019.

The judges described the business as an 'innovative organisation that practised what it preached' and said Warm was 'clearly pushing the boundaries of low-energy design'. It was an impressive achievement for an organisation that has only been in existence for 10 years.

Warm provided mechanical services design and Passivhaus consultancy for 13 Passivhaus two and three-bedroom houses and flats in Mill Road, Sharnbrook, built by Parrott Construction

The firm was founded by Peter Warm and his mechanical engineer daughter Sally Godber. 'My dad was working as a consultant on cutting-edge low-energy buildings, so when I joined him 10 years ago, Warm was born,' Godber says. "We were both really interested in low-energy buildings; when we set up Warm we said: 'We've got enough money to pay ourselves for a year, if we have a business at the end of it, great, if not, then at least we'll have done a year's worth of interesting stuff".'

From father and daughter, Warm's success has seen the size of the practice grow, so its workforce now totals seven. Most of the team are from an engineering background, with the exception of an architectural technologist. 'The roles we undertake are varied because we're most interested in doing the things that make the biggest difference to a project's energy use, so we get involved in everything from helping develop the form of the building to designing the hot water system,' says Godber.

In practice

Warm's involvement in a project usually starts with an approach from a design team or client looking to employ its low-energy design expertise and experience. 'Our client base covers a whole range of backgrounds: we're consultants to building services engineers and to architects, and we work directly for clients and contractors; our low-energy values are usually aligned with those of the people we work for,' Godber says.

It is when Warm is involved at an early stage in a scheme's design that it can have the biggest impact and deliver best value. Many design solutions proposed by Warm are informed by its experience monitoring the performance of completed buildings.

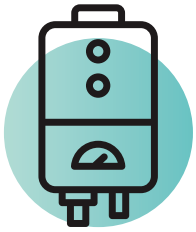
'It is often a painful experience because there are certain things that come up during the scheme's design – you opted for one solution and then, when you look at the post-occupancy feedback, you realise that, perhaps, the other option might have been the better solution,' Godber says candidly.

Warm's post-occupancy studies give it a good understanding about how buildings work, how they are being used, what occupants think of the design, and its energy consumption. Many findings feed back into its future design work.

> "One of the biggest lessons Warm learned from working on its own offices is an understanding of how difficult it is to make decisions as clients"

» 'This is the missing loop in construction,' observes Godber. 'There is nothing quite like saying "we've tried that and this is what happened". That kind of experience is invaluable in developing solutions that work,' she adds.

An example of the impact that post-occupancy studies can have on a design is in the practice's move away from specifying combi-boilers. 'Historically, we specified combi-boilers because it was a cheap way of dealing with heating and domestic hot water demand,' says Godber. 'But, through our post-occupancy studies, we found the efficiency of the boilers when they operate in hot water mode – which is nearly all of the energy consumption in a Passivhaus – was around 62%. This finding forced us look for alternative, more energy-efficient solutions,' she says.



62%

Average efficiency of combi-boilers revealed by post-occupancy studies

Warm carries out Passivhaus training sessions including a course for contractors and training on retrofitting www.peterwarm.co.uk/training/

Sally Godber and Peter Warm

Passivhaus roots

Warm's involvement with Passivhaus started soon after Godber and her father had joined forces.

'We started Warm in 2009 and that was when we got our first Passivhaus project, which was for 20 homes in Cornwall,' Godber says. 'The thing that really chimed with us about Passivhaus was that it was based on a huge amount of research derived from the best low-energy building solutions from around the world. The Passivhaus standard and all the technical guidance around it are based on real data of how buildings actually perform,' she says.

Father and daughter were struck by how well Passivhaus had been thought through in terms of the tools and processes it had in place to support the design team in optimising a design. They were also impressed by the requirement for a scheme to be certified as part of a rigorous quality assurance regime.

'To certify a scheme, you have to have an independent specialist – someone who understands building physics – to check over everything in the design, which is quite unusual,' says Godber.

Passivhaus is 'a good way of ensuring quality and low energy for any buildings that are occupied by people, as opposed to empty warehouses, where there is a need to keep people comfortable', says Godber.

She warns that if Passivhaus, or something similar, does not become mainstream construction practice, the UK will be 'truly screwed' in terms of what is needed in building carbon savings. 'We need our buildings to be performing as designed,' she says.

If the UK adopts Passivhaus as a compliance standard, is there a danger that build costs will rise? 'At the moment, there is a significant over-cost because Passivhaus is unusual and, therefore, perceived as high risk because it is not something contractors are used to doing,' says Godber.

She says if it becomes mainstream, this over-cost should soon start to disappear. 'In Brussels, Passivhaus is what everyone builds. Here, it has »

Warm advised on all aspects relating to Passivhaus at the University of Leicester's Centre of Medicine including the integrity of insulation and ventilation commissioning

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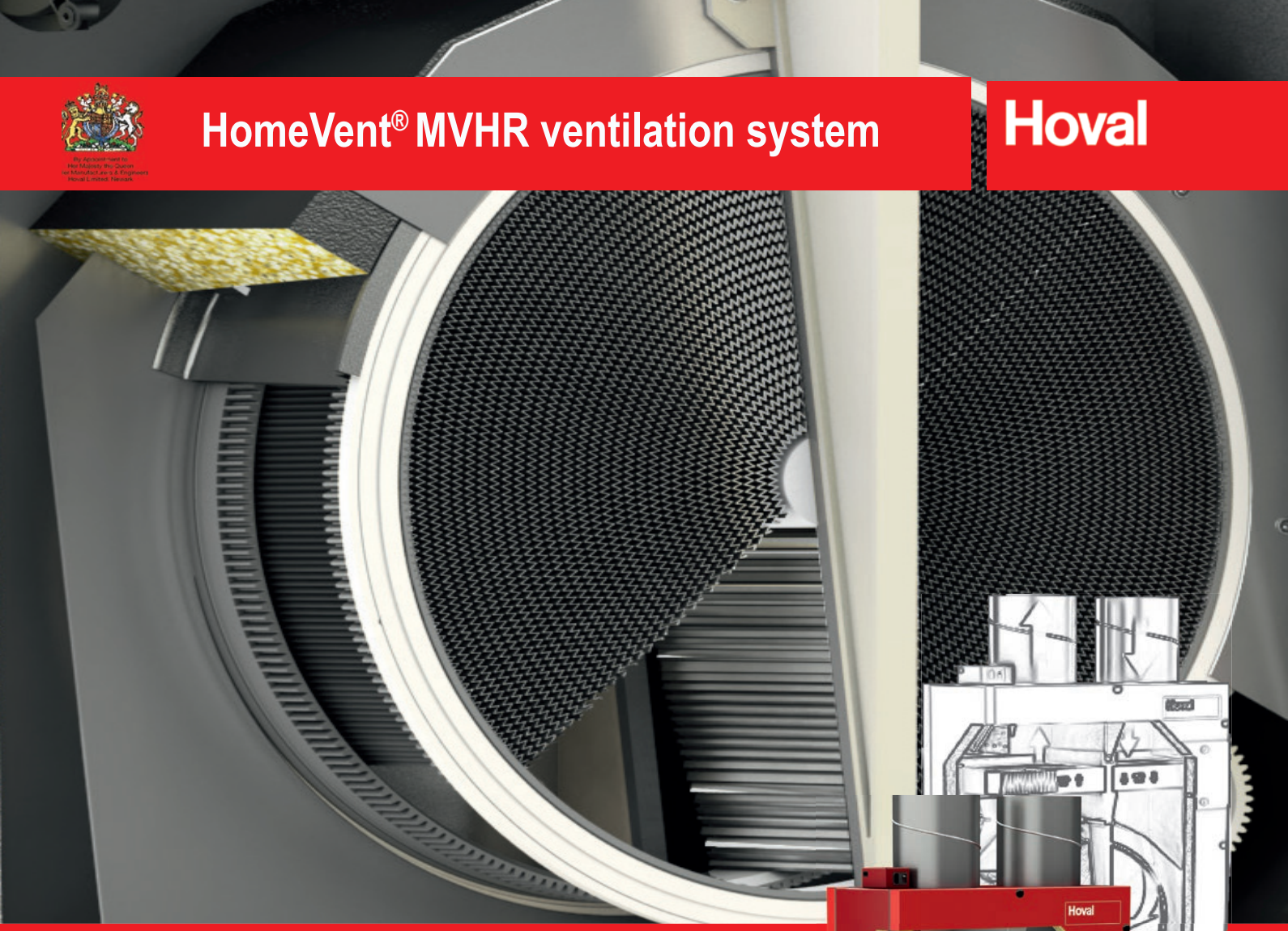

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Responsibility for energy and environment

» been shown that, once it becomes normal, there is no real relationship between building energy performance and build cost,' she says.

Most contractors Warm works with are keen to learn about Passivhaus. 'We provide a lot of support to contractors and builders who are trying to build low-energy buildings, and to make them airtight,' says Godber. She says most contractors have 'an exceptional attitude because they see Passivhaus as an opportunity for them to prove that they can do a good job – it's not technical, it's just about building really well'.

Becoming a client

Warm had a chance to put into practice its low-energy credentials and contractor support mechanism when it decided to refurbish its offices to Passivhaus EnerPHit standards. 'To get a proper understanding of the issues faced by contractors and clients, there is nothing like doing it for yourself,' Gober says. One of the lessons learned from the experience was how difficult it was to fit the rigid external insulation it had specified onto the office's rough façade.

Warm's EnerPHit proposal had to be certified by an independent consultant. 'You cannot certify your own scheme, so we got another independent certifier to certify the design,' says Godber, adding that it was a positive experience.

'There is nothing like having someone check your work – there is so much going on when you're designing a project that you might miss a way to improve the performance of a particular detail, which the certifier will point out. Knowing that someone is checking it is incredibly valuable. It makes a big difference to how a scheme will perform in practice.'

'If we want good quality buildings, we need to invest in a good quality assurance system,' she adds.

One of the biggest lessons Warm learned from the experience of working on its own offices is an understanding of how difficult it is to make decisions as clients.

'When you're just focused on the Passivhaus, you only see things from one angle – what they've chosen is not the optimum – but, sitting on the client's side and having that compromise experience, you can understand and empathise with them,' says Godber. 'You come away feeling incredibly humble towards other clients and the compromises that they have to make,' she says.

Working on its office build, combined with Warm's experience of working with contractors and its post-occupancy monitoring of low-energy projects, has given a good understanding of the practical side of implementing design solutions. 'The big thing we've found from site support is the need to simplify everything,' says Godber.

Warm's post-occupancy monitoring has also highlighted how little maintenance goes on within buildings. 'Whatever your solution, make it simpler still for ease of use, maintenance and buildability,' says Godber.

Warm passes on its acquired low-energy and Passivhaus knowledge through the training courses it runs. 'We've always been surprised by how few building services engineers are interested in our training; it's a shame because it complements their skills perfectly, and is a huge opportunity for them to pick up this knowledge,' Godber says.

'We would like to see greater participation from building services engineers in Passivhaus projects because, if they do get on board, the project will really sing,' she adds.

Godber warns people to be wary of schemes described as 'designed to PH principles'. 'Anything can be claimed to be designed to Passivhaus principles – for example, they might have put loads of insulation on and claimed the scheme is Passivhaus, or they might have been really diligent and built the scheme correctly, you just don't know,' she says. 'The only way to be sure it is a Passivhaus is to ensure it is certified as such.' CJ

WARM'S SHAPE TOOL

'We like having a go at making tools, as you can see from the download page of our website,' says Godber. 'If there is something interesting that we've developed, we tend to share it with everybody.'

Warm's Shape Tool is aimed at architects to help them with the early stage massing of housing developments. 'It allows the architects to get an idea of how much insulation they need and how efficient the form of the massing is from an energy perspective because heat loss is a function of surface area,' Godber explains. 'So, if you don't want to spend money – and embodied energy – on fancy insulation, build a simple shape; simple buildings tend naturally to have fewer fiddly details and don't require fancy materials to make them work,' says Godber.

Warm provided Passivhaus consultancy for 72 homes in Primrose Park, Plymouth

WINDOWS OF OPPORTUNITY

Max Fordham's Passivhaus house features automated insulated shutters, developed to reduce night-time heat losses and to achieve an energy balance between gains and losses on a cold winter's night. **Liza Young** reports

Max Fordham's House will leave a lasting legacy. Not only because it was built to the Passivhaus standard, but also because the scheme features innovative insulated shutters, which Fordham hopes will become an energy efficiency solution for future retrofit and low-cost housing projects.

Designed and built in collaboration with Max Fordham LLP (the practice he founded), bere:architects, Price & Myers and Bow Tie Construction, the three-bedroom home, set in a tight, urban infill site in Camden – previously Fordham's garden – was completed in February 2019 and is undergoing Passivhaus certification.

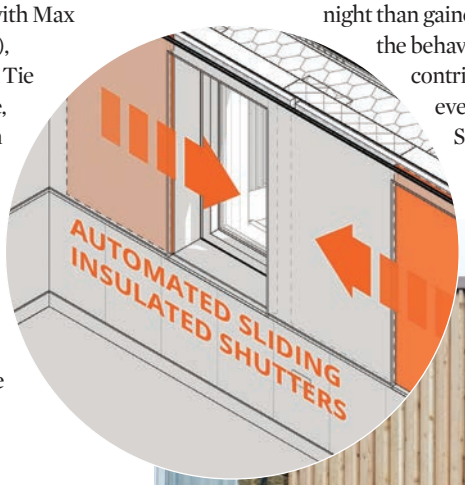
The building's thermal envelope, its ventilation system and windows are all designed so that the heat loss on an overcast, cold winter's day is no more than the heat generated by people living in the house.

Envelope

The building frame is concrete with insulated timber walls, with incorporated airtightness and moisture-tightness layers, eliminating thermal bridges and uncontrolled air exchange.

As well as allowing daylight into the home, removing the need for electrical lighting during the day, the windows allow solar radiation to warm the inside air. They feature automated insulated shutters that have been developed to reduce night-time heat losses and to achieve an energy balance between gains and losses on a winter's night.

Usually, on cold, grey days, more heat is lost through a window at night than gained during the day. 'We have altered the behaviour of the windows so they are net contributors to the building's heat balance, even on a freezing, overcast day,' says Ali Shaw, senior engineer at Max Fordham.



The shutters are integrated into the fabric of the home

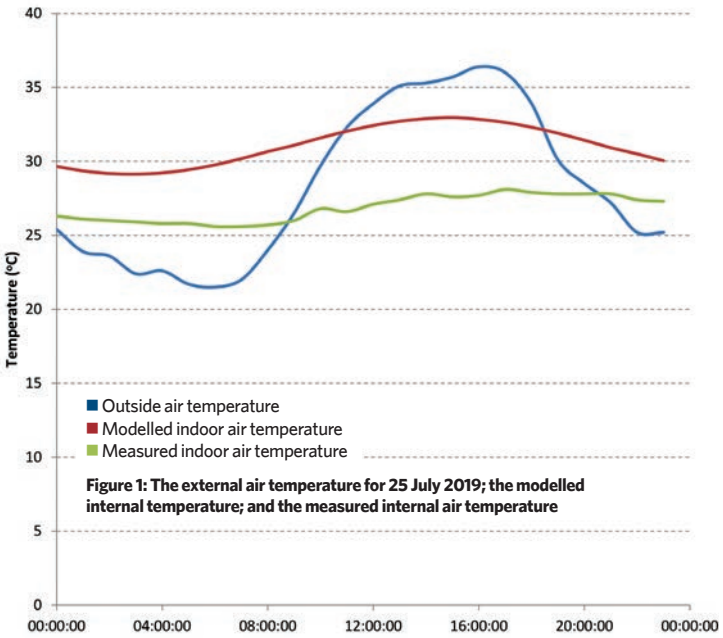


Figure 1: The external air temperature for 25 July 2019; the modelled internal temperature; and the measured internal air temperature

PROJECT TEAM

Client: Max Fordham
Architect: bere:architects
Passivhaus consultant: Max Fordham LLP in consultation with Passive House Institute
Energy rating assessment: Max Fordham LLP
M&E engineer: Max Fordham LLP
Structural engineer: Price & Myers
Main contractor: Bow Tie Construction

He says the horizontally sliding thermal shutters – constructed from polyurethane rigid foam (PUR) panels and integrated into the internal fabric of the building – are intended to maintain a constant comfortable internal temperature, and to defend against extremes of both external cold and heat.

The shutters allow the windows to become much more insulating at night so the windows are thermally a net benefit every day. It is hoped that this technical concept, when proven, can be replicated in low-cost housing projects as retrofit items.

To ensure a healthy indoor environment, ventilation is controlled mechanically, with heat recovery efficiency in excess of 90%.

Overheating risk is mainly mitigated by windows that open fully, says Shaw. The top-floor rooms, which have the most solar exposure, are dual aspect, and rooms with daytime occupation are thermally massive.

"The horizontally sliding thermal shutters are intended to maintain a constant comfortable internal temperature, and to defend against extremes of both external cold and heat"

The MVHR system provides a modest amount of night cooling, while the window/shutter design offers more night cooling through partially open window and shutter combinations.

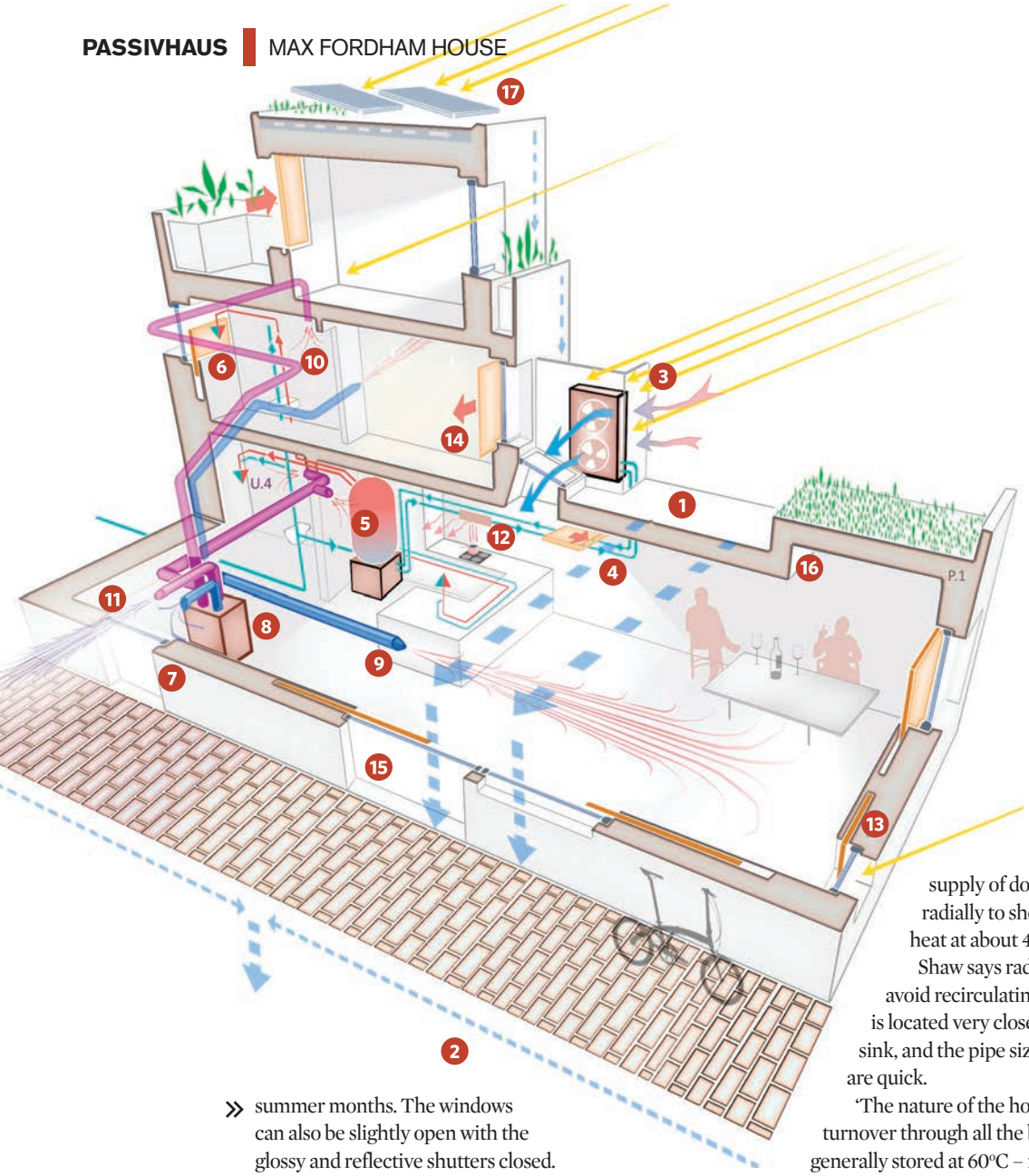
'We did an admittance calculation in line with CIBSE Guide A during the design stage. This is a fairly simple calculation that only looks at 24 hours, and we felt it showed the house would be reasonably comfortable during prolonged very hot weather,' says Shaw. 'This calculation was based around a very hot day in a 2050s London climate. We would expect a more sophisticated calculation that looked at a whole year to show cooler indoor air temperatures, and we would expect cooler indoor air temperatures in reality.'

The building performed well during the recent summer heatwave, adds Shaw, maintaining internal temperatures between 25-28°C through a diurnal cycle when London was between 24-34°C.

Figure 1 shows the external air temperature for 25 July 2019 – during the recent heatwave – which is similar to the day against which the house was modelled, the modelled internal temperature, and the measured internal air temperature. 'The building performs well in hot weather, and as expected,' says Shaw.

He says during warm nights with little wind, buoyant forces created by temperature differences would drive some natural ventilation. 'There is also some night cooling with the mechanical system as well,' he adds.

The risk of overheating is managed, partly, by the shutters, which can be closed during hot summer days to limit solar gains, and can be opened wide at night to purge excessive heat. North-facing windows have inbuilt timber slats to maintain privacy, and south-facing windows are partially shaded by a deciduous apple tree in the »



Max Fordham House

1 Rainwater absorbed into porous material on blue roof, and drained to lower roof and patio
2 Rainwater absorbed into porous attenuation volume beneath patio
3 First-stage air source heat pump on south-facing terrace
4 Hot refrigerant gas is pumped to second-stage heat pump
5 Second-stage heat pump in house heats one day's supply of DHW
6 DHW distributed radially to showers
7 Cold, fresh air brought into building from beneath undercroft
8 Heat is recovered from stale, moist exhaust air at MVHR unit
9 Fresh, tempered air supplied to inhabited rooms at high speed
10 Warm, moist air extracted from kitchens and bathrooms
11 Cold, moist, stale air is exhausted at high speed
12 Recirculating cooker hood extracts smells, not heat
13 Well-insulated envelope, with airtightness moisture-tightness layers
14 Insulated, actuated window shutters close at night, reducing heat loss
15 Windows open fully to purge ventilate
16 Thermally massive structure allows better use of incidental heat gain in winter, and absorbs daytime heat in warm weather
17 Upper roof is used for PV electricity generation

» summer months. The windows can also be slightly open with the glossy and reflective shutters closed.

Water supply

Domestic hot water (DHW) is the largest energy demand in the house. Although solar thermal technology was considered, heat pump technology aligns well with the continuing decarbonisation of the national electricity Grid.

A two-stage air source heat pump with an integrated DHW tank supplies the high-grade heat needed, and uses naturally renewed air as its heat source.

While some summertime efficiency may be sacrificed in the second compressor, this is compensated by the high wintertime efficiency, and the lack of immersion heating needed. The heat pump works in tandem with the MVHR system that is fitted throughout.

The heat pump's air-side heat exchanger is located within a suntrap on a south-facing terrace, and operates for an hour each afternoon, when air temperature is warmest and the heat pump is most efficient. This is also when the roof PV array is likely to be at its most productive.

Hot refrigerant gas is pumped indoors to the second-stage heat pump, which heats one day's supply of domestic hot water, distributed radially to showers. The second circuit takes heat at about 45°C and boosts it to 65°C.

Shaw says radial DHW distribution is used to avoid recirculating domestic hot water. The cylinder is located very close to the showers and the kitchen sink, and the pipe sizes are kept small, so draw-off times are quick.

'The nature of the house means we'd expect high turnover through all the branches. Meanwhile, DHW is generally stored at 60°C – rather than 50°C with weekly pasteurisation – which drove the selection of a two-stage heat pump that produces 65°C DHW fairly efficiently,' says Shaw.

HVAC

Cold fresh air is brought into the building from beneath the car undercroft. Heat is recovered from stale, moist exhaust air at the MVHR unit, and fresh, tempered air is supplied silently to inhabited rooms at high speed through 3D-printed jet nozzles.

Warm, moist air is extracted from kitchens and bathrooms, and cold stale air is exhausted at high speed.

Roof engineering

Planning was awarded for the home to be slightly higher than its neighbours, which maximises the effectiveness of the 5kW roof-mounted solar panel array, generating around 4,000kWh annually, almost all the energy needed for the house.

Rainwater is attenuated in the green roof and planters, absorbed into porous material, and drained to the lower roof and patio at a controlled rate. It is then absorbed into an attenuation volume below the patio, before being slowly drained away. A rooftop copse of hazel plants on the first floor also contributes to the biodiversity.

Max Fordham House won the RIBA London Sustainability Award 2019, a RIBA London Award and is shortlisted for the RIBA House of the Year 2019. And, this winter, it will undergo its biggest test – keeping its occupants warm without heating. CJ

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This award recognises products or innovations that make a significant contribution to the thermal comfort element of building performance. These can include solutions in the areas of heating, ventilation, cooling and humidification.

Product or Innovation - Wellbeing

This award recognises products or innovations that make a significant contribution to the wellbeing element of building performance. These can include solutions in the areas of lighting, acoustics, air quality, renewable energy and energy efficiency.

Project of the Year - Retrofit

This award recognises and celebrates the retrofit of a building that most effectively demonstrates high levels of user satisfaction and comfort while delivering outstanding measured building performance. Creating this type of exemplar retrofit is demanding and the BPA recognise the work and dedication of the team.
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Global architect Foster+Partners now has fully integrated environmental engineering in its design studios to optimise building performance. Piers Heath tells **Alex Smith** how scientific first principles are embedded in designs and shares plans to incorporate soft landings in every project

PIERS' REVIEW

Structure integrated with HVAC services and lighting at an Apple Store in Westlake, Ohio (top); Piers Heath is keen to encourage young engineers (above)

Foster + Partners is one of the most prolific architectural practices and, over the past eight years or so, has quietly extended its design capabilities to become a fully multidisciplinary powerhouse.

The London-based practice now undertakes key engineering functions in-house, having acquired the environmental engineering firm of PHA Consult in 2011, to carry out services design. In the same year, Roger Ridsdill Smith left Arup for Foster + Partners to head up structural engineering.

Piers Heath – who founded PHA Consult in 2005 with his then colleague Edward Garrod – joined Foster + Partners as a senior partner and head of environmental engineering. His team is now around 75-strong and offers a full gamut of services, including mechanical, electrical, public health and fire-protection engineering. This is enhanced by a very strong team of experts covering environmental sciences and sustainability, and architectural lighting – all of which are a passion for Heath.

The environmental engineering team plays a central part in ensuring Foster + Partners moves towards its commitments to reduce energy and resource use. For example, Heath is looking at how soft landings and post-occupancy evaluation can be incorporated into future contracts. The practice's position as a global architect gives it great leverage over clients based beyond the UK.

Foster + Partners has signed the World Green Building Council's net-zero carbon buildings commitment to make the operation of all its buildings carbon neutral by 2030. It is also a signatory of Architects Declare and Structural and Building Services Engineers Declare, which pledge to design buildings with a more positive impact on the environment.

PHA's full integration came after a long courtship, as Heath explains. 'Foster + Partners' interest in broadening its capability and gaining a greater understanding of environmental sciences – including passive design elements such as shading, natural ventilation, thermal mass, and so on – had been a driving force for many years. However, it took some time before their interests extended to a full in-house engineering offer.'

Heath first spoke to Norman Foster in 2008, but it took two more years and several meetings with senior figures before the practice decided it wanted to offer in-house architecture and engineering (AE). 'When asked if PHA would be interested to participate in this venture, I was excited by the unique opportunity it presented,' says Heath. 'I always felt the prospect had to include MEP engineering – after all, this is arguably the most measurable aspect of a building's performance.'

It was while he was at consultant Battle McCarthy that Heath first worked with


Foster + Partners' headquarters building

"Too often, engineers sit there thinking architects don't understand us – but you've got to understand them first"

Foster + Partners, on a competition for the redevelopment of a Renault factory outside Paris, on an island in the Seine. Heath found there was a shared philosophy around the importance of environmental engineering in design. When he formed PHA Consult, he continued to work with Foster + Partners, providing services design for projects such as Spaceport America, in New Mexico, and the Masdar Institute of Science and Technology.

'They never saw the environmental side as a separate subject; it either influenced the form or the form facilitated the environmental objectives,' says Heath. 'For me, a project is successful if the first principles are reflected in the outcome. Environmental engineers shouldn't be solving problems resulting from a lack of applying or adhering to good environmental principles.'

Norman Foster and the design board at Foster + Partners are strong supporters of sustainable design and actively respond to good environmental advice, adds Heath, who is impressed by Norman Foster's keenness to interpret and integrate engineering principles within design concepts. 'He will look you in the eye and ask: "What would you do with this?" – which is an inspiring challenge to our engineers; it really puts you on point.'

The increasing scale of Foster + Partners' projects was a factor in the practice taking on engineering and forming an integrated in-house offer. 'The ability to adapt quickly to change – and being part of the design reviews – is a huge advantage,' says Heath. 'You can provide advice immediately.'

While first principles may be adopted in design, engineers soon understand that it is the architect leading design for the project overall – albeit through an inherently collaborative process. 'You need to be flexible and adaptable around the challenges architects face,' says Heath. 'Too often, engineers sit there thinking architects don't understand us, but you've got to understand them first – and, if you do that, they'll quickly respect and respond to your needs.'

The attention to detail required to work within Foster + Partners – including servicing projects for clients such as Apple – can be challenging for some. 'If they don't want to see diffusers, you can't just pull a solution out of a manufacturers' catalogue,' Heath says. 'Instead, an integrated study is undertaken to find a suitable bespoke design.

'For large and/or complex projects, we tend to co-locate the engineering teams within the larger project teams. While this is a positive and inevitable benefit of integrated design, it's not without its challenges. We use regular engineering team meetings to maintain and build a strong, well-communicated culture.'

Diversity

Heath's team is refreshingly diverse. The proportion of female engineers is around 40%, rising to 50% on the environmental science team. 'Diversity is really important and I'm passionate about it,' says Heath. 'It's a shame that [environmental engineering] has, historically, been such a male-dominated area. Perhaps it's not championed enough

SQUARING THE CIRCLE

Foster + Partners has its own materials research centre to inform designers of the embodied energy and life-cycle of potential specifications. While it's straightforward to understand the life-cycle of a tiling finish, however, taking a cradle-to-cradle approach to installed services is more difficult, says Heath.

'When you dive into the specs of air handling units, fan coil units or cooling plant, it's hard to get to grips with. There's not much disclosed and there are a lot of components that come from far afield. Significant effort is going into gaining a better understanding of the life-cycle impact of our design decisions.'

Trying to measure embodied energy is complicated by the energy used in shipping materials from different parts of the world and varying work practices, he adds.


» Heath worked on Foster + Partners' Spaceport America


Engineering principles are interpreted and integrated with design concepts at Foster + Partners' London campus

Foster + Partners' materials library at Battersea campus (above); China Merchants Bank in Shenzhen (right)

Foster + Partners opens its doors

A seminar and webinar on integrated design organised by the CIBSE ASHRAE Group is taking place at Foster + Partners from 6-7pm 18 September.

The speakers are senior environmental engineer and partner Andy Jackson and architect and associate partner Matthew Heywood. More details at bit.ly/CJSep19Foster

» at schools. I like to encourage women in engineering because it helps us to see things from a broader perspective – we get different solutions. For the same reason, I encourage a wide range of ages and experience.'

When Heath set up PHA, he asked Ed Garrod, 18 years his junior, to join him. 'I wanted someone young and dynamic, who understood the latest thinking and was motivated by design. I didn't want someone blinkered by what you can and can't achieve,' he says. Garrod was one of the first to champion the wellbeing agenda, adds Heath, on projects such as the Samson Pavilion at Case Western Reserve University, and Cleveland Clinic, in Ohio.

Now, says Heath, clients all over the world incorporate this as a specific requirement in their request for proposals. 'We are currently designing an HQ for China Merchants Bank in Shenzhen, and wellbeing is at the core of the brief. For example, they want operable windows – even though the climate rarely favours such a strategy – because they want staff to have connectivity with the outdoors and the psychological wellbeing that offers.'

All the engineering services design is done from London, where engineers have access to the resources at Foster + Partners' Battersea campus. Here, there is a large materials library and numerous prototyping tools, such as 3D printers and CNC laser cutters.

The international dimension to Foster + Partners work means it frequently deals with local engineers and designers. Often, projects involve only 50% design service, which makes it challenging to ensure the design intent is realised in the operation of the building.

'We may not have ultimate responsibility, but we want to be sure that what is built, commissioned and put into operation is as the design intent,' says Heath. 'You can't walk away once a building is complete and working. We ask ourselves how the buildings will last, and whether they are adaptable, climate-change tolerant and good to use.'

A soft landings mechanism being developed by Heath for use in project agreements sits under Stage 7 of the RIBA Plan of Works and will include design reviews and post-occupancy evaluations (POEs). MEP engineers have always been sensitive around POE, he says, because performance gaps imply they haven't delivered what they promised. 'We have to be bigger than that and, if we have to face the music, so be it,' he adds.

There are ongoing discussions within the practice about how to offer this for up to three years after completion, which would align with the Well Standard. Bill Bordass and the Probe studies (1995-99, and published in the forerunner to *CIBSE Journal*) left a lasting impression on Heath. 'I was fascinated by the difference between predictive and active. It gave me a better understanding of what a significant role dynamic modelling has on a building's life.' (See panel 'Digital design'.)

He is aware of Foster + Partners' unique position to influence clients to choose a more sustainable approach to buildings and systems, and says glazing technology is reaching its limit of practical environmental performance. 'There is a greater burden of responsibility on how liberally we use [glass]. We need to be more considered, placing emphasis on exposure and orientation while delivering views and light,' he says.

Environmental engineering will have an increasingly prominent role as society responds to the climate emergency, says Heath, who tracks its growing influence from the 1990s, when the effects of CO_2 on global warming entered public consciousness. Current awareness among the younger generation is now really driving the agenda, he adds. 'They are pushing society to ask more questions. There's no way we can go back. The world's woken up to the challenge, at last.' CJ

DIGITAL DESIGN

The vast computational power now at the disposal of designers makes it possible to model much more realistic performance scenarios than Heath was able to with the 'hellishly inaccurate tools' he used earlier in his career. However, accurate modelling still depends on designers' understanding of buildings in use and the human factor, he adds.

Foster + Partners is turning its buildings into a test bed for digital technology to better understand how buildings can be more attuned to end users' needs. It is installing advanced controls and sensors, and incorporating mixed-mode ventilation, to see if it can turn back systems and save energy.

AI will reduce laborious tasks, says Heath, but he worries that commoditisation may take engineers away from the design interface. 'Design should be about thinking and collaboration with the help of quality tools.'

Bank of VRLA batteries being used to support a KUP PowerWAVE 9000DPA modular UPS system

ALL THINGS CONSIDERED

Although lead-acid batteries are long-established, with a majority market share, lithium-ion is starting to pick up pace. **Alex Emms**, of Kohler Uninterruptible Power, compares the two technologies

For uninterruptible power supply (UPS) system builders and users today, two battery chemistries predominate: lead-acid – typically valve-regulated lead-acid (VRLA) – and lithium-ion (Li-ion).

While Li-ion has limited presence in the UPS market, it has been growing in popularity in other areas as a result of advances in technology and power output, plus a reduction in cost. Li-ion is finding large-scale use within motive power and electricity grid storage applications and, with its rapid response, is often found in wind and solar renewable energy systems.

Li-ion batteries have a better power-to-weight ratio than similarly rated VRLA types (see Table 1). They also discharge more efficiently than VRLA at high discharge rates, although this advantage becomes less important at lower rates (see Figure 1).

Charging rates from a fully discharged state are also higher, as long as the charger can deliver the required power. Full recharging can be completed in three hours, compared with a typical 80% charge in six hours for VRLA.

Another advantage is a very wide usable temperature range, although discharge rates and longevity can normally be optimised by operating at 23°C ± 5K. Li-ion batteries have improved resilience to temperatures outside this range, with much better low-temperature discharge capabilities, than VRLA. This makes Li-ion much better suited to uncontrolled temperature environments where free cooling can be employed using the lower-temperature outside air.

However, like VRLA, operating at excessively high temperatures significantly reduces Li-ion batteries' useful life. Figure 2 gives more detail on the two chemistries' relative temperature/lifetime profiles.

Cost is another critical factor. Prices have fallen significantly – up to 85% – over the past decade, and these reductions naturally increase Li-ion's appeal. Nonetheless, as Table 2 shows, Li-ion pricing is still a barrier.

However, we are definitely in the early stages of adoption. While prices aren't decreasing as fast as previously, they are still tracking down, creating a significant upturn in adoption.

In Europe and the Middle East, there are lags in Li-ion adoption, but there is increasing deployment in North America and Asia. Figure 3 shows historical and projected future trends for battery pack manufacturing costs.

Design life is another factor, for which manufacturers are quoting up to 15 years. Operational life is probably nearer 10-12 years, but is not yet proven. This compares with a real-life norm of 7-8 years for VRLA.

Why not Li-ion?

Li-ion enthusiasts point to the batteries' longevity as an advantage offsetting its higher capital cost. However, Kohler Uninterruptible Power's experience shows that UPSs – correctly installed in a suitable environment and properly maintained and supported – are typically reliable for 15 years. This neatly matches two consecutive 7-8-year VRLA lifetimes, but raises replacement coordination issues with 12-year Li-ion batteries.

Li-ion is also disadvantaged by the true costs of achieving suitable autonomy, which is traditionally 10-15 minutes for UPSs. However,

200kW N+1 modular system*	Li-ion solution		VRLA solution	
Autonomy	W x D x H in mm	Weight kg	W x D x H in mm	Weight kg
Seven minutes	650 x 600 x 2,055	550	1,870 x 900 x 2,450	2,700
15 minutes (19 min Li-ion)	1,300 x 600 x 2,055	1,100	2,480 x 800 x 2,000	2,700
30 minutes (35 min Li-ion, 31 min VRLA)	1,950 x 600 x 2,055	1,650	2,490 x 875 x 1,900	4,900

Table 1: Comparison of Li-ion and VRLA battery dimensions and weights

*** 'N' is the number of UPS units required to meet the design load demand, '1' indicates that a single UPS unit failure will not adversely affect meeting the load**

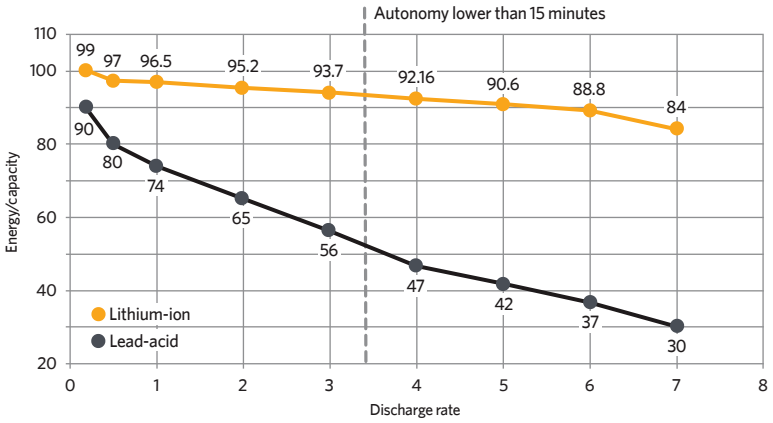


Figure 1: VRLA versus Li-ion discharge efficiency

The discharge rate (known as C) relates to the current drawn from the battery over a period of time. 1C is the current to discharge the battery in one hour. A two-hour discharge is described as 0.5C and faster discharges, for example 30 minutes, are described as 2C

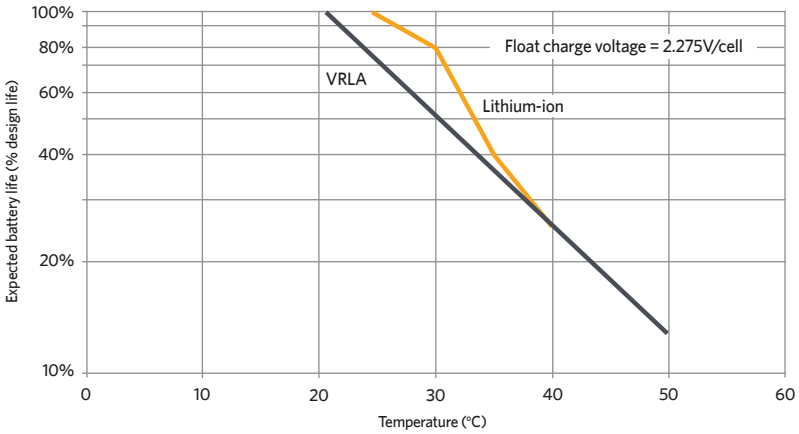


Figure 2: Expected battery life versus temperature for VRLA and Li-ion

This shows that, between 20°C and 30°C, Li-ion degrades much less than VRLA; however, at higher temperatures, degradation is similar

200KW N+1 modular system	Li-ion over VRLA cost elevation
Autonomy	
Seven minutes	90%
15 minutes (19 min Li-ion)	233%
30 minutes (35 min Li-ion, 31 min VRLA)	324%

NB: VRLA systems include battery management system

Table 2: Percentage cost elevation of Li-ion over VRLA for various autonomies

in reality, most blackouts last three minutes or less, or for closer to three hours.

While VRLA costs can be decreased by designing for this lower autonomy, the same isn't true for Li-ion. Such short autonomies can only be achieved from more expensive higher discharge-rate cells. Accurately and cost-effectively sizing for different loads is also difficult with Li-ion's – currently very limited – choice of capacities.

There is also an element of mistrust. Manufacturers have progressed considerably in addressing safety fears, through highly segregated cell designs, and mandatory advanced monitoring and management systems; however, Li-ion is still sometimes seen as unproven, and a safety risk.

End-of-life creates further problems; an exhausted Li-ion battery primarily comprises hazardous waste that's difficult to recycle, and which is subject to high costs and restrictions during transportation.

By contrast, VRLA is up to 98% recyclable. However, as the volume of exhausted Li-ion batteries starts to grow, so will pressure to find sustainable recycling solutions. This is reflected, for example, in the US Energy Department's launch in January of a Li-ion battery recycling research centre. The department is investing US$15m in the project, and hopes to boost the collection and recycling rate to 90% of all lithium-based technologies, up from the current rate of just 5%.

Recycling of Li-ion batteries from electric vehicles (EVs) is limited in the UK; direct recovery of precious metals from these batteries– such as cobalt, nickel and lithium – is undertaken by specialist facilities abroad, mainly in Asia, although Europe is now starting to build processing capacity.

Currently, the barriers that Li-ion faces mean its uptake is mostly limited to fast- »

Lithium-ion technology is ideal where fast charging and discharging is essential

» discharge or limited-space applications that particularly need its benefits. However, UPS Li-ion battery solutions are still in their infancy, with potential for further advances.

Prices are expected to continue falling, albeit more slowly, driven primarily by growth in the EV and motive-power industries. As this happens, and Li-ion becomes more accepted by UPS owners and operators, the technology's penetration of the data centre battery market can be expected to increase.

This growth will be accelerated when viable recycling strategies become available. In any case, the data-centre industry is motivated to replace VRLA because of perceived reliability problems and environmental restrictions.

Bloomberg New Energy Finance (BNEF) forecasts a market share increase from 15% in 2016 to 35% in 2025. According to BNEF, this is against an expected data-centre battery backup market growth from 3.5GWh to 14GWh over the same period.

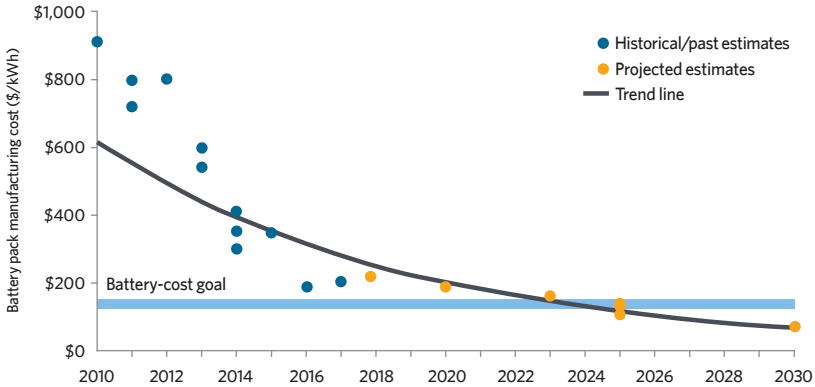


Figure 3: EV battery manufacturing cost trends. Manufacturing costs are falling and this is expected to continue

> "Li-ion enthusiasts point to the batteries' longevity as an advantage, offsetting its higher capital cost"

However, VRLA will also continue developing. While not mandatory for VRLA, increasing use is being made of battery monitoring and management systems. These can increase VRLA battery lifetimes, potentially by up to 30%. This can, for example, increase battery life by monitoring and warning of when attention is required, and by management of the equalisation process, which corrects the charging voltage operating range. CJ

ALEX EMMS is operations director at Kohler Uninterruptible Power

CONTINUOUS FLOW - SYSTEM DESIGN EXCELLENCE

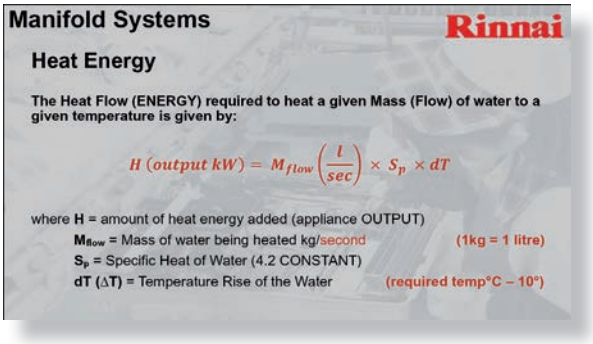
This Rinnai CPD gives an in-depth explanation into the design parameters of a continuous flow hot water system.

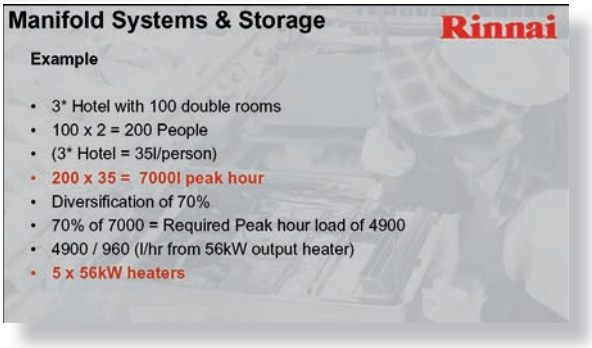
The course comprehensively covers the following critical design considerations;

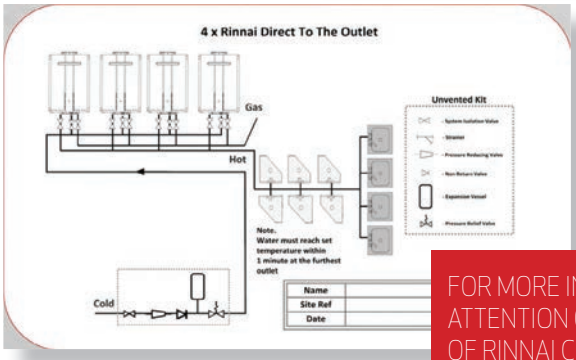
- heat energy and how it is used in the sizing of a commercial hot water delivery system
- what applications are suited to it
- how to size a semi-storage system

The course also covers other important design factors such as the system components that must be fitted to satisfy G3 requirements. It also delves into basic hydraulics and gives an understanding of ACOP L8 whilst explaining the benefits of continuous flow in designing best practice for legionella prevention.

As a continuous flow water heater always deliver TEMPERATURE that is set on water heater we can determine the flow rate exactly that the Water Heater will deliver.







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Cost model

Aecom's MEP cost consultants **Paul Barnard** and **Craig Thomas** examine the capital costs of delivering a heat pump energy system instead of traditional space heating and hot-water systems

Heat pump energy systems

Building designers are driven by legislative and market aspirations to create buildings that are more energy efficient and carbon friendly, and to work towards Grid decarbonisation.

The National Grid's electricity system operator is aiming for it to be zero carbon by 2025. To achieve this, the system needs to be transformed so it can be operated safely and securely at zero carbon, whenever there is sufficient renewable generation online to meet the total national load. This means reductions in the demand for high-carbon-generated electricity.

Since January 2019, the Greater London Authority (GLA) has required designers to use SAP 10 emissions factors for planning permissions. These have far lower emissions factors for electricity, and are forcing engineers to rethink HVAC design.

Traditionally, residential buildings include gas-fired boilers and, potentially, combined heat and power (CHP) and air or water-cooled chillers. Increasingly, these appear to fall short of the new London Plan's requirements. Also, many new residential developments are prone to overheating in risers and corridors, largely driven by internal gains and new building methods.

A heat pump energy system employing an 'ambient' or 'neutral' loop can typically offer standalone heating, cooling and hot-water systems – or a mixture of services to flats and commercial spaces. The heat pump energy system can, potentially, offer the designer more flexibility in choosing the most suitable type of plant.

During the summer and winter seasons, the communal low-temperature heat loop employs plant to regulate the water temperatures circulated around the loop for heating and cooling – for example, ground and/or air-source heat pumps or a chiller. Excess thermal energy from the air source heat pumps can also be injected back into the low-temperature heat loop, giving a further reduction to plant sizes. To meet peak-time demands, thermal stores should be used to manage plant operations. Lower temperatures in the loop compared with traditional gas CHP also means there is less heat loss in transmission.

There are two types of system – ambient loop, on which this cost model is based, and a central air/water loop.

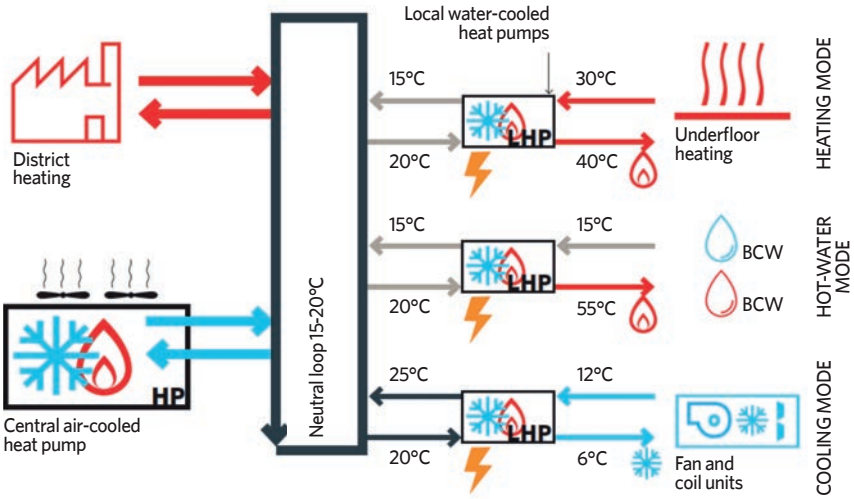
A system primarily consists of centralised plant, an energy loop and a selection of heat pumps. The heat pumps are connected to an energy loop, which is a water circuit maintained at 25°C flow temperature and 15°C return water temperature.

This energy loop is regulated within its operating parameters using centralised heating and cooling plant, or is connected to a wider area heat network.

The communal low-temperature heat loops are connected from the mechanical risers to a compact air source heat pump, installed in each flat and commercial mixed-use space.

Cost drivers

A heat pump ambient loop system also replaces the need for



independent heat interface units (HIUs) and/or cooling interface units (CIUs) by providing hot water, space heating and/or comfort cooling within each flat or mixed-use commercial space – using radiators, underfloor heating, fan coil units or heat convectors, for example. Hot water is provided by a localised cylinder, which is charged by the heat pump.

Savings can be increased with a dual heating and cooling pump energy system, for simultaneous operation.

Compared with conventional high-pressure heating systems using HIUs in flats, a heat energy system is more efficient, because lower temperatures reduce the community energy losses from 25-30% to 2-5% and – as a result of lower distribution temperatures – overheating in risers and corridors is reduced significantly.

The units can be supplied in prefabricated, self-contained modular sections, reducing installation times and onsite labour hours, and offering design coordination and commissioning benefits.

Other potential construction costs that can be considered when designing a heat pump energy loop system include reduced sizes of distribution pipework, compared with traditional carbon steel for low-temperature hot water (LTHW) and chilled water (CHW), and a reduction in thermal insulation.

The initial costs of installing a 'heat only' pump energy system are more expensive, but savings can be achieved:

- Carbon tax payment per flat can be reduced by 40-45%
- Plantroom spaces can be decreased in size by 40-50%
- Riser spaces increased similarly by 40-50%
- Cost per kWh thermal reduced by 25-30%
- Tenant running costs reduced by 15-20%.

Cost model

A traditional heating and cooling design, consisting of a 450kW gas boiler and a 70kWe gas CHP unit linked to HIUs, providing heating and hot water to each flat. Residents are provided with cooling via a 560kW centralised chiller on a dedicated chilled water network linked to CIUs.

The heating-only table shows a net increase in development costs of up to £2,415 per flat by adopting a heat pump energy system for a heating-only scheme, compared with one using CHP and a gas boiler.

By using heat pump technology as the central plant, and offsetting carbon tax payments, the total net increase in development costs is reduced to £1,645 per apartment.

The heating and cooling table shows a net saving in development costs of £150 per flat by adopting a heat pump energy system for a heating and cooling scheme, compared with one using CHP and a gas boiler with chiller.

With the addition of using heat pump technology as the central plant, and offsetting carbon tax payments, the total net savings increase to £1,850 per flat. CJ

- The cost model is purely for M&E installations and takes no account of changes to building elements

- **PAUL BARNARD** is an associate and **CRAIG THOMAS** a project surveyor within the London MEP cost management team at Aecom

Heating only

Description	Cost per apartment £
Additional plant costs per apartment	
4kW heat pump cylinder combination unit in apartment	3,700
Instantaneous domestic hot water (DHW) and heating production in each apartment	1,000
Sub-total	**4,700**
Generated savings against traditional systems	
HIU for each apartment, including installation	(1,000)
Meter for HIU	(150)
Cost to fit and commission meter	(550)
Boiler size reduction	(120)
Thinner insulation specification on riser/corridor pipework	(50)
Savings on valve sizes and spindle lengths (four per apartment)	(70)
Reduction in pipe size on apartment spur from 28mm to 22mm	(20)
Change from copper to plastic	(25)
Removal of modifications to smoke-extract system for corridor purge ventilation (overheating abatement)	(300)
Sub-total	**(2,285)**
Net cost/saving per apartment	**2,415**
Changing central plant to a heat pump, removal of technologies such as PV to achieve carbon compliance	(300)
Carbon tax saving from changing to a heat pump	(470)
Sub-total	**(770)**
Total net cost/savings cost per apartment (potential)	**1,645**

Heating and cooling

Description	Cost per apartment £
Additional plant costs per apartment	
4kW heat pump cylinder combination unit in apartment	3,700
Additional cost of cooling in heat pump	350
Additional 50l buffer tank or 7m of 100mm pipework for fan coil	300
Upgrade of fan coil to work with heat pump	300
Instantaneous domestic hot water (DHW) and heating production in each apartment	1,000
Sub-total	**5,650**
Generated savings against traditional systems	
HIU for each apartment, including installation	(1,000)
CIU for apartment, including installation	(1,000)
A meter for each of the heating and cooling HIUs	(300)
Cost to fit and commission heat meters	(1,100)
Boiler size reduction	(120)
Thinner insulation specification on riser/corridor pipework	(50)
Savings on valve sizes and spindle lengths (four per apartment)	(140)
Reduction in pipe size on apartment spur from 28mm to 22mm	(40)
Change from copper to plastic pipework	(50)
Removal of modifications to smoke-extract system for corridor purge ventilation	(300)
Removal of chilled water distribution from building risers and corridors (changing from four pipes to two pipes)	(1,500)
Removal of cooling pipework in apartment (changing from four pipes to two pipes)	(200)
Sub-total	**(5,800)**
Net cost/saving per apartment	**(150)**
Changing central plant to a heat pump, removal of technologies such as PV to achieve carbon compliance	(300)
Removal of chiller if adjacent to water source	(1,000)
Carbon tax saving from changing to a heat pump	(400)
Sub-total	**(1,700)**
Total net cost/savings cost per apartment (potential)	**(1,850)**

Heating only and heating and cooling cost comparison

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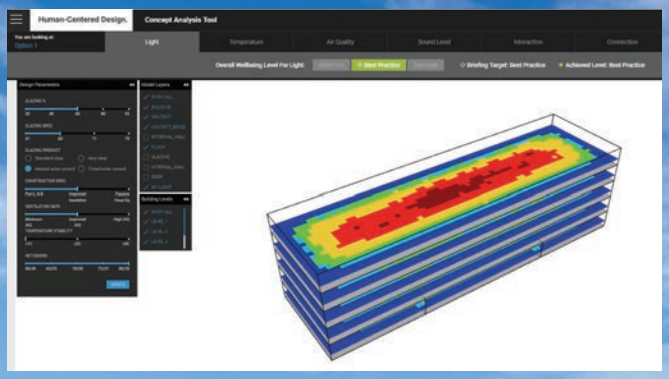

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The challenge was based on a fictitious four-star hotel in the seaside town of Folkestone

CHALLENGE ACCEPTED

To streamline the concept design stage for building services, four teams took part in a challenge to automate common project workflows. CIBSE's digital engineering lead **Carl Collins** explains

In July, the Society of Digital Engineering (SDE) held a design challenge to see what can be done to automate common project workflows. This could increase accuracy, decrease the amount of work required and reduce the time taken to create standard concept design stage deliverables – including any extras that some organisations also choose to provide – by using automation techniques and a few clever workflows.

This was the first time the SDE had tried this challenge, so we invited member organisations SNC Lavalin Atkins, BDP, BuroHappold Engineering and Jacobs to see how – or even if – this would work.

Below are some of their takeaways from the challenge, which was run over a single working day (9am to 5pm), with an hour at the beginning and end to download materials and upload the finished products.

The teams were each given some basic descriptions of the required deliverables, basic design parameters and four potential building typologies prior to the challenge, but the exact nature, layout and location of the building were kept secret, so there could be no cheating.

The building was a fictitious four-star hotel in the seaside town of Folkestone. It was a very simple building, as we wanted to test the digital principles, rather than complex engineering (see Figure 1).

At the feedback event, held a few days later, each team reported back what they had achieved, which was – in the eyes of this observer – truly remarkable. Here is what they found:

Ben Roberts, SNC Lavalin Atkins

We integrated a wide selection of analysis tools, passing the geometry and/or specific data between tools. We were able to assess site conditions by referencing the postcode against geospatial data to show the impact of local flood plains, rail noise, road noise and Area of Outstanding Natural Beauty (AONB) status. This showed within minutes that planning consent for this site would be very unlikely, given the environmental protection in the area.

Nonetheless, we continued to assess the feasibility of different energy sources by exporting the geometry to our Excel-based low and zero carbon tool, giving an idea of payback and carbon savings for our site and building type.

This provided a basis of design for space-loading calculations; using »

"Speeding up the time taken to produce Stage 2 deliverables enables us, as designers, to spend more time interrogating our outputs"

» Dynamo to pass data between Revit and Excel enabled automatic production of treatment plans and room data sheets. We were then able to get detailed feedback on human-centred metrics, such as daylighting, interaction and temperatures, using our in-house concept analysis tool to help the team see the impact of design variables such as percentage glazing or building fabric types.

Structural options were generated using parametric components, giving the total embodied carbon, cost estimates, and impact on programme for a range of different approaches.

We also used the opportunity to test automation on a simple level, using core Revit features to add loads into end-caps, which calculated the required flowrates and passed that data into the duct and pipe systems, allowing auto-sizing of distribution routes without the need for terminals or final runouts.

Although we were able to do a lot of analysis and produce some great deliverables in one day, there was no time allowed for changing options or including feedback from the wider team.

However, the output that we managed to create was excellent material to facilitate such conversations and to make much more informed decisions at these early stages.

We found the day really enjoyable and will definitely be doing this sort of thing more regularly in-house to test our processes.

Marta Castelo Becerra, Jacobs

Prior to the day of the exercise, we met as a team to decide on strategy and agree roles and responsibilities. We prepared design parameters and base information for each of the four options under consideration.

On the day, teamwork was key. Once we knew it was a hotel, we decided the engineering solutions to apply, the deliverables according to BSRIA BG6/2014 and the data that would be in the design report. Our focus was to provide a concept design that met the brief.

Everybody knew their task. We moved through the day using Excel, Dynamo and Revit. Dynamo allowed us to set up the worksets in the model and automatically push information from Excel to Revit and vice versa.

Also, the 3D modelling was undertaken mostly by the engineers. In our report, we listed a few options for further discussions to improve the design: rotating the building to maximise the site space, considering including PV, solar water heating and a desalination plant, among others.

It was a great exercise to test our approach to design and keep improving.

Mike Bartyzel and Michal Dengusiak, BuroHappold Engineering

A task schedule with those responsible was created, which ensured all the tasks were assigned, that they were done in a logical order and that everyone knew what they were doing, when they were doing it and we included some notes to help them based on previous experience.

After downloading the architecture, we referenced the file into our analysis model in Revit, which uses our SAM 2.0 system to inform our analytical tools and ported the geometry across to TAS, using our 'model laundry' tool to make sure the geometry was suitable for analysis.

Our design tools had pre-loaded 'thermal templates' to help us assign suitable design values to ascertain the heating, cooling, lighting and other loads. Once the loads were in our analytical tools, the automated loads calculations were performed, ported back to our Revit model to create the block diagram drawings and tagged with all the relevant data, read straight from the space objects in the model.

Further outputs from these analytical tools included psychrometry for each space and air handling unit, which we used to create a room data sheet for each space.

The TAS model generated computational fluid dynamics (CFD) »

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D-AHU
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up to 6.95 m3/s

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Modular P

0.13 m^3/s
up to 4.16 m^3/s

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» analyses of the worst-case space to understand how the required airflows would be perceived by the occupants and to look at the predicted percentage dissatisfied (PPD) and predicted mean vote (PMV) in multiple locations within the space.

This exercise was very useful, as it shows the tools that we have created are working, and how we can further integrate them to develop a seamless workflow.

Aidan Kelly, BDP

Stage 2 is the time for exploration of design options to enable the best solution. For environmental engineering and design disciplines to respond – and inform development – to architecture, automation is the name of the game. As a multidisciplinary practice, we embraced the challenge as an opportunity to test and expand how we use digital tools on projects.

To speed along the initial BIM set-up, a series of Dynamo scripts were used to import the architectural information and ensure all the deliverable sheets and schedules were set up instantly within the Revit model. We then produced a quick visualisation of the building using Lumion. Something like this is extremely useful for MEP engineers to understand the architectural concept before providing an engineering design, and allows us to find answers to key questions:

- What is the architect's vision?
- Are there ceiling voids or are services going to be on display?
- Is there an atrium?
- Are there any changes in level?
- Are service zones likely to be large enough?
- Can an alternative riser arrangement minimise the service zone and, potentially, increase ceiling heights or reduce overall building height?

The architectural information was then sent through an automated Excel-based calculation tool categorise rooms instantly within the architectural scheme, applying a basis of design template and quickly producing initial calculation outputs.

This basis of design template incorporated rule of thumb information across mechanical, electrical and public health disciplines, as well as acoustic and lighting design considerations.

With a summary of room and building loads estimates available to hand within minutes, data was then pushed back into Revit to produce an immediate set of shaded strategy plans, while plant loads were passed into the space allowances tool. This tool generates plant solutions based on loads and user-guided parameters, and the results were immediately imported in 3D directly into Revit.

While these initial calculation and sizing activities were carried out, a parallel study of daylight, building orientation and façade optimisation was initiated using Grasshopper.

This produced some instant visualisations of the impact of a changing form or orientation on the daylighting design, and also allowed for shadow analysis and incident solar gain. Further analysis on the building can happen in parallel, without disruption to the design process, as this can be repeated for any new building form or arrangement.

Lessons learned

Even with all these new technological shortcuts and the production of some great outputs, we are not yet close to finalising a design in a single day. But, by speeding up the time taken to produce Stage 2 deliverables, it enables us as designers to spend a bit more time interrogating our outputs, and allows quality assurance processes to be implemented earlier, as much of the information is available up front.

> "Even with all these new technological shortcuts and the production of some great outputs, we are not yet close to finalising a design in a single day"

This workflow does, however, rely on a set of agreed tools being available, and may not be appropriate at later stages of Stage 2 when the design has progressed in some ways. A review of Bsria's BG6 to reflect modern working methods, digital engineering advances, existing processes and automation may be another area worth exploring to help integrate these processes into the wider industry.

Events like this are a great way of raising the profile of new ways of working, and we all feel like we greatly benefited from both the design day and an evening of presentations and discussion. Let's do it again. **CJ**

- From the feedback we have received, we will be running this event again, and will be inviting anyone who wishes to participate. More information about how the teams got these results will be available at Build2Perform 2019 in November at Olympia.

- **CARL COLLINS** is digital engineering lead at CIBSE

Vent-Axia aims to reduce plastic waste by making fans modular

Units feature individual modular components that can all be replaced separately

To help social housing providers lessen their impact on the environment, a ventilation company is designing modular products to cut plastic waste.

One million tonnes of plastic go to landfill every year in the UK, so Vent-Axia has developed fans that are easier to repair and recycle.

In the past, many manufacturers have recommended that a faulty fan be replaced – which has meant unnecessary waste being sent to landfill. Vent-Axia aims to tackle this issue by designing fans – such as the Revive – with individual modular components that can be replaced separately.

This reduces the amount of plastic waste considerably and should the exterior of the unit need replacing, the fans are made of recyclable ABS plastic.

Tom Wodcke, product marketing manager at Vent-Axia, said: 'We are working hard to help social housing providers reduce their environmental impact and make cost savings by developing products that can be repaired, rather than replaced, should they develop a fault.'

The firm's new positive input ventilation unit also features a removable inner cartridge, which makes repairs and replacement easy. Installers can unplug and remove the central cartridge, leaving the ductwork and back plate intact. This means the ductwork, wiring and mounting are left undisturbed during re-installation.

The Revive has modular components

By only replacing the inner cartridge, there is less plastic waste and less fuel for shipping, which lowers the installation's carbon footprint, the manufacturer claims.

Since it reshored the balance of its domestic fan manufacturing from China back to the UK in 2013, Vent-Axia has invested in logistics, which has helped lower the embodied energy of products by reducing carbon emissions.

A reduction in international shipping and flights has resulted in a saving of up to 15 tonnes of CO_2 a year.

See page 25 for more on building services and the circular economy.

SINGLE-USE PLASTICS MUST BE THING OF THE PAST

In construction, the reliance on single-use plastic has been declining drastically. As an industry, however, it is the second-largest consumer of plastic, behind retail.

Richard Beresford, chief executive of the National Federation of Builders said the government must stimulate investment and opportunity in material sciences and embrace new ways of recycling plastic.

'From recycled-plastic roads, and homes made out of recyclable materials, to waste sorting and onsite recycling, the construction industry is a key player in solving the challenges plastic poses to society and the environment,' he said.

'We now need the government to think more deeply about how, together, we can find solutions and embed them through best practice and innovative approaches.'

The EU Parliament has voted to ban some single-use plastics from 2021.

Airedale chiller on the Energy Technology List

Airedale International's TurboChill Spray evaporator range of chillers has been included on the Energy Technology List (ETL).

The ETL is a government-managed list of energy-efficient plant and machinery. Its purpose is to encourage businesses to choose energy efficient products when making capital purchases, to help overall environmental goals.

Any capital purchases from the list qualify for the Enhanced Capital Allowance (ECA) tax scheme and can be fully offset against any taxable profit for the same year.

The chiller, with R1234ze refrigerant, incorporates centrifugal compressor technology, which offers 30-100% variable speed control for tighter setpoint management. The spray flooded-type evaporator technology allows the range to reduce refrigerant evaporator charge by up to 70%, and overall unit charge by up to 50%.

Technology investment for Elta

Elta Fans' applied technology division has invested in two new machines for its specialist production plant in Fareham, Hampshire.

The site processes raw materials to produce fan casings and ancillaries, before assembling them.

The first new, £60,000 machine, which replaces a 1975 press brake, is used for folding metal – a critical part of the sheet metal process.

Matt Targett, operations manager at Elta Fans, said: 'We are dedicated to investing in modern technology, to maximise our current capabilities and develop better products. We know that our specialist factory is a key selling point for customers, and purchasing new machines provides the opportunity to upskill our workforce and, ultimately, improve staff morale.'

Another addition to the site is a pneumatic jig, which is used to assemble 2-metre hub impellers. Impeller manufacturing and assembly requires precision, as consistency of blade angles directly relates to a fan's operational efficiency. The jig ensures that blade angles no longer have to be set by hand, which is a significant time saving given the numerous variations of impellers manufactured at the site.

Voice control for air conditioning

Voice control with the Google Assistant and Amazon Alexa has been introduced to Panasonic's air conditioning portfolio.

This functionality offers benefits for the commercial and residential markets. Once paired via an app, Google Assistant or Amazon Alexa can be used for simple tasks, such as on/off, operating modes, temperature settings and checking operating status.

In the commercial sector, users can pre-determine working environments. For example, settings on the app – such as temperature – can be activated by voice command to pre-cool an office before employees arrive. This service can be administered by any worker via Amazon Alexa, or by inviting them to join via the Google Home app.

Smart tech keeps fans turning

Schneider Electric has launched a ventilation system that monitors filter and airflow status for multiple control panels or electrical distribution enclosures.

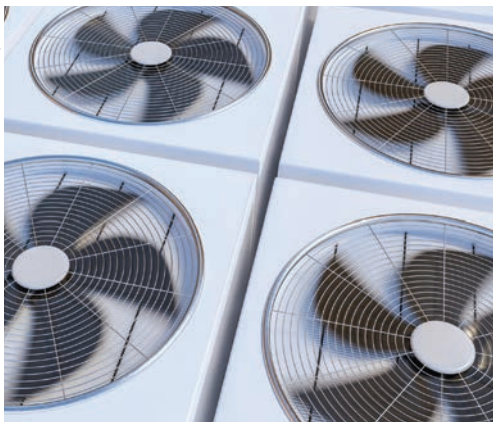
The ClimaSys system helps avoid downtime by automatically alerting maintenance personnel when filters or other ventilation parts need servicing or replacement.

'When ventilation system filters become blocked with dust or dirt, enclosures can quickly overheat and cause equipment failures or fire,' said Josep Lopez, offer manager at Schneider Electric. Enclosures operating in harsh environments are particularly susceptible to filters becoming clogged, reducing internal airflow, he added.

A central controller collects and analyses information from filter and fan sensors across one or more enclosures. A filter with an integrated dust sensor uses infrared technology and algorithms to determine the level of accumulated dirt. Sensors also measure air temperature passing through inlet and outlet grille locations, giving delta-T values for each enclosure.

Additional sensors measure RPM, fan current, and temperature of the 'transported' air around each fan. This enables measurement of fan efficiency and indicates whether internal temperature is exceeding fan capacity.

Four years of growth for US air con market



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Smart revolution has made an impact on the commercial market

The value of the US central plant air conditioning market rose by around 6% in 2018, to reach US$3.2bn (£2.6bn), BSRIA has found.

Its *Central plant air conditioning study* showed the market experienced growth in residential, commercial and industrial applications. The central plant figures include the combined sales for chillers and airside products (AHUs, fan coils, VAVs and other terminal units).

Over the past five years, product replacement has been fuelled by higher efficiency, green products and technology convergence.

In 2018, the central plant market expanded on the back of economic growth and increased investments in renovation and construction. Growth, generally, did not exceed 5% in any product category, but prices were under inflationary pressure as a result of the trade war between the USA and China, the study found.

Air conditioning prices are expected to continue to rise over the next few years, driven by a shift towards more energy efficient systems and the use of new refrigerants, the report said.

The chiller market expanded modestly in 2018. Sales were propelled by higher efficiency systems, the use of new refrigerants, and add-ons from suppliers, such as remote monitoring.

AHUs are expected to move towards increasing fan motor efficiency, more controls, and features to improve indoor air quality, the report added.

PACKAGED MARKET LEAPT TO US$20BN IN 2018

The value of the US market for packaged air conditioning solutions rose by more than 14% in 2018, reaching US$20.4bn. The figure, from BSRIA's *Room, packaged, unitary and furnaces air conditioning study*, includes the combined sales for windows/through-the-wall units, PTAC, moveables, minisplits, VRF, roof-tops, indoor packaged, US-style ducted splits, evaporative coils, furnaces, and close control units.

There was more than a 6% increase in volumes, although prices increased above this level, driven by warm weather and a relatively healthy US economy. In 2019, BSRIA estimates further growth of just less than 4% in terms of volume, but more than 8% in value, to exceed US$22bn this year.

New CPD programme for consultants and installers

Toshiba Air Conditioning has launched a new continuing professional development (CPD) programme for consultants, installers and end users to update their technical and legislative knowledge.

The free courses, certified by CIBSE, focus on improving their understanding of the impact of new legislation on air conditioning for buildings, improving system design and product application for energy efficiency, and environmental protection.

In addition to courses on the fundamentals of air conditioning, there are modules on the latest F-Gas legislation, the application of existing and new refrigerants, an overview of Breeam and how it relates to air conditioning, and updates on the latest compressor technology and variable refrigerant flow (VRF) systems.

Guidance calls for holistic approach

Chemical products now rival vehicle emissions as the biggest source of urban air pollution

Draft guidance on indoor air quality has been published by the National Institute for Health and Care Excellence (NICE).

The consultation document, *Indoor air quality at home*, was published in June. It recommends adopting a whole-house approach to heating and ventilation to ensure indoor air quality (IAQ) is maintained to minimise household exposure to particulate matter while achieving standards for energy use.

It also advises local authorities to embed a plan for improving IAQ into an existing strategy, and emphasises the need for a balanced approach to ventilation, insulation and heating to achieve good IAQ.

Poor IAQ costs the UK more than 204,000 healthy life years, with 45% lost to cardiovascular diseases, 23% to asthma and allergy, and 15% to lung cancer, according to the National Institute for Health and Welfare.

Exposure to indoor air pollution from cookers, damp, cleaning products and fires can irritate the lungs and exacerbate asthma symptoms, as well as cause long-term adverse health effects, said Jenny Smith, head of marketing at Vent-Axia. 'Recent research points to chemical products that contain compounds refined from petroleum, such as household cleaning products, rivalling vehicle emissions as the top source of urban air pollution.'

iStock.com / Urban78

The guidance is due to be published on 11 December.

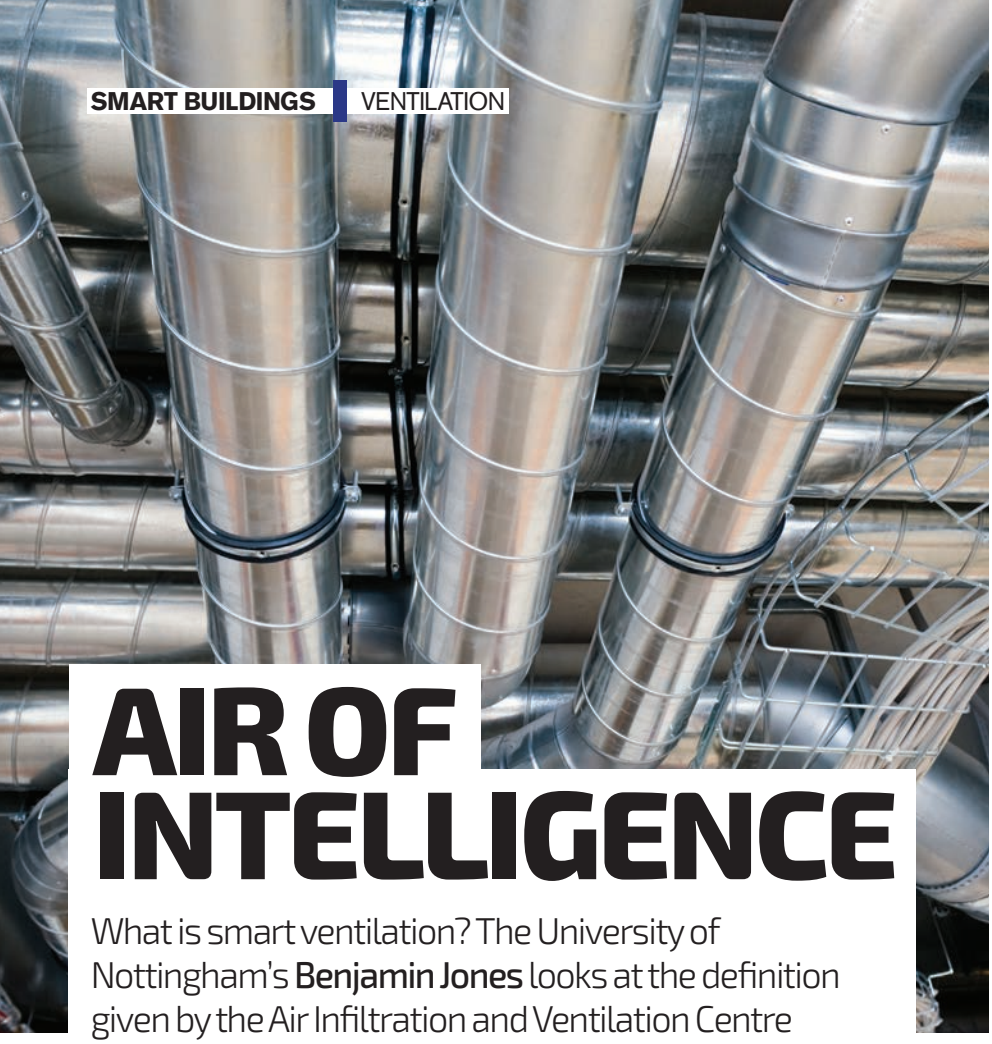
New Italian HQ and training facility for GIH

GI Holding (GIH) Group – which is working with Fujitsu General to develop and sell commercial air conditioners – has opened a new headquarters in Latisana, northern Italy.

The HQ has a 1,500m^2 showroom and training facility – The Cooling Academy – and will be used by Fujitsu for technical training on GIH products for UK customers. The HQ also features a manufacturing plant for small and medium-sized chillers.

GIH offers a range of liquid chillers, heat pumps and multifunctional four-pipe units, with cooling capacities ranging between 50kW and 3.8MW, and a variety of refrigerant options.

By focusing on long-term environmental impact during design stages, GIH designs products to use ultra-low global warming potential (GWP) refrigerants, such as the HFO-R1234ze, with a GWP of less than one, said Ian Carroll, chief operating officer at Fujitsu General Air Conditioning UK.



AIR OF INTELLIGENCE

What is smart ventilation? The University of Nottingham's **Benjamin Jones** looks at the definition given by the Air Infiltration and Ventilation Centre

For many building systems, claiming to be smart has technological and commercial advantages. In March 2017, a working group of Air Infiltration and Ventilation Centre (AIVC) experts from several countries agreed that 'smart ventilation is a process to continually adjust the ventilation system – in time and, optionally, by location – to provide desired indoor air quality (IAQ) benefits while minimising energy consumption, utility bills and other non-IAQ costs (such as thermal discomfort or noise).

A smart system adjusts ventilation rates to: occupancy; outdoor thermal and air-quality conditions; electricity grid needs; direct sensing of contaminants; and operation of other air-moving and air-cleaning systems. It can supply information on operational energy consumption and IAQ to building owners, occupants and managers, and signal when systems need maintenance or repair. A smart system can adjust ventilation depending on demand – for example, if the building is empty. It can also time-shift ventilation to periods when: a) indoor-outdoor temperature differences are smaller (and away from peak outdoor temperatures and humidity); b) indoor-outdoor temperatures are appropriate for ventilative cooling; or c) outdoor air quality is acceptable.

Being responsive to the electricity grid needs means providing flexibility to electricity demand – including direct signals from utilities – and integration with electric grid control strategies. Smart systems can have sensors to detect airflow, pressures or fan energy use – so system failures can be detected and repaired – and when components need maintenance.

Contributor to smart buildings

Smart ventilation requires a more complex system than one without controls. This additional complexity is needed to get smart ventilation – including electricity grid interaction or controls, depending on outdoor conditions – to optimise energy use without compromising IAQ. This increased integration of the ventilation system environment in its control strategy is part of the trend towards smart buildings. It is made possible because of the progress made on sensors, and on information and communication technologies.

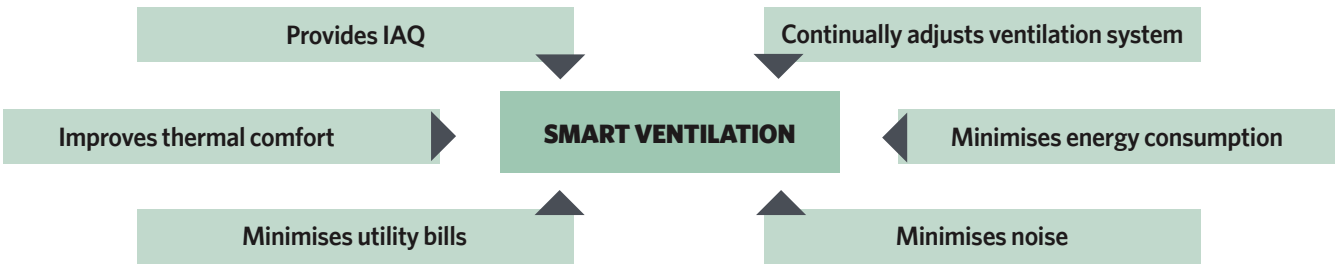
In the proposal for a revised Directive on the Energy Performance of Buildings, the European Commission – citing the need to define a smartness indicator – explained that the smartness of a building covers 'flexibility features, enhanced functionalities and capabilities resulting from more interconnected and built-in intelligent devices being integrated into the conventional technical building systems. The features shall enhance the ability of occupants and the building itself to react to comfort or operational requirements, take part in demand response and contribute to the optimum, smooth and safe operation of the various energy systems and district infrastructures to which the building is connected'.

Although this mainly refers to energy, it is clear that smart ventilation is a key contributor to the smart readiness of buildings for reducing energy impacts and providing IAQ.

Standards and regulations

Europe

In the standards that support the Energy performance of buildings directive (EPBD), smart ventilation can be considered using the control parameter f_{ctrl}, defined in the European Standard EN 16798-7:2017. But this standard offers little information on how to determine this characteristic for specific systems.



Main features of smart ventilation

It is a system characteristic that depends on the control strategy (including the quality of the sensors), and on the occupation scenario, climate or calculation time step. In Europe, there is currently no standard to characterise the f_{ctrl} parameter for such systems, but several countries – for example, Belgium and France – have schemes, or rules, for this, restricted to demand-controlled ventilation.

The European regulation 1253/2014, implementing the Energy-related Products Directive, also includes a ventilation control factor (CTRL) for residential ventilation units that influences the specific energy consumption of the unit to be declared by the manufacturer or importer. It defines the control factor for two types of systems that may qualify as smart under our present definition:

- 'Central demand control' – demand control of a ducted unit that continuously regulates the fan speed(s) and flowrate based on one sensor for the whole ventilated building or part of the building at central level
- 'Local demand control' – demand control for a unit that continuously regulates the fan speed(s) and flowrates based on more than one sensor for a ducted ventilation unit or one sensor for a non-ducted unit.

USA

ASHRAE Standard 62.2 covering residential ventilation and IAQ incorporates smart ventilation. It includes a prescriptive standard setting continuous ventilation rates, but there is also an 'equivalent ventilation' section, which says that any system will comply if 'the same or lower annual exposure [...] would be provided' and that the 'calculations shall be based on a single zone with a constant contaminant emission rate'. The exposure needs only be calculated for the period the building is occupied.

This makes ASHRAE Standard 62.2 a pollutant-exposure – not a ventilation – standard. Because we do not yet know the specifics of the contaminants of concern, the standard assumes constant emission of an unspecified contaminant to derive equivalence with the prescriptive ventilation rate.

The standard offers an operational approach for determining the equivalent ventilation rate to show compliance. This calculation can be used in a smart system that allows the scheduling of ventilation rates. The approach is best when the needs – based on occupancy, utility rates, weather or outdoor air quality – are known in advance. Annual exposure during occupied periods must be shown as equivalent to the constant ventilation result.

The second method involves real-time control. It requires more sensing and control technology, but allows the ventilation system to respond to changing conditions – for example, occupancy, outdoor air quality or energy costs. Exposure of the previous time period (typically a day) must be shown as equivalent to the constant ventilation result.

Traditional demand-controlled ventilation (DCV) systems are sometimes used in commercial buildings. To date, there are no non-residential standards in the US that allow smart ventilation systems beyond DCV. **CJ**

- This is an abridged version of: François Durier, Rémi Carrié, Max Sherman, 2018. Ventilation Information Paper no. 38: *What is smart ventilation?* AIVC.

- **BENJAMIN JONES** is associate professor at the University of Nottingham

OPENING REMARKS

Designing adequately sized windows for natural ventilation while ensuring occupants' safety is a challenge. **Benjamin Jones**, **Patrick Sharpe** and **Chris Iddon** offer guidance ahead of CIBSE's Applications Manual 10 update

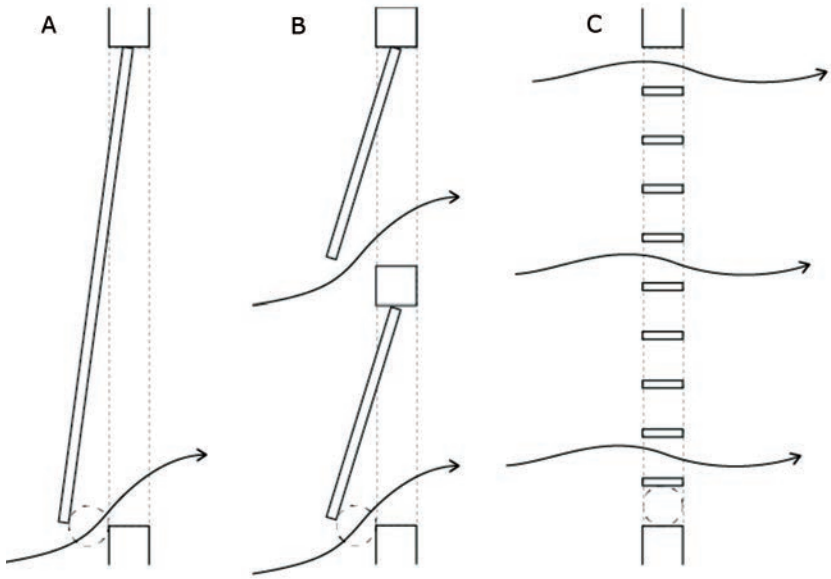


Figure 1: Alternative configurations of openable windows within the same structural openings. Vent openings are restricted to 100mm, but greater airflow can be achieved from configuration A to C respectively

Windows may be ubiquitous, but it is still surprising how little we know about their aerodynamic performance.

The release of the latest *BB101: Ventilation, thermal comfort and indoor air quality 2018* was accompanied by a spreadsheet-based effective area calculator (Jones & Iddon, 2016). This allows engineers to enter a window's dimensions and opening angle (or stroke length) to determine an effective area that can used for calculations of ventilation rates. 'Effective area' is defined here as the product of the discharge coefficient and free (measurable) area (see 'Air of credibility', *CIBSE Journal*, May 2016).

The calculator also gives free and equivalent areas, and discharge coefficients, although these are not recommended parameters because they introduce user error.

The predictions of the calculator can only be considered approximate, so the University of Nottingham is working to provide more robust data. In the meantime, the calculator should be used to size window openings in the absence of manufacturers' data. All other ventilation openings should be sized using data contained within CIBSE AM 10 and Guide C.

The choice and configuration of windows and other opening types within a natural ventilation scheme can have a significant impact on building performance and occupant comfort.

Single or multiple opening

One of the key choices to make when designing a natural ventilation strategy is whether to use a single or multiple opening system. Compared with single-opening systems, multiple-opening systems are more efficient because they can have larger mean pressure differences across the openings.

By increasing the height between openings to maximise the stack effect – and by locating them in different façades to maximise the impact of wind-pressure differences – the strategy's efficiency can be improved further.

To increase the robustness of the system, care should be taken to ensure the outlet remains in a negative wind pressure region.

Single-opening designs are often used where compartmentalisation is required, such as in cellular offices. They are simple and intuitive to operate, but have reduced airflow per area as a result of bi-directional and turbulent flow. To maximise natural ventilation flowrate through single openings, the stack effect can be exploited. This can be achieved with high height-to-width ratios, and using centre-pivot and side-hung windows, which concentrate open areas towards the top and bottom. Short top- or bottom-hung windows can be more effective in winter, when control is more important.

Mixing/displacement ventilation

Generally, there are two key approaches to the design of ventilation regimes – mixing ventilation and displacement ventilation. In mixing ventilation, cool air is supplied at high level and encouraged to mix with the internal air before entering the occupied zone. This is ideal for winter, because it minimises discomfort associated with cold draughts. In displacement ventilation, air is supplied at low level and warmer stale air rises from occupants and collects at the ceiling, where it can be extracted. This is ideal for summer. To maximise the potential for appropriate natural ventilation the position of available openings can take account of this.

Maximising effective area

A key limitation in the operation of windows in public buildings can be the requirement to restrict openings to prevent people entering or falling out. Approved Document K defines this opening limit as the distance between the window and its frame so that a 100mm diameter sphere cannot pass through it. This can be severely restrictive to natural ventilation, and often results in large windows

underperforming. Increasing the window area will increase the ventilation rate, but with diminishing returns, as it is limited by the 100mm stroke depth.

To avoid this, multiple smaller windows can be used instead of a single large opening – although this may present greater control challenges. A second solution is to locate the openings high up, so there is no requirement to restrict the opening stroke depth. This requires high floor-to-ceiling heights, however. A third technique is to fit the opening with a rigid grid or louvres in front of an open-in window. This enables full operation of the window without restrictors, but impacts the visual permeability of the opening. These techniques may involve a formal separation of windows for viewing and openings for ventilation.

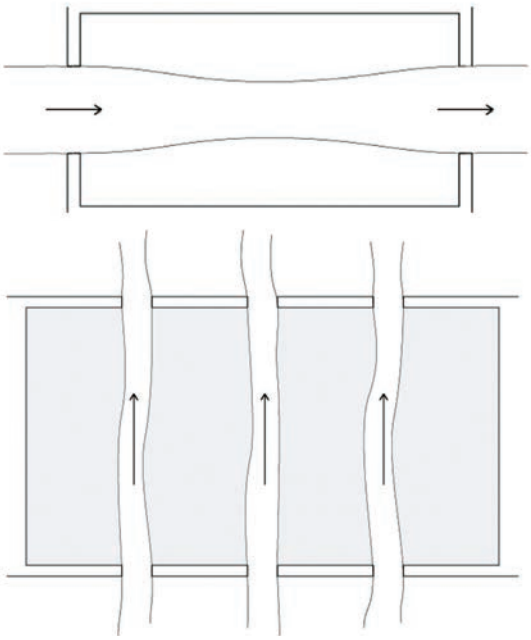


Figure 2: A stream tube can form between two aligned openings

Separating the inlet and the outlet

When two openings are aligned and located so that one solely supplies and the other extracts air, a stream tube can form between them. This may increase the volume flowrate through the openings. However much of the air will short circuit and leave the building without mixing effectively, and can lead to overheating.

The inlet and outlet should be separated to minimise the chance of interaction between the two. One of the most effective ways to do this is to locate the outlet in the roof or to use a central stack. This has the added benefit of incorporating stack effect into the ventilation regime. Another technique is to use obstacles, or partitions, to break up the jet as it moves from the inlet to the outlet. CJ

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Window Effective Area Calculator DOI: 10.13140/RG.2.2.10748.08323

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- The CIBSE Natural Ventilation Group is updating Applications Manual 10 and will include the Effective Area Calculator information, adding details as they become available

- **BENJAMIN JONES** is associate professor and **PATRICK SHARPE** a PhD researcher, University Of Nottingham; and **CHRIS IDDON** is chair of the CIBSE Natural Ventilation Group

DO INDOOR CO_2 LEVELS DIRECTLY AFFECT HEALTH OR WORK PERFORMANCE?

How do higher CO_2 levels impact health and productivity at work? **William Fisk**, **Pawel Wargocki** and **Xiaojing Zhang** summarise ten studies that explore the effect of poor IAQ

This article summarises the findings of 10 recent studies investigating whether increased carbon dioxide (CO_2) concentrations – with other factors constant – influence perceived air quality, health or work performance.

Concentrations of CO_2 in occupied buildings exceed outdoor concentrations because CO_2 is a product of peoples' metabolism. Indoor CO_2 concentrations are indicators of the rates of building ventilation with outdoor air per person.

A higher indoor CO_2 concentration is often considered an indicator of poorer indoor air quality (IAQ), although many factors unrelated to indoor CO_2 concentrations influence IAQ. When indoor CO_2 concentrations increase and decrease, concentrations of other air pollutants emitted from indoor sources – particularly bioeffluents from humans – may also increase and decrease.

Increased indoor CO_2 concentrations have often been associated (correlated) with decreases in perceived air quality, increases in acute health symptoms, and reductions in aspects of human performance.[1-3]

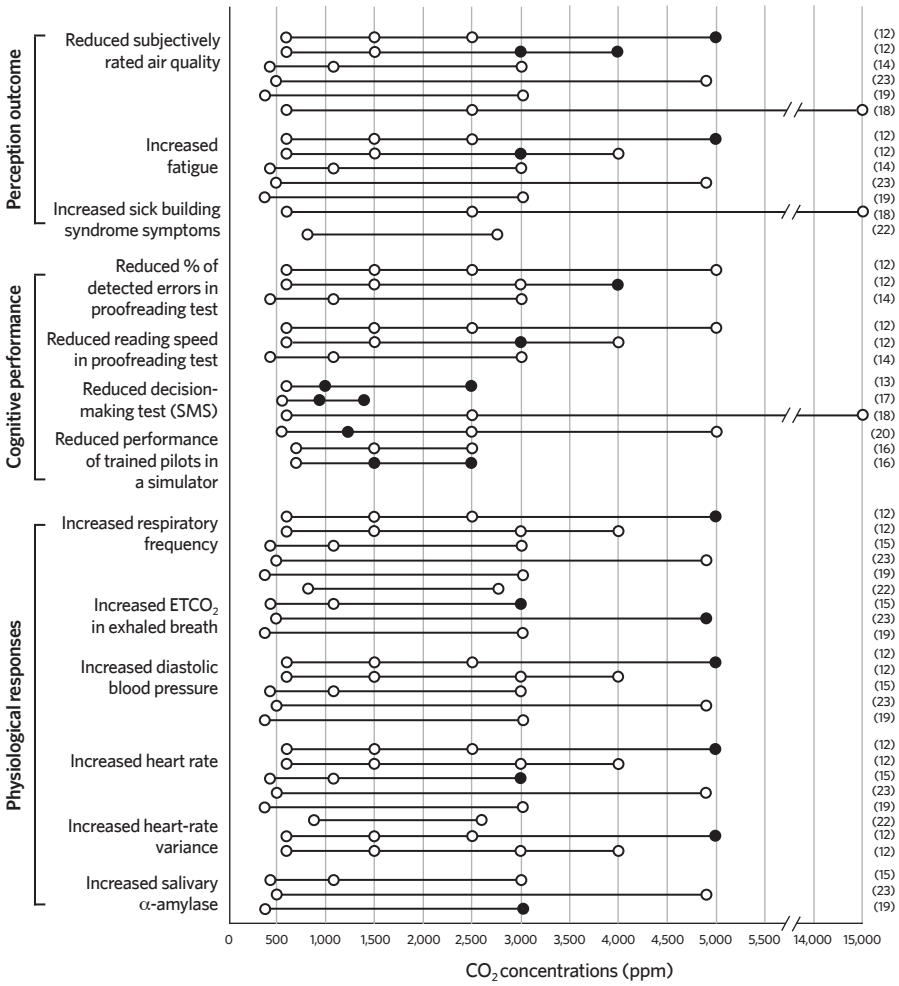
Research before 2012, although often with conditions atypical of normal buildings, indicated that levels of CO_2, with other conditions constant, had no significant impact on people's health or performance unless the CO_2 concentrations far exceeded the levels found in buildings.[4-10]

The occupational limit for CO_2 in the US is 5,000 parts per million (ppm) for a 40-hour work week.[11] So, the previously documented associations of indoor CO_2 concentrations with perceived air quality, health symptoms and performance have been attributed to the other indoor air pollutants with changes in concentrations indicated by the changes in indoor concentrations of CO_2.

Since 2012, ten studies[12-23] have investigated whether increases in moderate CO_2 concentrations, with other conditions constant, adversely influence perceptions of IAQ, health or cognitive performance in humans. The study features are described in Table 5 on the IAQ Science website,[24] and key findings are illustrated in Figure 1.

These studies have been performed with subjects in research facilities, enabling CO_2 concentrations to be modified by adding pure CO_2 to indoor air while maintaining all, or nearly all, other conditions constant. By providing high ventilation rates, these studies have maintained low concentrations of bioeffluents, and – in all studies – subjects were unaware of the CO_2 concentrations. All studies recruited healthy adults, often college-age adults, as subjects. One study employed pilots[16, 21] as

Increased indoor CO_2 concentrations in the workplace are often associated with reduced human performance



* Each horizontal line representing results from a single study. Filled in circles indicate a statistically significant worsening in the outcome at the indicated CO_2 concentration relative to the CO_2 concentration denoted by the left-most circle

Figure 1: Results of research on whether CO_2 concentrations affect human perceptions, health or cognitive performance

subjects, another employed submarine staff,[18] and a third employed staff trained as astronauts[20]. All but one of the studies[18] measured changes in perceptual, health or performance outcomes for each subject, with each exposed to multiple CO_2 concentrations.

This design eliminated the potential errors that may occur when comparing different groups of subjects. One study[18] employed a design with three groups of subjects, each exposed to a different level of CO_2 in the indoor air.

Figures 1 depicts the major results of this body of research with each horizontal line representing results from a single study or a part of a study.

With respect to subjects' cognitive performance, there are substantial inconsistencies among the results of these experiments. Five studies[12, 13, 16, 17, 20] found statistically significant (SS) decreases in aspects of cognitive performance, when CO_2 concentrations were increased and, in some instances, the performance decreases were quite substantial in magnitude.

Concentrations of CO_2 as low as approximately 1,000ppm, relative to 500-600ppm, greatly reduced performance.[13, 17] Four of these five studies[13, 16, 17, 20] employed demanding tests of cognitive performance – either a 90-minute assessment of decision-making via a test system called the strategic management simulation (SMS) or a 180-minute test of pilots' performance in flight simulations.

One of these studies[20] found a SS reduction in decision making performance at 1,200 ppm CO_2 relative to 600 ppm, but performance decreases were not found at 2,500 or 5,000 ppm CO_2. Besides assessing performance in decision making, this study also employed a battery of more traditional cognitive performance tests and performance in this battery of tests was generally not affected by CO_2 concentrations. The exception was a general trend toward reduced performance with 1,200 ppm CO_2 with the reduction in speed at 1,200 ppm being SS.

The fourth study[12] found a SS decrease in performance of a proofreading task, but not in other tasks, when CO_2 levels were increased to 3,000ppm, and proofreading performance decreased only in one of two experiments. Five additional studies[14, 18, 19, 22, 23] found that CO_2 levels had no SS effects on performance.

Four of these studies[14, 19, 22, 23] used tests of task performance – for example, arithmetic tasks, text typing, proofreading, and memory – as well as tests of reaction time and attention. In one study,[23] CO_2 levels as high as 5,000ppm did not influence performance. One of these studies[19] was conducted at high indoor air temperature of 95°F (35°C)

and increased CO_2 did not modify responses attributable to increased temperature. The fourth study[18] found CO_2 levels as high as 15,000ppm did not affect performance in the SMS test.

Overall, among the ten studies, three [13, 16, 17] provide strong evidence of reductions in cognitive performance with increased levels of CO_2. Two additional studies [12, 20] provide limited evidence of cognitive performance decreases with increased CO_2 levels, but also include evidence of CO_2 not affecting performance. The results of one additional study, [22] suggest a possible effect of increased CO_2.The mechanism by which increased CO_2 concentrations may affect cognitive performance was not clearly identified in any of the studies. A possible explanation is provided by another study,[22] albeit one that increased CO_2 levels by restricting ventilation rate per person, so concentrations of other bioeffluents increased when the CO_2 levels were higher. In this study, as subjects were exposed to levels of CO_2 increasing from approximately 400ppm to 3,000ppm, their forced expiratory volume in one second – and forced vital capacity – decreased.

Using models and previously published data, the authors predicted that – with exposure to higher levels of CO_2 – there would be increases in arterial CO_2 partial pressure and corresponding increases in the bicarbonate content of the blood, with a reduction in blood pH. The increased blood bicarbonate and reduction in blood pH was suggested as the explanation for a change in brain functioning when occupants are exposed to higher levels of CO_2.

Two papers[15,19] hypothesised that the level of stress associated with the cognitive performance test might explain the discrepancies among findings. Higher CO_2 levels were associated with diminished performance primarily from studies with very demanding, likely stressful, tests of performance. In support of their hypothesis, they found a tendency for subjects to have higher salivary α-amylase concentrations, suggesting higher mental stress, when CO_2 concentrations were increased. Further support for this hypothesis comes from findings that pilots' performance in flight simulations was reduced when their heart rate variability indicated a high level of stress.[21] Also, two studies[12,15] report some increases in blood pressure with exposure to higher CO_2 levels, suggesting higher levels of stress.

The authors of two papers hypothesized that the discrepancies among research findings when subjects took stressful cognitive performance tests was a consequence of the different types of subjects. In one paper,[20] the authors suggested that the astronaut-like operations personnel and submariners might have been better able to compensate for effects of elevated CO_2 due to their prior training. The authors of the other paper[18] hypothesized that their subjects (submariners) might have been unaffected by CO_2 as a consequence of their prior regular occupational exposure to CO_2 at 2,500 ppm or higher concentrations.

Five studies[12, 14, 18, 19, 23] investigated whether subjects' perceptions of IAQ – acceptability of indoor air – was influenced by CO_2 concentrations. One study[12] found subjects reported air quality as less acceptable with 3,000ppm, 4,000ppm, and 5,000ppm CO_2 relative to 600ppm.

Six studies, reported in eight papers,[12, 14, 15, 18, 19, 21-23] investigated whether the level of CO_2 influenced health symptoms reported on questionnaires or health-related physiological outcomes, such as blood pressure, pulse, respiration rate, markers of stress, and exhaled concentrations of CO_2.

Four studies that included questionnaires on acute health symptoms,[14, 19, 22,23] including fatigue, found that CO_2 levels had no SS effect on symptoms. One study[12] reported that subjects were significantly more tired with 5,000ppm CO_2 relative to 600ppm CO_2.

This study[12] also found that blood pressure, respiration rate and volume, and mental effort – based on heart-period variability – increased with higher CO_2 concentrations. In contrast, other studies[15, 19,23] generally found no statistically significant effects of CO_2 levels on a broad range of physiological outcomes, except for increases in the concentrations of CO_2 in exhaled air, called end-tidal CO_2, and two instances of increases in heart rate.

> "With respect to acute health symptoms and perceived air quality, all but one study found no effects at CO_2 below 5,000ppm"

In one study,[15] heart rate decreased less during the exposure session with 3,000ppm CO_2 versus 500 ppm CO_2 while another study[22] reported a SS increase in heart rate with exposure to 2,680 ppm CO_2 relative to 700 ppm CO_2. Another study[19] found that levels of α-amylase, markers of mental stress, were higher with 3,000ppm CO_2 compared with 380ppm CO_2.

Other research[26] has shown that exposure of mice to 2,000 and 4.000 ppm CO_2 for two hours triggers an inflammatory response and vascular injury with generation of microparticles by immune system cells. Also, in human immune system cells, microparticle generation resulted from increased CO_2 exposures.[27]

The main findings of the research are listed below:

- There is very limited evidence that CO_2 levels below 5,000ppm influence perceived air quality, acute health symptoms, or physiological outcomes other than end-tidal CO_2 and heart rate. The studies using mice and human immune cells (in vitro) indicate that higher CO_2 levels trigger inflammatory responses, but these findings have not yet been demonstrated in people
- With respect to acute health symptoms and perceived air quality, the study results – with one exception[12] – are consistent and find no effects at CO_2 below 5,000ppm
- The results of research on the effects of moderate CO_2 levels on human cognitive performance are not consistent. Some studies find effects of higher CO_2 concentrations on cognitive performance, while other studies find no effects on this outcome
- There is substantial, but still inconsistent, evidence that performance on challenging tests of decision-making and challenging flight simulations is worsened by CO_2 concentrations as low as 1,000ppm. The mechanisms underlying the reductions in performance are unknown.

Further research is needed to address the discrepancies among the current findings. Additionally, research to date has not investigated the effects of CO_2 on children, the elderly, and people with health problems. The effects of long-term, continuous or periodic exposures to elevated CO_2 levels has also not been investigated. Finally, the extent to which CO_2 mediates the influence of other factors on health or performance requires more research. **CJ**

This article also appears in the September *ASHRAE Journal*.

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Many debates around indoor air quality will have an impact on the revisions to CIBSE TM40, which will soon be published. CIBSE technical manager **Julie Godefroy** examines some of the issues

FRESH THINKING

A key focus for the revision of CIBSE TM40 *Health and Wellbeing in Building Services* has been to define performance criteria for significant environmental factors, underpinned by scientific evidence from medical bodies such as the World Health Organization and Public Health England wherever available (see the June 2019 *CIBSE Journal* Health and Wellbeing Special). But the work is constrained by gaps in current understanding, which can be separated broadly into three strands:

- How individual environmental factors affect health, comfort and cognitive performance
- The impact of combined factors. Guidelines are typically based on the impact of a single factor rather than the concurrent exposure to several factors, as is likely in real life. For example, exposure to air pollution and noise in locations near busy roads, or the effects of cold, damp and inadequate ventilation in low-quality housing
- How to cater for a wide range of physiologies, medical conditions, personal preferences and other criteria that contribute to the needs of the individual.

Some of these knowledge gaps may be filled in the future; the complexity of others means a precautionary approach will be required, with information accumulated from monitoring over time to evolve a range of environmental conditions and design measures that do not have detrimental effects.

Air quality and humidity

Broad guidelines for indoor air quality (IAQ) are available as a starting point. In England, for example, the National Institute for Health and Care Excellence (NICE) has recently published a consultation guideline for IAQ in homes.[1] However, there are still gaps in a number of areas:

- Exposure to multiple pollutants – cumulative effects and mixture effects ('cocktails'), which may reduce or dampen the overall effect
- Emerging pollutants, whether new or potentially barely studied – for example, those emitted by consumer products such as air fresheners, cleaning or personal care products, or by fire-retardant materials in furniture, furnishings and so on
- Effects on cognitive performance and productivity (see panel 'Effects of internal CO_2 levels on performance')

"The precautionary principle does not prevent innovation, but requires a cautious review of claims, possible effects, and monitoring and evaluation, to keep new uses under review"

- Mould, microbial contaminants and allergens, such as dust mites. Guideline levels would be very complex to define and are unlikely to emerge in the near future. Instead, CIBSE guidance follows recommendations by WHO[2] and refers to a recommended range of relative humidity, surface temperatures and ventilation, based on empirical evidence of environments that reduce the risk of detrimental conditions, such as mould growth and fabric degradation.

Additionally, current guidelines are simplified to apply to most cases for healthy adult populations. Established guidance for specific parts of the population that may be more sensitive – such as children, pregnant women, the elderly, or people with existing medical conditions – is scarce.

This complexity is illustrated by allergies, asthma and sensitivities, an area where our understanding of causes and effects is still relatively limited. In some cases, individuals who exhibit strong responses to exposure to a particular substance may be seen as 'canaries in a coal mine' as they exhibit a more immediate, obvious and acute reaction to something that affects us all but to lesser degrees.

Others, such as food allergies, produce reactions that are specific to the individuals – whether as a result of medical conditions or other factors, such as medication or drug use – while the rest of the population does not risk harmful effects from exposure.

In other cases, individuals are convinced that exposure to a particular factor is causing them harm, and they suffer from real symptoms, but the science does not support a causal link to the factor being blamed.

For example, this is the case with 'electrosensitivity', or perceived hypersensitivity to electromagnetic fields (EMFs), where meta-analyses and double-blind experiments do not support a link between such symptoms and short- or long-term exposure to EMFs.[3,4]

Some evidence suggests there may be broader causes, such as personal circumstances or the acceptance (or not) of new technologies, particularly when these technologies are perceived as imposed without personal control. This means that built environment professionals need to recognise, and understand, the potential distress of individuals, while being able to support their design proposals with the best available knowledge.

Innovative solutions for IAQ

R&D has been undertaken into how to deliver the most appropriate environments. Some features being researched, such as indoor planting and the use of traditional building materials, have been around for a number of years. The main uncertainty is about the claims being made for their effect.

There is much more uncertainty and risk of unintended consequences with new products, or even with well-intentioned phase-outs and substitutions: for example, some concerns have been expressed that the use of low-volatile organic compound (VOC) paints may lead to increased risks of bacteria and mould growth, or to the use of biocides that themselves have adverse effects.[5]

The following approach is recommended when examining potential new solutions:

- Are the product's claimed benefits based on real-world experiments? If so, how were the multiple parameters of a real-world environment controlled for? In the case of laboratory studies, how representative are they of real-life situations?
- Are the effects expected and proven in the long term?
- The proposed solution may have proven positive impacts on specific target pollutants, but have possible reactions with other components in the air been considered?
- What is the required extent of application of the system or product (such as in exposed area per room volume), and is this realistic? »

EFFECTS OF INTERNAL CO_2 LEVELS ON PERFORMANCE – CIBSE AND ASHRAE REVIEWS

Recent research reviews by CIBSE (Godefroy) and ASHRAE (Fisk, Wargowcki & Zhang), published in the June 2019 *CIBSE Journal* Health And Wellbeing Special, have reached similar conclusions on the right limits for internal CO_2 levels, and the associated potential for improvements to cognitive performance.

They say CO_2 does appear to have an effect on its own, other than simply being a proxy for ventilation effectiveness. But the evidence is still somewhat inconsistent, and most statistically significant effects are shown as occurring at CO_2 levels well above the CIBSE recommended range (itself based on BS EN 15251, with similar or higher levels recommended in its replacement BS EN 16798:1-2019).

- If a pollutant is claimed to be 'removed', what process would be applied? In the case of absorption (or other 'fixation' process), is it proven over time, taking account of possible re-release? In the case of decomposition, what are the by-products and their effects?
- Are the claims based on independent research?
- Is data available from existing case studies?

The following examples illustrate the importance of these questions.

Photocatalytic removal using titanium dioxide – this has been studied for many years to address a range of pollutants, with potential indoor and outdoor applications, including paints or wall coverings and internal duct surfaces. A recent independent comprehensive review[6] on its potential to reduce levels of nitrogen oxides (NO_x) concluded there is little evidence of an impact in outdoor applications, or that the impact would be very small and require very large exposed areas.

It does appear to reduce NO_x levels when applied indoors, but there remains much uncertainty as to other possible consequences – for example, other hazardous pollutants such as ozone may be generated from the photocatalytic decomposition of NO_x and other air pollutants.

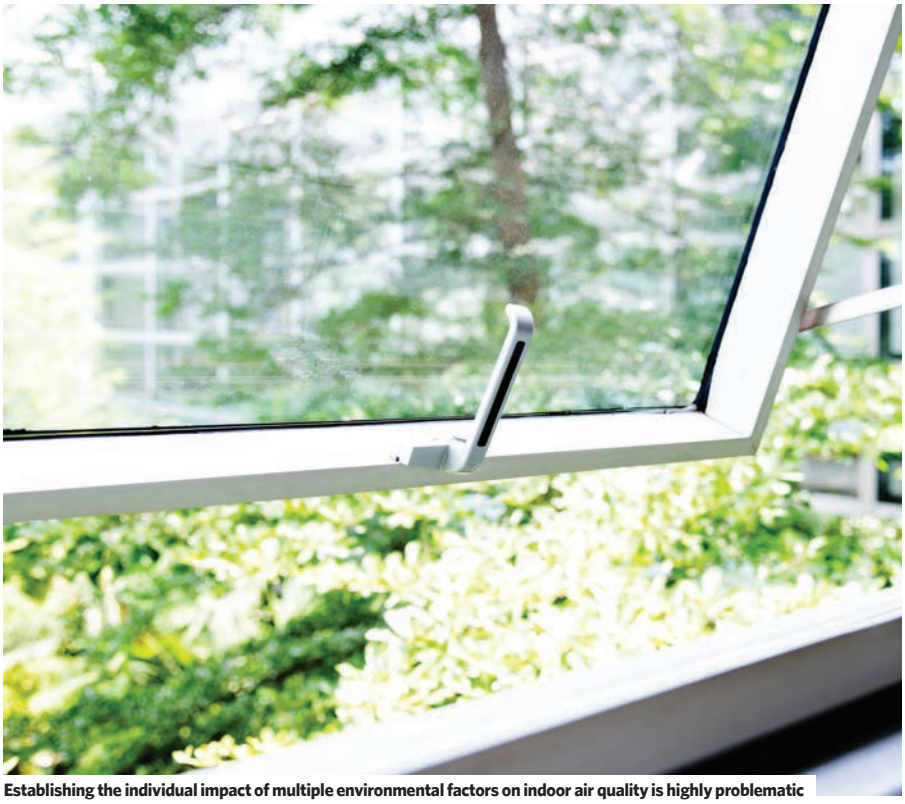
VOC-reducing materials – a number of claims are being made about materials that may help reduce indoor VOC levels, either by absorbing or decomposing them. One example is wool, which has been shown to have VOC-absorbent properties. The extent would depend on the type of wool, and the air would need to be in contact with the wool, which implies applications for furniture, floor and wall coverings rather than insulation.[7] The body of evidence is not yet substantial, and the effect may be small, but long-standing historic applications mean there is little risk of unintended consequence.

Indoor planting is a large R&D topic in itself, so it is not discussed here but, in addition to recent *CIBSE Journal* articles, a CIBSE publication on this is planned.

Other new products claim to decompose VOCs into 'inert products', which would then be either released into the air or bound to the product in question. However, there is little public data on the mechanisms and by-products, and claims should be examined carefully.

An important conclusion from this evolving field is to follow the precautionary principle and apply source control, as some effects on health may only manifest themselves in the long term, as in the case of asbestos and lead paint. This does not prevent innovation, but requires a cautious review of claims, possible effects, and monitoring and evaluation, to keep new uses under review. **CJ**

"Some of these knowledge gaps may be filled in the future; the complexity of others means a precautionary approach will be required"



Establishing the individual impact of multiple environmental factors on indoor air quality is highly problematic

- Articles in the next few months will cover other topics, including housing refurbishment and its impact on comfort, air quality, humidity and energy consumption; and air quality monitoring procedures and equipment.

DR JULIE GODEFROY is technical manager at CIBSE

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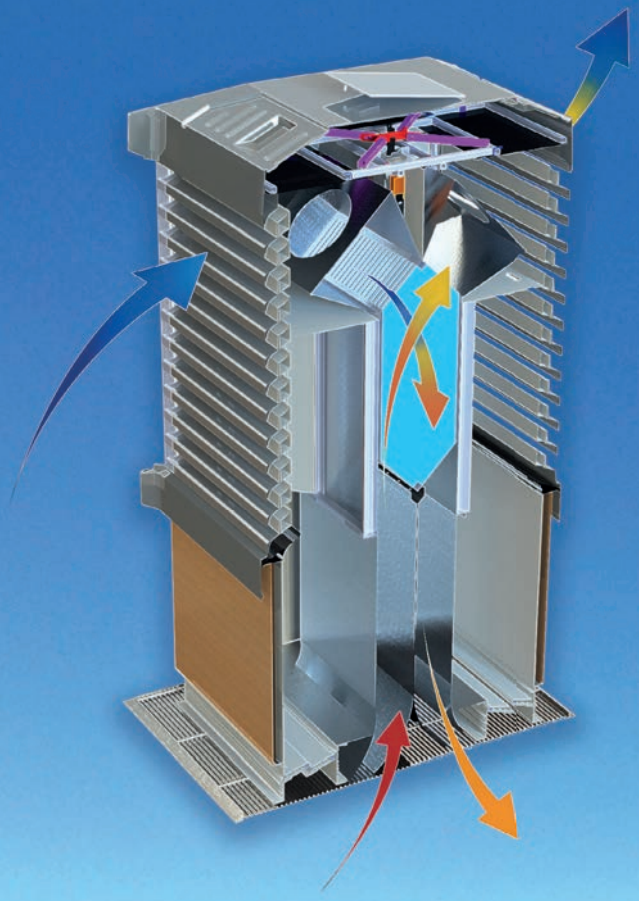

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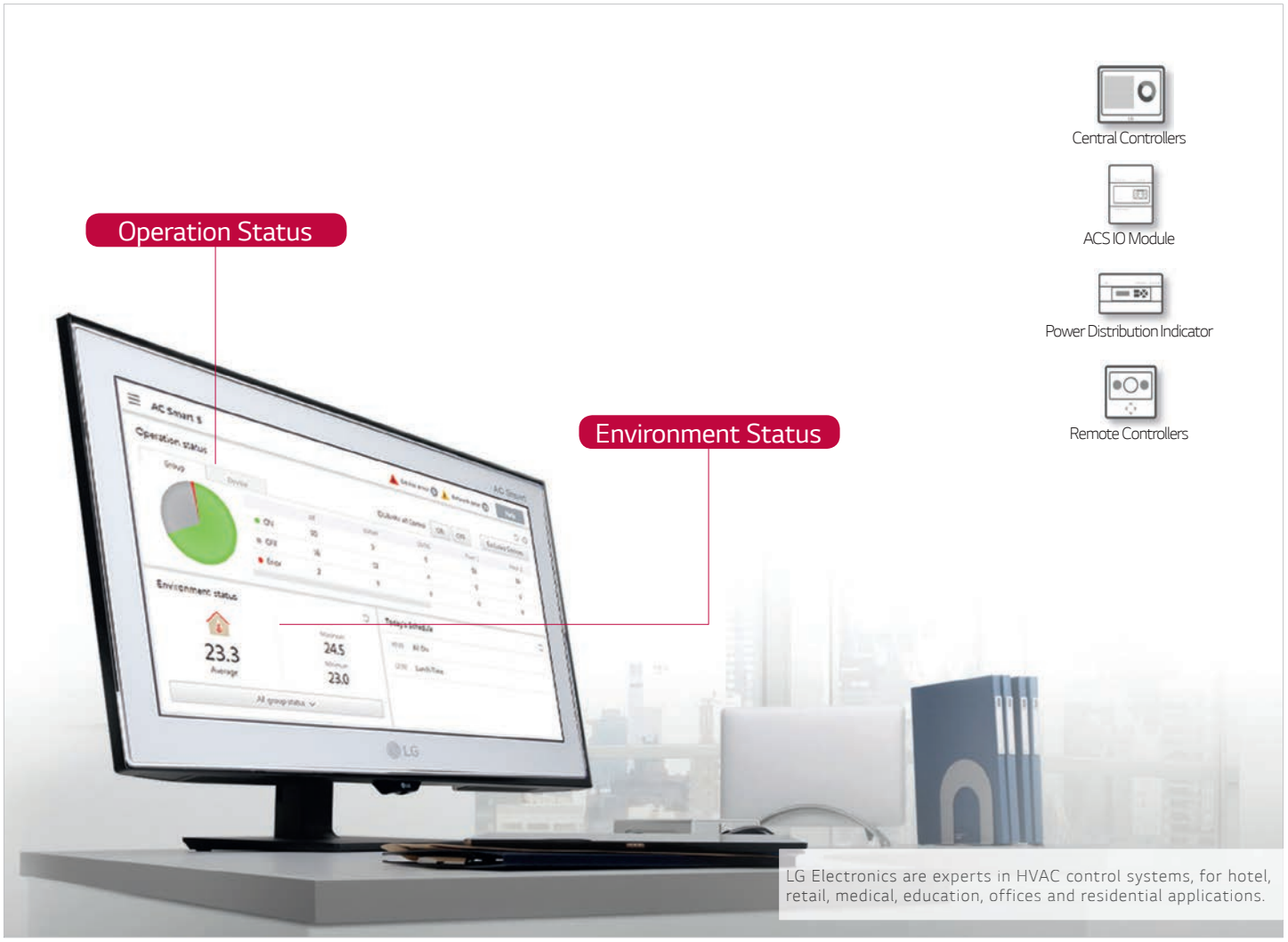

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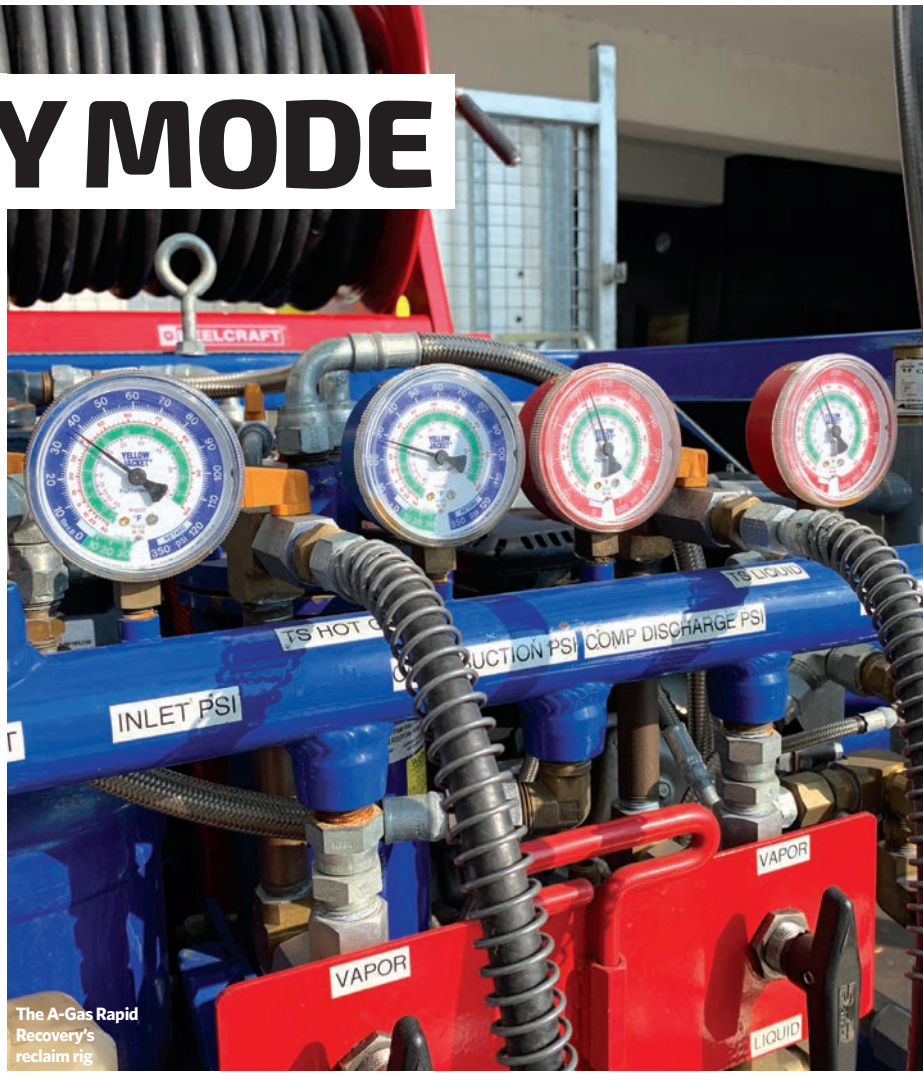
RECOVERY MODE

Refrigerant recovery allows for the reuse of a valuable resource without impacting on the environment. Daikin uses reclaimed R410A in two products and offers partners incentives to reclaim old refrigerant, says the company's **Martin Passingham**



The A-Gas Rapid Recovery's reclaim rig

Earlier this summer, Daikin announced that it was using reclaimed refrigerant in some of its VRV systems, as well as its Commission with Confidence service, which offers refrigerant supply, system charging, and commissioning.

To try to increase the amount of refrigerant reclaimed, Daikin also offered to reward some of its partners – known as D1 and D1+ partners – if they used its Reclaim with Confidence service to retrieve refrigerants via recovery specialist A-Gas Rapid Recovery.

As part of the EU's F-Gas regulations, manufacturers must reduce the HFC's they are using and switch to gases with a lower global warming potential. They must develop a more sustainable supply of F-Gases for installation and ongoing servicing.

The UK has committed to reducing F-Gas emissions by 68% between 2015 and 2030. More reductions will be required to reduce emissions to near zero by 2050.

F-Gas regulations define quotas for how much fluorinated gases can be produced by manufacturers, with the aim of phasing them down, step by step. In 2018, the quota reduced by 37% and it will reduce once more in 2021, by 55% against the baseline.

However, the F-Gas quota does not include refrigerant already in the market. Reclaimed refrigerant has zero impact on the F-Gas quota, so it is not restricted in the same way. That's because reclaiming refrigerant avoids the carbon emissions associated with manufacturing new F-Gases. As a result, systems that use reclaimed refrigerants have a lower environmental impact overall.

Daikin's new VRV IV+ systems and existing VRV IV S-series units now have certified reclaimed refrigerant allocated to them during production, so they have zero impact on F-Gas quotas.

The company claims that the reclaimed refrigerant currently allocated to these units avoids more than 300,000 tons of CO_2e being generated in the production of virgin refrigerant. Throughout the lifetime of a system, the responsible recovery and recycling of components and refrigerants can contribute to a circular economy. Instead of seeing redundant parts and contaminated refrigerant as expensive waste to dispose of, it sees them as valuable assets for reprocessing, so they can be reclaimed for future use.

What does reclaiming refrigerant involve?

There is often confusion about the difference between recovery, recycling and reclaiming refrigerant.

Recovery is when you remove the refrigerant from a system to a yellow-top cylinder. A hazardous-waste consignment note must be completed and it can then be returned to the supplier for reprocessing.

Recycling is when a refrigerant is removed from a system into a receiver cylinder, so it may be used again on the same site. It cannot be transferred to another site, or stored for longer than 12 months. It is best practice not to use recycled refrigerant when a compressor has failed or is being changed.

Recovery and receiver cylinders should be kept separate and clearly identified to avoid contamination and reduce separation costs at the processor.

»

Refrigerant recovery specialist A-Gas Rapid Recovery

Recovery lines are attached to the three gauge ports of one of Daikin's heat recovery outdoor units at Bristol Water's HQ

» Reclaiming refrigerant is a much more extensive process of cleaning and reprocessing recovered refrigerant to meet the requirements of AHRI Standard 700-2016.

- First, the recovered gas is tested in a laboratory, then distilled to boil off the F-Gases
- Any sludge, particulates, moisture, acid or oil are disposed of safely
- Next, any noncondensable gases – such as nitrogen and air – are removed
- The gas is then dried and analysed to check its purity levels
- If other refrigerants are mixed in, these are separated – in a distillation column – into individual pure components for re-use or disposal.

Many people assume all recovered refrigerant is incinerated, but that's not the case. If it is separated and recovered according to best practice, as above, in dedicated reclamation facilities, it can be separated and reclaimed to the same level of purity as new refrigerant.

That's important, because refrigerant recovered from a site can only be resold, passed on or exchanged if it meets the requirements of AHRI Standard 700 or equivalent. This specifies purity requirements for fluorocarbon, hydrocarbon and carbon dioxide-based refrigerants – from whichever source they come.

Using refrigerant that meets the requirements of AHRI Standard 700 is vital for the performance, efficiency and long life of a system, and to ensure the warranty remains valid.

When a unit is supplied with reclaimed refrigerant it should be certified as having the required quality and quantity of refrigerant.

Certified quantity means that the reclaimed refrigerant allocated to the unit is equivalent to its factory charge, so the unit has zero F-Gas quota impact. Meanwhile, certified quality means the refrigerant has been reclaimed to the same quality as virgin R410a.

The certified reclaimed refrigerant is mixed with virgin refrigerant at a factory in Ostend, Belgium, where the VRV units are manufactured. All units are charged with this mixture of reclaimed and virgin refrigerant.

Daikin says its goal is to make its activities carbon neutral by 2050 and – as well as recovering and reclaiming refrigerants – it will be looking to reduce the impact of materials throughout the entire life-cycle of products. **CJ**

MARTIN PASSINGHAM is DX product and training manager at Daikin

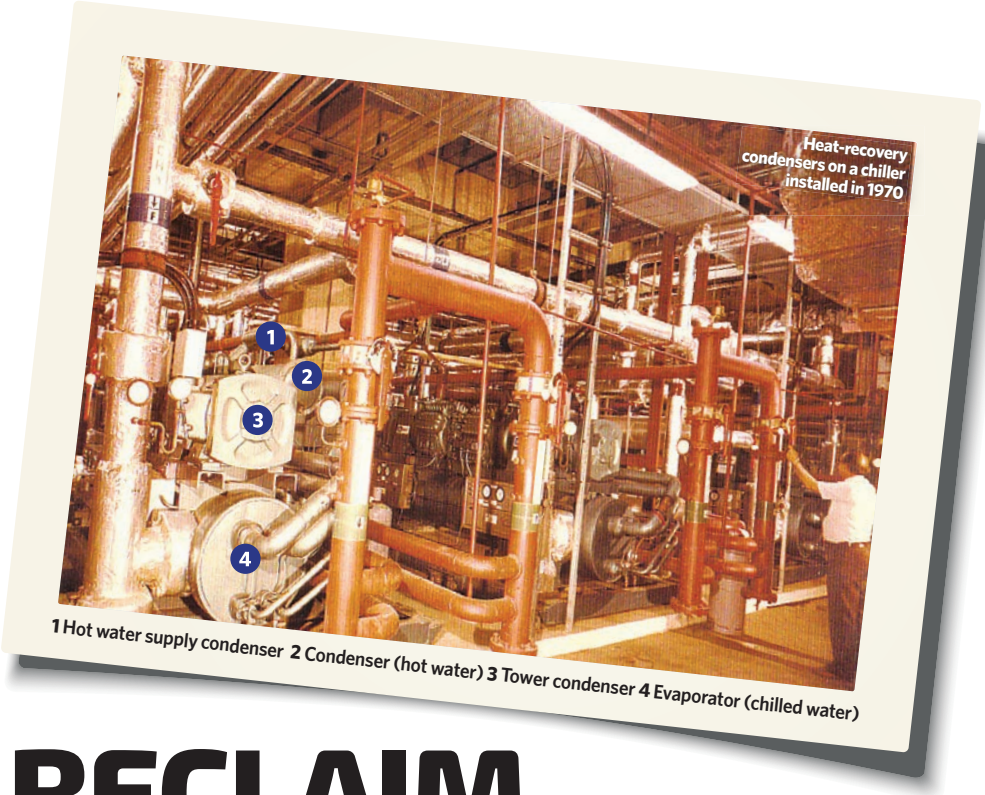
TRIAL RUN

The gas recovery was trialled at Bristol Water's HQ in Bedminster Down, which has three heat recovery outdoor units serving 25 indoor units. The system is charged with 40-45kg of R410A.

After four years, one of the outdoor units needed work that required the recovery of the entire refrigerant charge. A reclaim rig delivered by vehicle had its recovery lines connected via 30 metres of hose to three gauge ports on one of the modules. The recovery mode was activated on all three linked modules and, within 60 minutes, 38.5kg of R410A was recovered.

The machine was then switched off and the system pressure dropped to zero psi. As the accumulators had iced up because of evaporation, they were sprayed with hot water and left for 30 minutes until the remaining refrigerant had boiled off.

Once the pressure had risen, the reclaim machine was run for a further 20 minutes and another 6.6kg of R410a was recovered, and the system pressure dropped to -10 inch Hg. Once the component was replaced, the system was recharged with fresh gas. The process meant there was no need to hire cylinders.



Heat-recovery condensers on a chiller installed in 1970

1 Hot water supply condenser 2 Condenser (hot water) 3 Tower condenser 4 Evaporator (chilled water)

RECLAIM THE HEAT

Chiller upgrades offer an opportunity to turn buildings into power stations by recovering heat for hot water and heating, and installing PVs. Energy consulting engineer **John Hammond** explains how redistributing heat can eliminate the need for boilers

In the 1970s, A I McFarlan published hourly breakeven temperature (BET) calculations in ASHRAE journals, showing that most medium/large buildings – once occupied – have a surplus of heat and an overheating problem, even in the depths of winter.

Using a cold-day or week BET calculation usually gives more realistic results. McFarlan proposed the use of the summer building chillers as winter heat pumps to redistribute surplus heat from the hot zones to the cool zones, often eliminating the need for boilers.

These internal heat pumps have a far higher coefficient of performance (COP) than external heat pumps, enabling them to be powered by an economical use of PV solar panels and battery storage. This means existing buildings and well-insulated new ones have the potential to become power stations, exporting electricity to the grid, similar to the Chiltern Hills property described in 'Rise to the challenge', *CIBSE Journal*, May 2019.

The photo (above, right) of one such self-heating building plantroom – installed in north London in around 1970 – shows three chillers using R22 refrigerant incorporating two heating heat-recovery condensers and one hot water supply (HWS) heat-recovery condenser.

The three chilled water evaporator circuits were connected in series, as were the two heating heat-recovery condensers' water circuits and the three cooling tower heat-rejection condensers, in a counter-water-flow arrangement, improving the COP from about 3.25 to about 3.65 at full load, and more at part-load.

The three condensers (triple bundle) seen on the chiller in the photograph are: top – small HWS heat-recovery condenser (refrigerant desuperheater); middle – large, general heating heat-recovery condenser; and, bottom – cooling tower condenser for rejection of heat.

The HWS single-pass, counterflow desuperheater/condenser allowed the HWS water to be heated above the design 'condensing' temperature, enabling use of a lower general heating temperature »

» with a relatively high overall COP. On new, well-insulated buildings with lower supply air/water temperatures, the heating COP can be 7 or more, reducing operating cost even further.

The replacement of these old machines allows for improving their COP to about 4.3 by reducing the logarithmic mean temperature difference (LMTD) between the refrigerant to chilled water and refrigerant to heat-recovery water by about 3.5 fold. This reduces operating costs in summer and winter, justifying the economical upgrade to current refrigeration machine heat-transfer design practices. This lowers the electrical demand, requiring fewer PV panels/battery storage, and their installation becomes viable, enabling the building to be a net yearly exporter of electricity to the grid.

Unfortunately, in the event of one winter heat-recovery machine failure, there can be a problem meeting the heating requirement fully during very cold weather. So, during the installation of new, upgraded machines with safer refrigerants, an additional heating heat-recovery condenser on the third machine is suggested, to give standby capability.

This additional condenser, however, means that all three heat pumps need only operate at two-thirds capacity to meet the maximum heating demand. Having the series circuitry with the counter-water-flow arrangement, increases their winter COPs by about 4.7 (heating COP 4.7 + [1 motor energy] = 5.7). This energy saving justifies the installation of the extra heating condenser instead of a standby emergency boiler.

The installation of only one HWS heat-recovery condenser can, again, cause problems if it fails. Instead of installing an electric/boiler standby heater, the fitting of an additional standby HWS condenser on the second machine would enable the two HWS condensers to warm the HWS to higher temperatures and provide standby coverage.

> "Varying the amount of additional cool winter outdoor air from a heat-balance detector controls the loading/unloading of the winter heat pumps and the heat they produce"

Heat from lights during morning – instead of afternoon – cleaning reduces the size of the heated (water) storage vessel required for the early morning preheating of the building. Stored heat is collected from the previous day(s) surpluses, which usually eliminates the need for natural gas boiler(s) or electrical heaters.

Varying the amount of additional cool winter outdoor air (more than minimum ventilation air requirement) from a heat-balance detector (thermostat in flow [supply] pipe) controls the loading/unloading of the winter heat pumps and the heat they produce. This extra outdoor air produces a far healthier indoor environment.

The CPD article in *CIBSE Journal* July 2019 shows some environmentally safe replacement refrigerants. One manufacturer is considering a new refrigerant, HFO-1336mzz(E), which eliminates the safety issues present with some replacements. Its safety rating is A1 – with zero ozone depletion potential (ODP) and a global warming potential (GWP) of about 32 – but it has a low density (about one-seventh of R-410A). The manufacturer is testing a new high-speed – about 17,000rpm – high-volume, small-screw compressor to address this issue. Preliminary tests on an 18kW unit indicate that, with modification, it is likely to be more efficient and environmentally safer than the R410A it replaces.

Breweries, among others, use ammonia – with its ultra-low GWP and ODP – as their refrigerant . When replacing old machines, engineers should consider the incorporation of two extra heat-recovery condensers, as described previously. This would enable free heating of HWS and general heating from the chillers, which operate throughout the year for product creation.

Adding PV solar panels/battery storage reduces operational costs and carbon emissions even further, allowing the facility – at times – to be, potentially, an exporter of electrical power. **CJ**

JOHN HAMMOND
is an energy consulting engineer

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Smart city heating and cooling

This module considers the growing need for integrated and efficient heating and cooling solutions to meet the demands of increasingly urbanised living

The development of smart cities is underpinned by the creation of safe, healthy, environmentally responsible and sustainable built environments. Around 75% of people in Europe already live in an urban setting, consuming significant resources, and this is set to increase. To deliver truly 'smart' cities, the planners, developers and designers will need to evolve sustainable heating and cooling solutions that are correspondingly clever.

This CPD will review some of the evidence that predicts the growing need for integrated and efficient heating and cooling for increasingly urbanised living, and will discuss the application of heat pumps employing low global warming potential (GWP) refrigerants as a means of maximising the primary energy resource, and so reducing environmental impact.

Recent analysis[1] by Moran *et al* indicates that 54% of the total global population is clustered in urban areas but accounts for more than 70% of global energy use. By considering carbon footprint data, the research suggests that the top decile of earners drive 30%-45% of emissions, and the 100 highest-emitting urban areas account for 18% of the global carbon footprint. This will become more challenging as an increasing proportion of the population become urban dwellers in countries with developing economies and in more prosperous countries, such as those in western Europe, where 90% of people are predicted to live in urban environments by 2050.[2]

The urban heat island effect means that cities are warmer than their surrounding areas. This is primarily caused by meeting the needs of a high population density (comfort and appliances); the structures that absorb and store heat that is re-emitted at night; and limited cooling from evapotranspiration of vegetation, compared with rural areas. The cooling required to maintain comfort and productivity can itself be a significant contributor to the heat island effect, as well as a consequence. It is estimated[3] that air conditioning can raise temperatures by more than 1K overnight in some cities. Higher outdoor temperatures increase the overall need for cooling and reduce cooling system efficiencies (for air-cooled systems), leading to increased primary energy use, higher temperatures and increased use of cooling in a classic feedback loop.[4] Across a range of potential urban growth scenarios, Güneralp *et al*[5] estimate that the annual global energy use for heating and cooling may increase 7%-40% from 2010 levels by 2050, so there is plenty of opportunity to seek out improved systems to minimise their environmental impact and cost.

To meet heating and cooling demands, there can be significant benefit in employing heat that is 'rejected' from buildings' cooling systems and processes to meet the thermal loads around the city in an attempt to reduce the consumption of primary energy. In addition, there is potential for waste heat generated from power stations, the service sector, infrastructure (such as metros and power distribution) and industry, as a by-product of their principal activity. The most recent European Commission report on this, *An EU Strategy on Heating and Cooling*,[6] highlights that, theoretically, enough waste heat is produced in the EU to heat the entire building stock. In some cases, this otherwise wasted heat can be used directly in the same buildings (or complex), if there are »

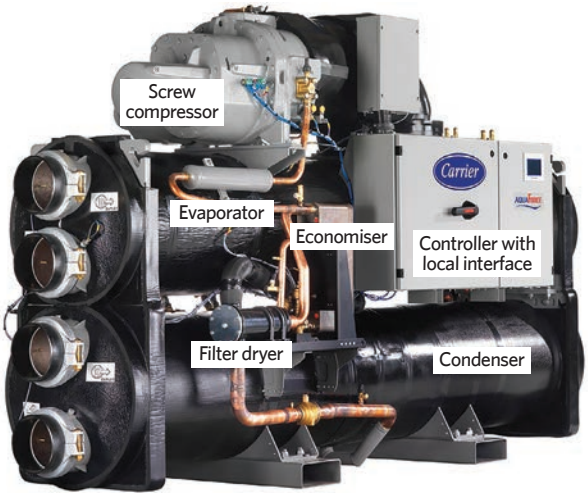

Figure 1: An example of a commercially available heat pump with variable speed twin-rotor screw compressor employing R-1234ze and flooded heat exchangers (Source: Carrier)

» appropriate concurrent heat demands or thermal storage facilities, although, in many buildings, much of the heat cannot be usefully used immediately on site. This presents opportunities to redistribute this heat while, at the same time, being able to integrate large-scale renewable heat sources, using heat networks. However, the EU's most recent assessment[7] on the uptake of renewable energy sources notes that for heating and cooling 'the barriers are mainly due to shortcomings related to the capacities of the district heating networks'.

Currently, district heating provides 9% of the EU's heating; in 2012, the main fuel was gas (40%), followed by coal (29%) and biomass (16%).[6] District heating can integrate renewable electricity (through heat pumps) by exploiting natural heat resources, such as geothermal, ground and water sources.

Also, as stated in the European Commission document,[6] 'synergies between waste-to-energy processes and district heating/cooling could provide a secure, renewable and, in some cases, more affordable energy in displacing fossil fuels.'

Driven by F-Gas legislation for new low-GWP refrigerants – and the requirements of Ecodesign and standards such as BS-EN 14825[8] to meet increasingly robust efficiency requirements (as measured by seasonal coefficient of performance (SCOP) and seasonal energy efficiency ratio (SEER)) – heat pumps have been designed that are capable of delivering relatively high hot-water temperatures at high system efficiencies. This has increased the opportunity to employ such systems so that large heat producers – for example, data centres – can be used to provide heat for heat pump-powered district heating systems. The prime objective in controlling a data centre environment is to provide the correct amount of cooling, as efficiently and as reliably as possible, so as to allow the computing equipment to operate most effectively. The operational effectiveness, in terms of energy, is typically measured in terms of its power usage effectiveness (PUE), although there is increasing interest in the additional evaluation of energy reuse effectiveness (ERE), which indicates how otherwise wasted energy is used (see boxout 'PUE and ERE'). Traditionally, cooling has been provided using mechanical vapour compression cooling, with the heat being rejected to the outside atmosphere through an air, or water, heat-rejection system. As data centre cooling represents a significant proportion of the building's energy consumption, and is typically considered to be around 40% of total energy use, there is an increasing focus on improving the efficiency of cooling solutions to reduce the real PUE and provide a smaller ERE.

Whether using mechanical cooling equipment alone or in combination with evaporative or air-based cooling systems, this still involves 'rejecting' heat to the local environment. A common design approach is to recover the heat directly from the cooling system at the relatively low temperatures associated with vapour compression refrigeration, using heat recovery condensers or desuperheaters added between the compressor and the condenser. Using heat-recovery condensers, such systems can achieve water temperatures up to 50°C or, when using desuperheaters, up to 60°C (but with significantly less heat available in the latter case). Depending upon the application, such water temperatures, combined with the significant amounts of available heat, can offer economic advantages and reduce the ERE. However, as the rejected heat is typically not at temperatures required for many district heat networks, heat pumps can be applied to deliver the heat at a more usable temperature. Modern refrigeration technology and low-GWP refrigerants such as the hydrofluoroolefins (HFOs) can provide heat pumps capable of delivering hot water up to 85°C. The temperature that a heat pump, such as that shown in Figure 1, is able to produce economically will be dependent on the temperature of the source heat, as well as the design and operational characteristics of the heat pump.

Manufacturer's data[12] indicates that, for example, the heat pump in Figure 1 can economically deliver temperatures of 85°C (COP 2.26) at a modest source water temperature of 20°C (leaving the evaporator at 15°C). The COP of the heat pump system can be significantly improved by employing two modular heat pumps in series, as illustrated in Figure 2. Series-connected heat pumps can economically deliver temperatures that are associated with standard low-temperature hot water heating from a relatively low temperature source. These can provide an efficient means of heat recovery, either as stand-alone installations or to supplement traditional boilers in applications such as district heating or industrial processes. By using ultra-low GWP refrigerants, such as HFO R-1234ze, in well-designed and installed systems, the potential environmental impact is reduced significantly compared with previous-generation hydrofluorocarbon (HFC) refrigerants. Such systems can simultaneously produce chilled and hot water to supplement boilers as well as replace chillers, and attain an operating COP of 3.0 or more, so benefiting the ERE.

PUE AND ERE

The power usage effectiveness (PUE) is defined as the total energy needed for everything used in the bounds of the data centre facility divided by the energy used for computing

$$\text{PUE} = \frac{\text{(Cooling energy + small power energy + lighting energy + IT energy)}}{\text{(IT energy)}}$$

Conventional data centres typically have a PUE of about 2.0; many current 'hyperscale' facilities have achieved PUEs better than 1.2.[9,10]

Energy reuse effectiveness (ERE) provides an indication of the useful energy recovery from a data centre that is used, for example, to heat buildings or drive an industrial process (aside that this is used directly in heating and cooling for the data centre itself).

$$\text{ERE} = \frac{\text{(Cooling energy + small power energy + lighting energy + IT energy – reused energy)}}{\text{(IT energy)}}$$

On its own, an ERE of 1.0 does not imply an efficient data centre infrastructure – PUE and ERE together provide a better impression of the performance of data centres that reuse energy.

See *ERE: A metric for measuring the benefit of reuse energy from a data center*[11] for a more detailed explanation of the evaluation of ERE.

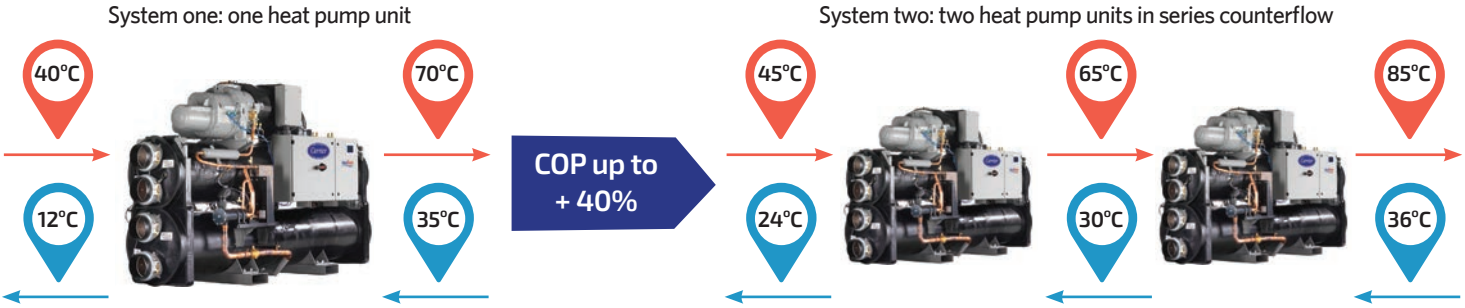

Figure 2: A comparative example of the impact on the COP of using single and dual-series connected screw compressor, flooded heat exchanger, HFO heat pumps (Source: Carrier)

In the emerging smart cities, there are opportunities to pool the thermal resources of the disparate users so that the net heat producers reduce primary energy use in other parts of the city that require heat. As illustrated in Figure 3, buildings that have excess heat connect into the heat recovery (cooling) loop that broadly maintains the temperature (and so the exergy) of the 'waste' heat. This loop supplies the evaporator of the separately located heat pumps that can supply water (from the condenser) at, for example, 85°C to the district heating loop. The low temperature 'heat recovery' flow and return can extend to a number of nodes, where discrete, individual heat pump substations can supply heat at the required temperature to local groups of loads.

There are several well-established projects in Europe that take the heat from data centres in this way to meet residential and commercial heating loads, which have displaced the need for numerous individual fossil-fuelled boilers. The end users benefit from a more sustainable, metered, reliable supply of heat without the need to host and maintain heating plant – and, by spreading the loads across districts and cities, the variabilities of overall load demand are reduced and efficiencies maintained.

The same concept may be usefully applied where there is sufficient diversity of load in a single building (or development), to effectively maintain its own self-contained heat networks. As described by Nick Boid[13] in the June 2016 *CIBSE Journal*, an example of this is the Riverlight development, adjacent to the River Thames near Battersea, London, which includes 812 residential apartments, retail sites, restaurants, bars, leisure facilities and a child daycare centre. To balance the load requirements, this scheme employs an open loop ground source of eight deepwater wells to store and recover energy that is linked, through plate heat exchangers, to the heating and cooling systems. There are three 500kW R134a water-to-water heat machines that are controlled to provide optimum conditions to produce hot water or chilled water to meet the overall loads. A 60m^3 central thermal store integrates the heat generated from the ground source heat pump and the site's combined heat and power (CHP) plant to serve the distributed heating systems. In heating mode, the heat pump produces hot water up to 45°C, and can operate with a COP of more than 6.5 because of the availability of the warm water ground source. In cooling mode, the system produces chilled water for comfort cooling, using ground water as a condensing medium. When a chilled water supply temperature of around 10°C is required, direct cooling from the wells may be used and, alongside some heat pump power, deliver a combined energy efficiency ratio (EER) of 10. In mixed mode, the system provides cooling for the building, while also catering for the domestic hot water requirements.

The successful integration of heat pumps into city- or district-wide systems undoubtedly requires a holistic design approach, to ensure that the application is appropriate and that all affected parties are involved, so it meets their needs while delivering high levels of operational effectiveness, low environmental impact and good value. However, if planned and executed correctly, there are potentially many opportunities where the smart application of heat pumps can deliver high-performance district heating and cooling schemes, while reducing primary energy use.

Turn to page 86 for references.

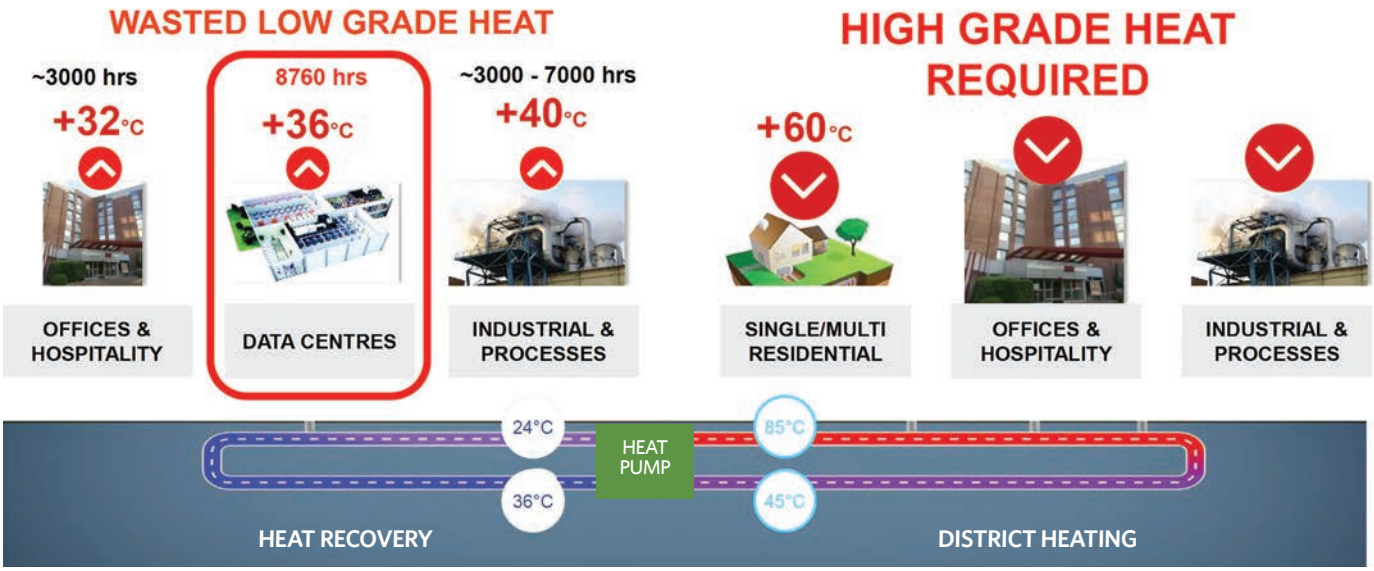

Figure 3: City or district heat recovery loop boosted with heat pump to provide district heating, showing typical annual hours of heat availability (Source: Carrier)

Module 151

September 2019

» **1. What is the predicted proportion of the European population expected to live in urban environments by 2050?**

- ☐ A 50%
- ☐ B 60%
- ☐ C 70%
- ☐ D 80%
- ☐ E 90%

2. What is quoted as the estimated overnight temperature increase in some cites because of air conditioning?

- ☐ A Less than 0.25K
- ☐ B 0.25K
- ☐ C 0.5K
- ☐ D 0.75K
- ☐ E More than 1K

3. Which metric is used to assess the useful energy recovery from a data centre?

- ☐ A COP
- ☐ B EER
- ☐ C ERE
- ☐ D PUE
- ☐ E SEER

4. In the illustrated example of the heat pump, what temperature was delivered with a source temperature of 20°C while operating at a COP of 2.26?

- ☐ A 45°C
- ☐ B 55°C
- ☐ C 65°C
- ☐ D 75°C
- ☐ E 85°C

5. In the Riverlight example, what is the quoted heat pump COP for producing water at 45°C when making use of warm water ground source?

- ☐ A At least 3.5
- ☐ B At least 4.5
- ☐ C At least 5.5
- ☐ D At least 6.5
- ☐ E At least 7.5

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ModuSat Fusion utility cupboards score big on efficiency and cost savings

Units feature 'plug and play' communication connection for diagnostics, commissioning and data metering

With demand for housing in the UK greater than ever, and an increase in the use of communal heating systems for flats, many developers are choosing to install prefabricated MEP utility cupboards. These require less time on site for installation, use less space in a flat, offer the opportunity to reduce cost and risk, and enable faster project delivery.

Responding to this demand, Evinox Energy has launched the ModuSat Fusion, the 'perfect fit' prefabricated utility cupboard for communal and district heat network developments.

Cupboards are supplied fully fitted, pre-tested and ready to install, and come complete with heat interface unit (HIU), optional cooling interface unit (CIU), a mechanical ventilation and heat recovery (MVHR) unit, and all associated piping and electrics.

The ultra-compact design allows for all utilities and services to be contained in one area away from the kitchen and living space, making it practical and visually pleasing in a modern setting.

"The ultra-compact design ensures all utilities and services are contained"

Engineered and manufactured off site to an approved design, Evinox uses 'lean' manufacturing principles with full assembly and end-of-line testing, and quality approvals – including ISO9001, IS14001, BSOHSAS 18001 – to ensure the highest possible product quality and consistency. Utility cupboards are available in a standard configuration or built bespoke to project design requirements. Evinox's in-house design and manufacturing capability enables high-volume supply, with the ability to meet the most demanding of timescales.

ModuSat Fusion offers the combination of ultra-compact design with 'smart' high-efficiency HIU performance, with features including: timed keep-warm functionality, which allows for minimal use of heat network energy; high performance at low temperatures to meet the GLA requirements and SAP; domestic hot-water return temperatures of less than 25°C, as recommended in the CIBSE Code of Practice; and the ability to deliver an excellent volume weighted return temperature (VWART) – all backed up by independent testing to the UK standard from BESA, with published results.

ModuSat Fusion cupboards also feature 'plug and play' communication connection for diagnostics, commissioning and metering data – and everything can be accessed across shared building infrastructure. Evinox also provides open protocol access to metering data through a customer configurable web access to the SmartTalk data logger.

Visit www.evinoxenergy.co.uk or contact info@evinox.co.uk

JS Air Curtains expands sales team

JS Air Curtains has expanded its team with the appointment of Loredana Groza as its new technical sales adviser.

Groza, who has three degrees in engineering, environmental science and geology, will be supporting and assisting consultants, contractors and specifiers in all aspects of air curtain design, specification and installation.

Kerry Jones, UK and Ireland sales manager, said: 'Loredana's appointment will help us maintain the responsive technical assistance our customers rely on.'

Visit www.jsaircurtains.com

Live web chat for Waterloo

Waterloo Air Products, UK manufacturer of ventilation grilles, diffusers, weather louvres and VAV systems, has added a live-chat function for website visitors. Mark Purnell, director of customer experience at Waterloo, has been the champion for live chat and is pleased with the enthusiasm of customers using the service, with numbers increasing every day. He said: 'Waterloo has always put customer service first, and this development is part of our commitment to continually improve what we do.'

Visit www.waterloo.co.uk

Pumping hot water from a sink with Zip Tap

Space under a sink is often limited, while dedicated hot-water pumps can be relatively large, creating an installation problem.

The well-proven, compact solution is a Pump Technology DrainMinor wastewater pumping system with a Jung Pumpen U3K Special (SL) pump. This features a mechanical seal rather than the lip seal normally found on small pumps.

Contact the Berkshire-based Pump Technology Jung Pumpen team for pump specifications.

Call 01189 821555 or visit www.pumptechnology.co.uk/drainminor

waterloo
AIR PRODUCTS PLC
Live Web Chat

Major extension at Novotel York Centre Hotel features award-winning Toshiba air con

Guests at Novotel's newly extended York Centre hotel will benefit from the installation of Toshiba Carrier UK's award-winning heat-recovery variable refrigerant flow (VRF) air conditioning.

The 2,500ft² extension includes 16 new deluxe rooms and six junior suites, air conditioned by four Toshiba Super Heat Recovery Multi (SHRM-e) VRF systems and additional Super Digital inverter systems. Ducted indoor units to rooms provide high-efficiency, low-noise cooling and heating for guests.

SHRM-e is Toshiba's latest and most advanced heat-recovery VRF system, winning four major industry awards as Air Conditioning Product of the Year.

Visit www.toshiba-aircon.co.uk/product/shrme-3-pipe-heat-recovery-outdoor

CIAT to cool lithium battery power storage stations in UK and Ireland

CIAT's high-efficiency packaged heat-pump systems have been chosen to cool a new generation of lithium battery power stations being built in the UK and Ireland. The facilities will each include 12 CIAT Vectios reversible heat-pump packaged air conditioning units – model IPJ-0090 – with a combined cooling capacity of 340kW. CIAT, a part of Carrier, will supply the units to the power-storage plants as part of strategic plans to improve the resilience and security of the electricity supply for the National Grid.

Visit www.ciat.uk.com/product/vectios-rpj-ipj

Carrier's new high-temperature heat pump harvests energy from rivers, lakes and industrial process water

Carrier has introduced a new high-efficiency, water-to-water heat pump for harnessing energy from rivers, lakes and industrial process applications that can deliver high-temperature water up to 65°C for sanitary use or radiator heating.

The Eurovent-approved Carrier AquaSnap 61WG monobloc water-to-water heat pump is available in six sizes, with heating capacities ranging from 29kW to 235kW at typical water conditions of 30/35°C, or 26kW to 200kW at higher-temperature water conditions of 55/65°C. It is designed for medium to large commercial applications requiring high-temperature, sanitary hot water, or traditional radiators.

Visit www.carrieraircon.co.uk or follow @Carrier on Twitter

Innovative module generates hot water from Toshiba VRF systems

Toshiba's Super Heat Recovery Multi (SHRM-e) variable refrigerant flow (VRF) air conditioning system can now be used to produce hot water up to 82°C by adding an innovative hot-water module.

The unit transforms Toshiba's award-winning three-pipe VRF air conditioning system into a highly efficient hot-water generator that is ideal for use in hotels, gyms, restaurants, shops and offices. With a wide operating range from -25°C to 40°C, it can produce hot water year-round without affecting normal cooling and heating operation.

Visit www.toshiba-aircon.co.uk

Carrier AquaSnap heat pump delivers reliable, clean comfort for Yew Tree Nursery

A Carrier air-to-water heat pump is delivering comfortable ambient conditions for children and staff at Yew Tree Nursery in Axbridge, Somerset.

Carrier's AquaSnap 61AF heat pump was selected to replace an oil-fired heating system that was proving unreliable and inefficient. The Carrier unit captures low-grade heat energy from the atmosphere and upgrades it to generate hot water for use in the nursery's underfloor heating, radiators and domestic hot-water supply.

The unit, which has an A+ energy rating, includes a soft-start system for low power draw, and freeze protection to maintain operation when outdoor temperatures dip.

Visit www.carrieraircon.co.uk or follow @Carrier on Twitter

Luxury hotel benefits from Elco boilers

As part of a major refurbishment, the 180-year-old Studley Castle Hotel, in Warwickshire, needed to refurbish its boiler plant to ensure guests enjoy highly efficient and reliable heating and hot-water generation.

To fulfil the property's complex requirements, three Elco TRIGON XL 570kW floor-standing boilers were specified and installed on the first floor of the main castle building, alongside eight bespoke INOX-MAXI cylinders.

These provide heating and hot water to the entire building, including 209 bedrooms, leisure facilities, swimming pool and treatment rooms, restaurants, bars, entertainment venues, and kitchen facilities.

Visit www.elco.co.uk

Reznor UDSA heating units

Reznor's UDSA heating units continue the firm's tradition of manufacturing high-efficiency heating equipment.

Reznor, part of Nortek Global HVAC (UK), describes the UDSA units as a technically advanced range of gas-fired unit heaters, designed to deliver outstanding energy, efficiency, performance and economy for reduced operating and life-cycle costs.

According to Reznor, the heat exchanger can achieve 92% (net calorific value) thermal efficiency, reducing energy and consumption and running costs. The UDSA units are also fitted with a high airflow axial fan for free-blowing applications with model heat outputs ranging from 11kW to 146kW.

All Reznor USDA units are available for natural gas (G20) as standard, but can be specified for use with propane (G31).

Visit www.reznor.eu

Swegon reports growing demand for 'one box' solutions

Global indoor climate company Swegon has experienced a rapid growth in demand for its flexible, innovative and energy-efficient 'one box' solution for water-based simultaneous heating and cooling.

The Omicron Rev S4 is a multi-function unit for four-pipe systems featuring chiller, heat recovery and heat pump combined that removes the need for boiler plant in a wide range of commercial buildings.

It is available in 16 models, offering cooling capacities from 100kW to 860kW and heating capacities from 100kW to 944kW.

The Omicron considerably reduces capital, maintenance and running costs for a wide range of commercial building applications. It also helps to satisfy growing demand for more flexible solutions that can help the building services sector meet the UK government's targets for reducing the country's carbon emissions.

There is no demand conflict between heating and cooling because the Omicron has in-built sequencing for load sharing. The chiller can switch instantly into reverse-cycle mode to operate as a heat pump, depending on demand.

Visit www.swegon.co.uk

MiniSteam E, the smart way to humidify small and medium-sized spaces

The new MiniSteam E from HygroMatik is the safe and smart solution for direct room humidification. An electrode humidifier, it operates with normal tap water to generate pure, mineral-free steam.

For rooms or houses in which there is no centrally controlled air-conditioning system, the MiniSteam E offers an excellent and efficient alternative for humidification. It is compact, therefore easy to install and mount on a wall.

According to HygroMatik, a maximum steam output of 5 or 10kg/h makes the MiniSteam E just right for the humidification of small and medium offices, and production and storage facilities.

Durable and efficient, its housing tray is made of corrosion-resistant stainless steel, as are its large-area electrodes. Both can be replaced without any tools. Maintenance is simple, too. The unit cover can be removed completely, and the reusable steam cylinder is easy to open and clean.

Call 02380 443127, email info@hygromatik.co.uk or visit www.hygromatik.com

Watts launches new training academy

Watts Industries UK has underlined its commitment to growing its UK business from St Neots by opening a new, bespoke training academy in its head office. Munish Nanda, president Americas and Europe, and managing director Nigel Woods led the opening ceremony for the new training facility, which will enable customers to connect with the company, learn and, in future, undertake CPD work.

Watts is a global leader in the commercial and residential water products space, and generated almost $1.5bn in worldwide sales in 2017. The head office in St Neots was established in 1900 and is supported by staff across the UK.

Kerry Harris, sales leader UK, said: 'Watts is proud to be based in St Neots and this new training facility provides modern accommodation to welcome and train our customers. We're excited to celebrate this new investment that signals our commitment to growing our business in the UK.'

Visit wattsindustries.co.uk

Rinnai – 'E' before 'I' or vice versa?

Rinnai has big-performance, heavy-duty, diminutive appliances that offer virtually limitless volumes of hot water at usable temperatures, with 'E' (external) and 'I' (internal) versions.

Gas-fired appliances – such as hot-water heating units, or domestic or light-commercial boilers – tend to be wall-hung on the interior of a site. However, external models have become increasingly popular for a number of practical reasons.

Rinnai offers units in both versions in the more heavy-duty part of the product range – including the 1600, 1500 and 55 – but also at the smaller end, the 17e.

Visit www.rinnaiuk.com

Grundfos feeds your webination

As more of us turn to the internet for a wide range of information to help us in all aspects of our lives, websites are continuing to develop solutions to answer these needs. Grundfos has invested heavily in this area, and recent analytics show growth in new visitor numbers to its site, as well as increasing returning visitor numbers.

There are a variety of reasons for this. Grundfos Product Centre, an online search and sizing tool, helps customers choose the right pump to meet their needs, whether for a new or replacement project.

The Grundfos for Engineers hub also offers topics that are as varied as the roles of the commercial building specialists it supports.

Overlaying this is the Grundfos Ecademy, a 24/7 online training platform that delivers a wide range of topics of interest to our customers.

By combining the web with a range of useful tools and information, Grundfos is ready and waiting to feed your webination

Visit www.grundfos.co.uk

Myson introduces the all-new Vertical panel radiator

After the introduction of a range of premium panel vertical radiators last year, Myson has extended its offering further with the introduction of its new Vertical panel radiator.

Myson claims the Vertical is the ultimate space-saving solution. It is suitable for narrow walls where space may be at a premium and can be used in both commercial and domestic applications. It uses central connection technology, offering design and installation freedom and allowing pipes to be installed before the radiator is sized or specified.

As with all Myson radiators, the Vertical is tested to EN 442 and is available in four types, two heights and four lengths. According to Myson, it is also the only vertical radiator on the market available in types 10 and 21 – as well as the more common types 11 and 22 – giving specifiers and installers even more choice when it comes to choosing the correct solution for their project.

Visit: www.myson.co.uk

Pump Technology spotlights Jung Pumpen Compli

The Jung Pumpen Compli is a floor-mounted lifting station that promises years of reliable operation. Features include: a robust fixed float arm; a bonded metal tank plate for easy pump removal and replacement; a large inspection hatch; and multiple inlet positions and heights. With more than seven Compli models, plus a variety of impeller options and numerous pumping curves for each, careful selection is required to ensure the best match for an application. Contact Pump Technology's authorised Jung Pumpen team for an accurate specification.

Call 01189 821555 or visit www.jung-pumps.co.uk

JS Air Curtains fit in at 1Rebel gym

JS Air Curtains has recently supplied two Rund air curtains to 1Rebel boutique gym in Victoria, London. With two entrances into its reception, the building was suffering from a wind-tunnel effect and wanted to eliminate the draught to maintain a comfortable internal temperature for staff and customers.

The company's Rund air curtain was chosen by architects, in part because its cylindrical design complements the gym's industrialised, futuristic interior. The units were installed by mechanical contractors TMI Mechanical.

Visit www.jsaircurtains.com

iGuzzini Easy offers compact effectiveness

The Easy is a simple, compact and highly efficient downlight, designed to upgrade existing systems. Available in ø96, ø153, ø212, with heights <10cm, the general lighting version emits diffused light – up to 125 lumens/W – while the UGR <19 version is suitable for work environments and the Wall Washer solution provides asymmetric distribution. They offer guaranteed high-colour rendering, with CRI values of >80 and >90. A screen protects the product to ensure IP54 safety rating. The reflector is available in two finishes – anti-scratch metal or white.

Call 01483 468000, email info.uk@iguzzini.com or visit www.iguzzini.com

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Air Handling

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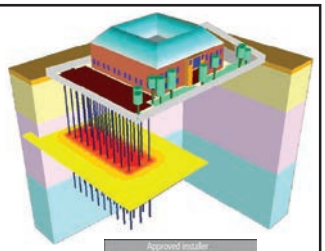

Air Conditioning

EVENTS

HIGHLIGHTS

Stefano Cammelli, technical director at WSP, will speak at a wind design event on 24 September

Dean Greer, ILEVE, at a Scotland and North regional event on 18 September

NATIONAL EVENTS AND CONFERENCES

Young Engineers Awards
10 October, London
Hear presentations from the Graduate of the Year finalists before the 2019 winner is crowned, and find out which firms have gone the extra mile in mentoring and supporting their staff in the Employer of the Year awards.
www.cibse.org/yea

Build2Perform Live
26-27 November, London
The free-to-attend event brings people together to learn about, discuss and collaborate on the current issues that are vital for delivering better building performance. With 60-plus sessions delivering content from more than 90 speakers, and around 70 exhibitors from major manufacturers and suppliers.
www.cibse.org/b2plive

CIBSE TRAINING

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

The importance of energy efficient buildings
4 September, London

Power system harmonics
6 September, London

Building services one-day overview
10 September, London

Low carbon consultant design training
10-11 September, Manchester

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

Low and zero carbon energy technologies
12 September, London

Energy monitoring and targeting
17 September, London

Building services explained
18-20 September, Birmingham

Mechanical services explained
18-20 September, London

Successful design management
18 September, London

Fire risk assessment to PAS 79
20 September, London

Low carbon consultant building operations
24-26 September, London

High voltage (11kV) distribution and protection
1 October, London

Low carbon consultant building operations
1-3 October, Birmingham

Mechanical services explained
2-4 October, Manchester

Emergency lighting to comply with fire safety requirements
4 October, London

Building services explained
7-9 October, London

Sanitary and rainwater design
7 October, London

Fire risk management system: PAS 7 2013
8 October, London

Below-ground building drainage
10 October, London

Fire detection and alarm systems for buildings – BS 5839 Part 1
10 October, London

Practical controls for HVAC systems
14 October, London

CIBSE GROUPS, SOCIETIES AND REGIONS

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

CIBSE ANZ seminar series: IoT – the neurology of building operation
3 September, Perth
10 September, Sydney
12 September, Melbourne
17 September, Auckland
19 September, Queensland
The ANZ seminar series returns with a look at the Internet of Things for better building operation.
www.cibse.org/cibse-anz-2019-seminar-series

Society of Digital Engineering: How digital tools are changing the way we work
3 September, Bristol
Speakers include Andrew Krebs, Ben Roberts and Joe Lally.

North East: Demand response and its comfort implications in a commercial building
3 September, Newcastle upon Tyne
With speakers Dr Sara Walker, director of expertise for infrastructure research at the School of Engineering, Newcastle University; and Dr Mohammad Royapoor, research associate at Newcastle University.

Northern Ireland: Golf social
5 September, Carryduff
Golf, followed by a meal at the clubhouse.

East Midlands: Cruising down the river
10 September, Nottingham
CPD presentation on heat pumps from Heatrae Sadia, followed by a River Trent cruise with buffet and drinks.

Scotland: Indoor air quality
11 September, Glasgow
An overview of key concepts and components of city pollution, its causes, effects, standards and solutions that reduce risk to the health and wellbeing of occupants.

Home Counties North East and South East: Membership briefing
11 September, London
Membership briefing focusing on routes to CIBSE Associate and Member grades, and registration with the Engineering Council at Incorporated and Chartered Engineer levels.

ANZ awards
12 September, Melbourne
ANZ annual cocktail function and Young Engineers Awards, at the Melbourne Gallery.

ILEVE Scotland and North regional event
18 September, Edinburgh
Join Dean Greer and Adrian Sims from ILEVE, discussing developing ILEVE and LEV Scotland and the north of England.

CIBSE and SoPHE South West: Blue roof design from an engineer's perspective
18 September, Bristol
Presented by Rod Green, of The Environmental Protection Group, covering different aspects of blue-roof design and how they tie into sustainable drainage systems.

HCNE: Wind design for building enclosures
24 September, London
With speaker Stefano Cammelli, technical director at WSP, who will discuss some wind engineering challenges associated with the design of building enclosures.

CIBSE application workshop
24 September, London
A workshop to help get your Engineering Practice Report started for Associate and Member applications.

South West: Building personal resilience in the construction world
26 September, Bristol
A panel discussion of industry experts sharing their career journeys, experiences and tips to develop soft skills.

South West: Networking boat trip
26 September, Plymouth
An interprofessional boat trip hosted by CIOB, CIBSE, RICS and RIBA.

The 2019 Passive House Canada Conference
17-18 October, Toronto
Two-day deep dive into the latest passive house projects and best practices from Canada's experts in high-performance building science.
phcc2019.com

SLL and CIBSE South West: Lighting and the Well Building Standard

2 October, Bristol, and 3 October, Exeter

Growing research and study into how we are affected psychologically and biologically by the non-visual effect of light has led designers to develop schemes aimed at improving wellbeing. This talk aims to identify the key lighting aspects within the Well Building Standard version 2, and the aspects to consider when trying to achieve Well accreditation. With speaker Pete Mardell, senior lighting designer at Arup.

CMR in complete control

CMR Controls manufactures low air pressure and air volume measurement sensors and control systems for standard air conditioning, clean rooms, sterile laboratories, containment facilities, and fume cupboard extract systems.

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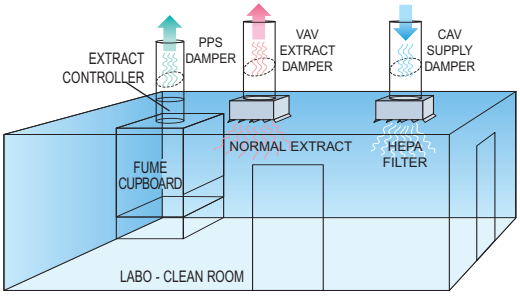
A complete turn-key system to control room pressure to +/-1Pa. Fume cupboard face velocity to 0.5m/s at high speed and provide constant air changes into the labo - clean room.



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Poly-propelene control and shut off valve incorporating the CMR Venturi Nozzle. This is essential when dealing with corrosive extract air especially from fume cupboard systems.

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