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

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

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

Advertisement sales
Display and sponsorship Jim Folley
jim.folley@redactive.co.uk
Tel: +44 (0) 20 7324 2786
Products & services Jonathan Adebayo
jonathan.adebayo@redactive.co.uk
Tel: +44 (0) 20 7880 6217
Recruitment advertising
cibsejournaljobs@redactive.co.uk
Tel: +44 (0) 20 7880 6215
Advertising production Jane Easterman
jane.easterman@redactive.co.uk
Tel: +44 (0) 20 7880 6248

Virtual reality

The annual CIBSE ASHRAE Technical Symposium is usually a great opportunity to meet people from across academia and industry, and to make serendipitous discoveries around the latest research and applications in building services engineering.

This year's online edition, on 14-15 September, will obviously be a very different experience, but there will still be the opportunity to watch presentations of around 60 academic papers and engage with the authors in live Q&As.

The on-demand presentations will all be available a week before the event, from 8 September, so there will be a chance to hone questions before the Q&As.

Many of the hallmarks of the Technical Symposium will still be present, including keynote addresses and the popular session of quick-fire poster presentations. Six poster authors will be putting themselves at the mercy of the online audience this year.

To give you a flavour of what to expect, we asked Joshua Martoo, senior mechanical engineer at Norman Disney & Young, to write up his presentation on thermal storage (page 48). The case study on Millennium Bridge House shows you what can be achieved with creative engineering. By using thermal storage, the proposed design stores and reuses heat and coolth that would otherwise be lost to the atmosphere. Using thermal storage also means HVAC plant can be removed from the roof, thereby freeing up space from which occupants can enjoy views across the Thames to St Paul's and Tate Modern.

One vital form of building services engineering that is hidden from view, as far as many are concerned, is local exhaust ventilation (LEV). This aims to safeguard the health of those who work with machines generating hazardous substances that can cause lung disease and cancer. Currently, 12,000 annual lung-disease deaths are thought to be attributed to past exposures at work, and there are 18,000 new cases of respiratory illness every year.

CIBSE's Institute of Local Exhaust Ventilation Engineers and BESA have produced a new document, *TR40 A guide to good practice for local exhaust ventilation*, that aims to ensure LEV systems are designed and installed correctly by the contract chain. There is a large section in the guide dedicated to making sure each part of the supply chain has the competencies necessary to design and install LEV. There are many points where the delivery of systems can fail, and while the consequences for the welder or spray painter may not be immediate, they may, ultimately, be deadly (page 29).

ALEX SMITH, EDITOR asmith@cibsejournal.com

CONTRIBUTORS

Hywel Davies
Looser planning requirements must not allow substandard housing to proliferate

Dave Cheshire
Co-author of CIBSE's guide to sustainability looks forward to more holistic methods of construction

Andy Pearson
CIBSE ASHRAE Technical Symposium keynote speaker on how we must tame the energy tiger

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The official magazine of the Chartered Institution of Building Services Engineers

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

CIBSE, 222 Balham High Road,
London SW12 9BS
Tel: +44(0)20 8675 5211

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

CIBSE Journal, ISSN 1759-846X (USPS 4070) is published monthly by CPL, 1 Cambridge Technopark, Newmarket Road, Cambridge CB5 8PB, UK.

The US annual subscription price is £100. Airfreight and mailing in the USA by agent named WN Shipping USA, 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA. Periodicals postage paid at Jamaica NY 11431.

US Postmaster: Send address changes to *CIBSE Journal*, WN Shipping USA, 156-15, 146th Avenue, 2nd Floor, Jamaica, NY 11434, USA. Subscription records are maintained at CIBSE, 222 Balham High Road, London, SW12 9BS, UK.

CREDITS
Cover image CGI by The Boundary P07 iStock.com / Shank_ali / Drazen_ P09 iStock.com / NORRIE3699 P12 iStock.com / Vladimirovic P33 iStock.com / Valentinrussanov P34 iStock.com / Satoshi-K P41 iStock.com / Jaminwell P44 iStock.com / Ugurhan P48-49 Credit / CGI by INK P52 iStock.com / FlairImages P63 Credit / Javarman, Dreamstime.com P70 iStock.com / Intpro

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abc
ABC audited circulation: 18,144 January to December 2019
Printed by: Warners Midlands PLC

Proposed planning rules could 'lead to slum housing'

Designers voice fears over extension of permitted development rights

The government's proposed radical reform of the planning system in England has faced a barrage of criticism from designers, housing groups and environmental activists.

Under the Planning for the Future strategy, local authorities will have to allocate land for developments that can be built without having to navigate the full planning process. Land will be designated for 'growth, renewal or protection'. New homes, hospitals, schools, shops, and offices would be approved automatically in 'growth' zones, while projects in 'renewal' zones would be given 'permission in principle'. In theory, no building would be allowed in 'protected' zones. The white paper also outlines plans for a new Infrastructure Levy.

Housing Secretary Robert Jenrick said the reforms would not undermine quality: 'Planning decisions will be simple and transparent, with local democracy at the heart of the process.'

The government expects new homes to produce up to 80% fewer CO_2 emissions compared with current levels.

However, RIBA condemned the proposals as 'shameful' as they would do 'almost nothing to guarantee the delivery of affordable, well-designed and sustainable homes'. 'There's every chance they could lead to the development of the next generation of slum housing,' said president Alan Jones.

Research from UCL and Liverpool University found that 72% of dwellings created through PDRs have single aspect windows compared to 30% for those granted planning permission.

CIBSE technical director Hywel Davies said: 'PDR units appear to have worse access to natural daylight and sunlight, and may be more difficult to ventilate, so are at greater risk of overheating. It is a huge concern that ensuring access to daylight and good ventilation is seen as "red tape".'

CIBSE technical manager Julie Godefroy, said: 'Incentives and fast-tracked processes for construction and the wider economy should favour those that demonstrate they contribute to carbon, environmental and health objectives, not the opposite.'

Tradespeople urged to get accredited to benefit from green grant scheme

Business Secretary Alok Sharma has called on tradespeople across England to make sure they are eligible to benefit from the Green Home Grants scheme, which is launching this month.

He said the scheme would 'create new work for many thousands of talented builders, plumbers and other tradespeople', but warned that some could miss out unless they signed up for the government's Trustmark accreditation scheme, or were certified by the Microgeneration Certification Scheme.

Many are already eligible for Trustmark status because of their membership of other industry bodies, but they still need to register, the Minister said. The government will fund up to two-thirds of the cost of approved green home improvements – capped at £5,000 (or £10,000 for low-income households) – including the installation of heat pumps, solar thermal systems and insulation.

Trustmark chief executive Simon Ayers said the scheme, plus £1bn to improve public buildings, was 'the best kick-start we could have hoped for'. He told a webinar hosted by the Building Engineering Services Association that the opportunity for building services contractors was 'colossal', with 24 million homes requiring upgrades to meet the government's 2050 net-zero carbon target. Thousands of small commercial properties are also likely to be converted into residential buildings.

IN BRIEF

Build, build, build plan on track

The government's 'build, build, build' promise is already showing signs of progress and starting to 'push projects through the pipeline and drive activity', according to market analyst Glenigan.

The total value of civil engineering approvals during the three months to July was three times higher than the previous year, at £4.43bn, the firm said, adding that major projects were up by 343% compared with last year, at £3.6bn.

'The planning changes may take some time to make a real difference, but with a solid pipeline of infrastructure projects, the government is clearly boosting confidence for the sector, with many high-value projects finally getting over the line thanks to government backing,' a Glenigan statement said.

Construction looking at V-shaped recovery

A surge in activity during June means the construction sector is heading for a 'V-shaped recovery', according to government figures.

It classified construction as the fastest-recovering industry, as output rocketed by 23.5% during the month, after a modest 7.6% rise in May. However, output was still more than 24% below February's level.

There was a 22% increase in new work, valued at £1.22bn, with private new housing accounting for 42% of the total, at £545m.

The infrastructure sector has almost got back to its pre-Covid level, at just 3.7% below the figure for February.

In addition, the government said construction had the largest proportion of workforce returning from furlough. More than 20% went back to work in June, compared with an average of 8.1% for the whole economy.

IN BRIEF

Allford triumphs after controversial RIBA election

Simon Allford has been chosen as the 78th president of RIBA after another headline-grabbing election.

Formerly fiercely critical of the body, he secured 58% of members' ballots in the fourth stage of the voting process, although the turnout was just 13.2%. He becomes president-elect and will step up to president in September 2021.

Allford is a visiting professor at Harvard and a trustee of the London School of Architecture. He is co-founder of the practice AHMM, the fifth largest in the UK.

Earlier this year, he launched a full-blooded attack on the institution, calling for architects to 'storm the asylum'. After his election, he said it was 'a privilege to have been elected and I look forward to working with members, council, board and staff to create a leaner, more open, productive, engaged and reinvigorated RIBA'.

Positivity on the up among architects

Architects are feeling more positive about the future, according to the RIBA Future Trends Workload Index, which rose to +3 in July, up from a rock bottom -17 in June.

The index revealed that 31% of practices expect their workloads to increase, 42% said they would stay the same, and just 28% anticipate another fall.

The private housing sector's score rose to +17, from -3 in June, while the commercial sector was also up, but remained negative, at -15 from -32, and the public sector reached -4 from -12.

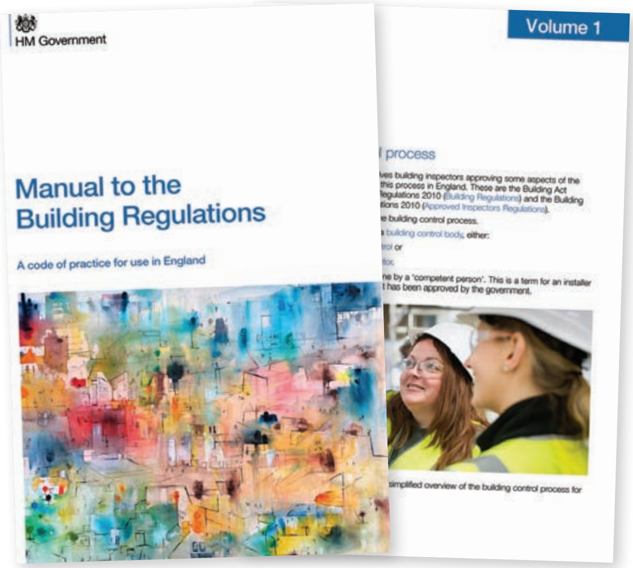
Fox takes over as BESA head of technical

The Building Engineering Services Association (BESA) has appointed Graeme Fox as its new head of technical. He will also continue in his current role as head of the F-Gas register Refcom.

'The building services sector is facing multiple challenges on several fronts, including achieving our low carbon commitments against a background of increased demands for proof of competency and compliance,' Fox said.

'I look forward to driving the technical agenda for our members, ensuring their expertise is sought and their voices heard.'

MANUAL AIMS TO DEMYSTIFY BUILDING REGULATIONS



The government has published a *Manual to the Building Regulations* in a bid to make the rules governing construction clearer to clients and the supply chain.

It includes an overview of the current Building Regulations and Approved Documents, and an explanation of the current system of building control. CIBSE's technical director Hywel Davies said: 'It is a PDF that every engineer should have easy access to.'

The government has also merged all the Building Regulations Approved Documents into one PDF. Both documents are available at **bit.ly/3iXuIql**

Airflow key to cutting risk

Research published by the Institution of Occupational Safety and Health (IOSH) has highlighted the importance of ventilation systems in reducing the risk faced by healthcare workers of infection from airborne viruses, such as Covid-19.

Reducing aerosol infection risk in hospital patient care was produced by researchers from Leicester NHS Trust and Turku University of Applied Sciences in Finland. It found that ventilation that mixes air increases exposure levels from air breathed out by a patient by up to six times when a healthcare worker is bending over a bed to carry out treatment. Systems designed to force air downwards reduce exposure by a third.

However, the study said careful consideration of how to design and position this type of system was needed to minimise the possibility of draughts and discomfort for patients.

The position of the exhaust was also found to be important, as most can only capture air from a short distance and cannot control room airflows. In the study, the most effective exhaust positions were found to be in the wall behind the patient's bed, or in the lighting panel above and behind the patient.

Dr Julian Tang, consultant virologist at Leicester NHS Trust, said ventilation engineering was the most effective level of control. 'The research has shown that there are certain types of ventilation – beyond just different speed and volume – that can benefit healthcare workers better without being detrimental to the patient.'

■ A group of UK-based researchers has tried to quantify the transmission risk of airborne Covid-19 according to activity and type of indoor space. They show how the risk of infection falls as ventilation rates are increased (see page 32).

Coronavirus HVAC guidance updated

ASHRAE's Epidemic Task Force has updated its guidance for operating HVAC systems to help reduce the risk of transmission of the Covid-19 virus in reopening buildings. The publication covers commissioning and systems analysis issues, including increased filtration, air-cleaning strategies, domestic and plumbing water systems, and overall improvements needed to reduce transmission risk.

It advises on pre- and post-occupancy flushing of rooms with outdoor air to ensure that infectious aerosol in the building is removed before the next occupied period. The building should be flushed for long enough to reduce concentration of airborne infectious particles by 95%, the guidance says.

The document also considers energy recovery ventilation (ERV) and whether a system using an energy wheel is well designed and maintained and, therefore, able to remain in operation. It may be possible to fix ERV problems and return the system to service, says ASHRAE.

To view the guidance, visit **ashrae.org/COVID-19** The latest CIBSE Guidance on Covid-19 includes version 3 of *Covid-19 ventilation guidance*, published in July, and *Lift use and occupancy guidance*, published in June. All guides are available at **www.cibse.org/Coronavirus**


Dame Judith Hackitt is not impressed by the attitude in some parts of the sector

Hackitt condemns return to corner cutting

Companies told to improve safety ahead of new regulatory regime

Professional bodies need to embrace their 'moral obligation' to improve standards and safety in buildings before a new, tougher regulatory regime is enforced later this year, says reformer Dame Judith Hackitt.

She said the Covid-19 crisis was being used as an excuse to return to a culture of 'corner cutting' and for further delay in adopting new working practices, adding that 'our urgent calls for proactive, collaborative leadership do not yet appear to have been heeded'.

Speaking at the launch of her Industry Safety Steering Group's (ISSG's) second report, she expressed frustration at the slow pace of change.

'In the past year, it has become clear that some parts of the industry are making real progress, but it has been equally frustrating for me and my colleagues on ISSG to keep hearing that others are waiting to see what the new regulatory regime looks like before they take action.

'Given the clear evidence that continues to emerge of concerns about high-rise building safety –which go beyond ACM cladding – we believe that there is a moral obligation on the industry to step up to a different approach.'

Dame Judith said the steering group, which was only intended to operate for two years, would remain in place until the proposed Building Safety Bill was passed into law and the new industry regulator was in post.

According to the ISSG report, some parts of the industry are rising to the challenge, including the Construction Leadership Council, which has set out goals to improve building safety in its Roadmap for Recovery.

CLC sets up Brexit guidance group

The Construction Leadership Council (CIC) has set up a group of industry leaders to prepare the sector for Brexit. It will publish an impact report later this month.

The council intends to highlight 'business critical' issues facing the sector in the event of a 'no deal' departure from the EU, and will promote opportunities for the industry linked to the ongoing trade-deal negotiations.

'Whether we reach an agreement or not, our relationship with our European neighbours and the rest of the world will change, and we'll be doing all we can to help the industry adapt, adjust and rise to meet the Prime Minister's "build, build, build" ambition,' said CLC co-chair Andy Mitchell.

The group has identified four key tasks in the areas of movement of people; movement of goods and materials; standards and alignment; and 'data adequacy'.

The CLC group will publish short guidance notes on each this month and deliver online seminars later in the autumn, aimed at helping businesses prepare for the changes.

UK can move faster towards renewable energy, says report

As much as 65% of the UK's energy demand could be met by renewable generation within a decade, according to the National Infrastructure Commission. It previously forecast the proportion would be 50% by 2050, but now believes the falling cost of deploying renewable technologies will allow the country to move faster and further.

In its latest report, *Renewables, recovery and reaching net zero*, the commission states that electricity generation will need to reach 465TWh by 2050, compared to 345TWh in 2019, accounting for population growth and electrification of more sectors, including heat. It says offshore wind should be complemented by large-scale solar and energy storage, adding that 'historical peak rates of deployment for each technology are near or above what is now needed in each year to 2030'.

Oxford firm claims PV performance breakthrough

A crystal discovered almost 200 years ago could boost the performance of photovoltaic (PV) panels by up to a third, according an Oxford-based solar technology firm.

By coating the PV panels with a thin layer of perovskite – discovered in Russia's Ural mountains in 1839 – Oxford PV says its next-generation solar panels are capable of converting more than 27% of available solar energy into electricity. The industry norm from traditional silicon cell systems is 22%.

According to the company, the crystal-coated panels absorb energy from different parts of the solar spectrum. They will also blend in better with roof slates because they are blacker than the blue-tinted silicon panels. The company hopes to make them available to the UK market within 12 months.

Cardiff heat network gets green light

A £26.5m district heating network connected to an energy recovery facility (ERF) in Cardiff has secured £15m in government funding. It is expected to start serving local homes and businesses within two years, saving more than 5,000 tonnes of carbon annually.

The Cardiff City Heating Network will use heat generated at Viridor's ERF, which already produces electricity for 70,000 households. The Welsh government has given a loan of £8.6m and the UK government a £6m grant.

The ERF uses about 350,000 tonnes of non-recyclable waste and heating will be provided to several large buildings, including County Hall and the Millennium Centre.

Household energy bills could be reduced by an average of 5%, project analysts claim.

CBI backs hybrid and hydrogen heating

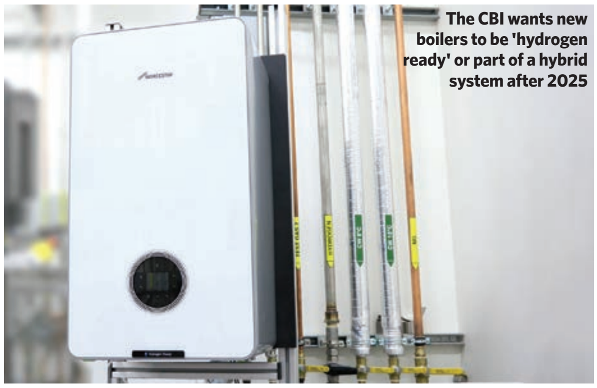
National industry group supports heat pumps and district heating to protect the planet and boost economy

All new domestic boiler installations should be part of a hybrid system or 'hydrogen ready' after 2025, according to a new report from the CBI.

Net zero: the road to low carbon heat was jointly produced with the University of Birmingham. It says the government should mandate a phased switch from natural gas boilers to other solutions, such as heat pumps and hydrogen technologies, including heat networks. By 2035, all new heating installations should be low-carbon, in line with the government's net-zero carbon policy, says the CBI.

The report wants new oil-fired boilers to be abolished by 2023 and increased funding for heat networks. All new energy-from-waste plants and waste heat-producing industries should also have to feed their waste heat into heat networks, where location permits.

CBI President Lord Bilimoria said: 'Aside from the moral imperative, there's a strong economic case for protecting our planet. Large-scale heat decarbonisation and energy efficiency would provide a huge jobs boost for the economy, at a time when new career opportunities are needed more than ever.'



The CBI wants new boilers to be 'hydrogen ready' or part of a hybrid system after 2025

Walking down 'heat street'

Energy distribution firm UK Power Networks (UKPN) has launched a study to find the most suitable low carbon heating solution for individual communities.

'Heat Street' is a joint venture with developers, property owners, local authorities, businesses, academics and consumer groups across London, and South and South East England. It will consider a range of low-carbon heating alternatives, including switching from gas boilers to heat pumps. The company will analyse energy efficiency trends and combine information about the types of buildings and socio-economics of each area to assess the best approach for achieving net-zero carbon emissions.

It will consider whether an area might be better suited to a heat network because it has higher-density housing or – in the case of a rural village off the gas grid – whether heat pumps should be used.

'We all know why we need to rapidly decarbonise heating – this project is about working out how,' said Ian Cameron, UKPN's head of customer services and innovation. 'We are excited to be getting out there, bringing together people from all backgrounds to create a local street-level map of net-zero heating pathways by 2050.'

IN BRIEF

Lighting Professional card introduced

The Society of Light and Lighting (SLL) has partnered with the Electrotechnical Certification Scheme (ECS) to introduce the Lighting Professional Related Discipline ECS card.

The card allows those who work in support of the electrical industry in specialised electrotechnical disciplines, but who do not carry out electrical installation, to attend and work on construction sites.

The Lighting Professional Related Discipline card is open to Associate Members (AMSLL), Members (MSLL) and Fellows (FSLL) of the Society of Light and Lighting. Applicants must successfully complete an ECS Health, Safety and Environmental Assessment, and attend an Electrical Safety Awareness training day and assessment.

Bob Bohannon, SLL president, said: 'The card provides our members with the very practical benefit of being able to access and work on construction sites as a recognised professional. Many of us need to work on site, for everything from site surveys, mock-ups and aiming, to construction monitoring and commissioning. We can now use our skills, as well as a sound knowledge and awareness of health and safety and electrical safety. This very useful new benefit for SLL members will create safer workplaces for all.'

For further details, and to apply, visit **www.cibse.org/sll**

2020 lift symposium

The 2020 Symposium on Lift and Escalator Technologies will take place online on 23-25 September.

The free-to-attend event will bring together experts from the field of vertical transportation, offering opportunities for speakers to present peer-reviewed papers on the subject of their research.

The programme includes sessions on: the future for standards in the lift industry; the computational environment for simulating the impact of building sway on high-rise lifts; computer-aided structural analysis of the lift car; and a study of evacuation routes in case of disaster.

For the full programme, and to register, visit **liftsymposium.org**

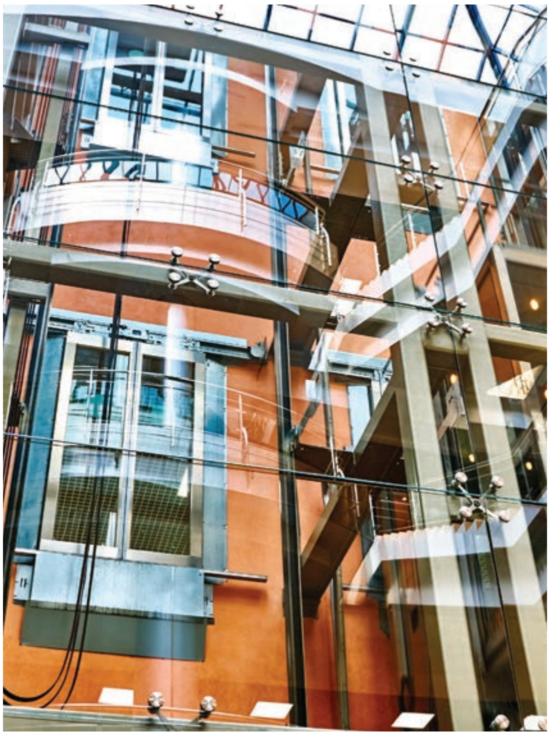
New transportation in buildings guide out

Firefighters and evacuation lifts sections rewritten to cover code changes

An updated edition of CIBSE *Guide D: Transportation systems in buildings* has been published.

First published in 1993, the guide has been updated on a regular five-year cycle, and offers a one-stop shop for practitioners involved in building transportation.

It will be of interest to architects and developers, as well as facilities and building managers who may not be directly concerned with lift and escalator design and installation but need to understand specialist advice. It should also be of value to students embarking on a career in mechanical, electrical or building services engineering, and those wishing to enhance their knowledge.



The guide notes how some things, such as components, change slowly, while others – such as drive systems – continue to evolve. These developments, together with the increased knowledge of this area, are presented in the new guide.

The design of any lift or escalator system must commence with a consideration of the traffic flow through the building. The guide covers the relevant factors for consideration, along with guidance on the location and arrangement of lifts, escalators and moving walks. It also covers lift design simulation and lift traffic design calculation, considering them together. The recommended design parameters have been updated to align more closely with those proposed by the British Council for Offices.

The guide reviews vertical transportation systems and has been updated with new products and applications, including bike lifts and rigid chain technology. The section on firefighters' lifts and evacuation lifts has been completely rewritten to cover extensive changes in codes and standards.

The publication provides guidance and recommendations and makes extensive reference to British and international standards throughout.

- Guide D is available from the Knowledge Portal at **cibse.org/knowledge**
- See CIBSE guidance on managing lifts during Covid-19 at **bit.ly/CJSept20lifts**

BPA entries deadline looming

With the entry deadline for the CIBSE Building Performance Awards 2021 fast approaching, make sure you enter to give your project, product or innovation the recognition it deserves.

The 14 award categories are free to enter, and the deadline is 3 September.

Categories include: Product or Innovation – Thermal Comfort and Wellbeing, an award launched in 2020; Consultancy of the Year; Collaboration; Building Performance Engineer of the Year; and the Project of the Year categories for Commercial/Industrial, Public, Residential and International.

The awards showcase the highest achievements in building performance across the construction and property industry. These are the only awards in the built environment sector that are judged on actual, in-use performance rather than projections or designed performance.

The 2021 awards 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 **cibse.org/bpa**

CIBSE Journal is 'top benefit' says membership survey

Covid-19 guidance, climate change and air quality identified as priority areas

CIBSE Journal has once again topped the poll of CIBSE member benefits, as voted in the CIBSE membership survey.

The biannual membership survey, which ran in June, received more than 1,500 responses – a 42% increase from the 2018 survey. *CIBSE Journal* came out the top-rated member benefit and was closely followed by the Knowledge Portal. Some 79% of respondents felt that being a CIBSE member had benefited their career, and 80% felt membership was considered important.

CIBSE received four out of five stars for overall value and customer service. When asked how we could improve in these areas, many members suggested improvements to the website and to speed up the membership application process. As a result, an upgrade to the website is planned for 2021 and an online application portal has been launched to make it easier to join or upgrade membership.

Unsurprisingly, there was a large shift towards a preference for digital services, with 64% of respondents preferring events to be delivered virtually, 57% preferring virtual training and more than 77% preferring digital knowledge items.

When asked how CIBSE could provide better value, many called for more online CPD, training and meetings. To provide value to members, regular free webinars will continue to be run and many CIBSE training courses are now available virtually.

Technical guidance and support around Covid-19, climate change and air quality were identified as priority areas for CIBSE over the next 12 months. CIBSE will continue to support members in these areas.

CIBSE would like to thank all those who participated in the survey.

Digital Engineering Awards open for entries

The digital engineering community is being invited to showcase its talent and achievements, by entering the Digital Engineering Awards.

Organised by the Society of Digital Engineering (SDE) and now in its third year, the annual awards are open to entries from across the full spectrum of the building services engineering industry. This includes engineers, technicians, designers, contractors and manufacturers or any teams or individuals who are making a difference in their respective companies.

Eight categories – including best innovation; best project and collaboration; best contractor; and best digital engineer – provide the opportunity to show off your digital skills and know-how. The awards were set up to raise the profile and reputation of digital engineering and engineers across the industry.

Entries need to be received by 23 October, with the winners announced on 24 November. An overall winner will be chosen from the winning entries in each category. The judges will be looking for ways in which the entrant has taken a manual process and applied a digital spin.

- For full details and to enter, visit **bit.ly/CJSept20SDE**

Last year's winner, Jagannatha Reddy

IN BRIEF

Alfred Leung Award

CIBSE Merseyside and North West region has announced a new annual prize, in honour of former regional chair Dr Alfred Leung, who died recently.

The Alfred Leung Award will be presented to the best building services student at The City of Liverpool College, where Dr Leung worked for many years.

Paul Guyers, CIBSE Merseyside and North Wales regional committee chair, said: 'Alf's friends and colleagues are still devastated by his untimely passing, but it is hoped that this award goes some way to keeping his memory alive.

'Alf was dedicated to facilitating high achievement of students past and present. We hope this award will ensure that his name will forever be synonymous with the high achievement of the students of the future.'

Dr Lynn Borthwick, deputy head of the School of Engineering and Logistics at The City of Liverpool College, added: 'It's a great honour to have the award gifted to the college for one of our students to be recognised.'

The winner of the first Alfred Leung Award will be announced in due course.

2020 vision for a 2030 reality

The CIBSE Australia and New Zealand (ANZ) region is hosting an online seminar series on 9 September, exploring what property owners, operators and building services consultants need to know to navigate towards net-zero and regenerative building practices.

The programme will bring together experts to share case studies of regenerative and net-zero buildings and practices. It will tackle policy changes in Australia and New Zealand that building owners, managers and services engineers need to understand to minimise risks to assets. To register, visit **bit.ly/CJSept20ANZ**

CIBSE ANZ podcast

CIBSE Australia and New Zealand region has produced a series of Talking Buildings podcasts. In the most recent episode, Davina Rooney, Green Building Council of Australia CEO, discusses how Covid-19 changes sustainability. Listen at **bit.ly/CJSept20ANZ2**

FEEDBACK

Using ultraviolet light to tackle Covid-19 in buildings should be done with care

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The risk of high frequency UV light

We read with interest your July 2020 article, *Light relief*,[1] on using ultraviolet (UV) light to limit the transmission on Covid-19. We agree that ultraviolet germicidal radiation is a technology with considerable potential for limiting exposure to Covid-19 and have received Innovate UK funding to develop it. As UV light is harmful in a number of ways, our approach is to use occupancy control to ensure no-one is ever directly exposed.

Our research in the area leads us to some concerns about the 'far' UV light at the high-frequency end of the ultraviolet spectrum, described in the article as an application that is safe to use in occupied spaces.

The view that far UV exposure is safe is based on the assertion that it cannot penetrate human cells – which is not based on experiments with human cells, but with hairless mice.[2] However, experiments on human volunteers have shown that radiation at 222nm, the wavelength discussed in the article, can cause the skin inflammation called erythema.[3] The human experiments used a higher UV dose than would be encountered in the workplace installations proposed, but the fact remains that, by clearly demonstrating far UV light penetrating human skin, they undermine the basis for stating that far UV exposure is safe. While it is stated that far UV technology needs to pass safety tests, our view is that the safety concerns are significant and it may not be possible to address them all experimentally.

Our concerns are:

1. The entire ultraviolet spectrum, including far UV, is classed as carcinogenic by the International Agency for Research on Cancer (IARC).[4] The carcinogenic activity is based on lifetime exposure, so the only protection against it is to minimise exposure, which is not compatible with continuous exposure in the workplace. IARC's position is that there is no identifiable safe threshold,[5] which makes it impossible to prove the safety of any level of intentional exposure. Any employer who installed it would be placing their employees' health at risk and would invite a lawsuit from any employee who develops a skin cancer.

2. The greatest acute danger of UV light is keratitis: damage to the cornea, which overlays the exterior of the eye. While the skin cells are protected by a layer of lipids and dead cells, the live cells of the cornea are more exposed, hence more vulnerable. The paper[6] referenced in *Light relief* contains the assertion that far UV light does not penetrate the cells of the cornea –but it does not back up the assertion with any evidence or relevant references. It is stated that the exposure to a far UV installation would not exceed the statutory daily limit, which is calculated to prevent keratitis, but the daily exposure is calculated based on an eight-hour working day[7] which, in practice, is often exceeded.

3. High-frequency UV light produces ozone, which is harmful. While peak ozone production is at 185nm, the European Commission's Scientific Committee on Health, Environmental and Emerging Risks states that ozone may be produced at any wavelength below 240nm,[8] so continuous use of far UV would cause continuous ozone production.

Germicidal UV light is routinely used to control infection and contamination in laboratories, healthcare facilities and food production – but, in all those cases, it is installed in such a way that no-one is directly exposed to it. Our view is that UV has a much broader role to play in the built environment, in limiting transmission not only of Covid-19, but also of other airborne viruses, such as influenza and norovirus, but any installation must be designed to prevent direct exposure.

We can expect to see an expansion of the use of UV light in workplaces and public places, and we hope CIBSE will take a lead in ensuring safety is not compromised.

● References can be viewed at **cibsejournal.com**

David Miles, of Atamate Building Intelligence and the London School of Hygiene & Tropical Medicine, and Dan Cash, of Atamate Building Intelligence

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It's good to talk

As the CIBSE ASHRAE Graduate of the Year Award celebrates its 25th anniversary, CIBSE Patrons chair **Nick Mead** explains why the presentation skills it showcases are a crucial part of a young engineer's development

It is sad, but rather appropriate, that the 25th Graduate of the Year award will be held 'virtually' for the first time on 8 October.

The award has always been a pioneering platform for communication skills, and engineers – like everyone else – are having to learn new ways of getting their points across to clients and colleagues in this Covid-19 era.

This year's finalists are being challenged to demonstrate their passion and commitment to their craft online. Just like the very first finalists, in Harrogate all those years ago, they are being taken out of their comfort zone in a bid to win. Inaugural award recipient Kevin Mitchell, now a CIBSE vice-president, made his points to the judges using overhead 'acetate' slides. PowerPoint has dominated since, but, now, finalists are being asked to rethink the tools they use.

Having good ideas and a strong conviction that your solution is the right one is no guarantee that you will win an argument in a project discussion. The founders of the award had this in the forefront of their minds. They felt there were plenty of awards for technical excellence and academic rigour, but none that challenged young engineers to take their good ideas and convince an audience of their merit.

Similarly, it was felt that there was a lack of collaboration between engineers and different parts of the building services supply chain. The graduate award was set up as a joint venture with the publisher of *HAC* magazine. While this ceased publishing in 2006, its award has continued, and the collaborative effort has been enhanced by the IMechE, which has hosted the awards event for more than a decade.

The finalists are now drawn from across the professions, showing progress from the first few years, when they were mainly chosen from the major engineering consultancies. Three winners have worked for contractors and a runner-up for a manufacturer, while increasing numbers of finalists come through the apprenticeship route. They also come from all over the world and there are 10 women among the previous winners. It can claim to have done its bit for redressing the gender balance.

It remains an award about presentation and in these days – when people are being forced apart and many feel isolated – communication has never been more crucial.

- For details of this year's online Young Engineers Awards, visit **www.cibse.org/yea**

Homes for the future?

The UK has had a housing shortage for some time. Hywel Davies looks at proposals to increase provision and possible unintended consequences

The UK has a shortage of housing and significant numbers sleeping rough, especially in London. The current pandemic has prompted exceptional efforts by local government and the charitable sector, but sustained effort is needed to maintain that momentum. Part of that must be the provision of new homes, whether social or private tenure.

In July, the government announced significant changes to permitted development rights (PDRs) and a major consultation on planning law. The Affordable Housing Commission has also called for significant, post-pandemic investment in new social housing.

Measures introduced in July, and due to come into force by September, remove the requirement for full planning applications for demolition and rebuilding of 'unused' buildings as homes. They allow commercial and retail properties to 'be quickly repurposed' to 'revive high streets and town centres'.

Homeowners will be allowed to add up to two storeys to a property through a fast-track approval process, which will 'carefully consider' the impact on neighbours and appearance of the proposed extension. This aims to reduce pressure to build on greenfield sites and provide more homes in keeping with the local area, 'without the red tape'.

The government also set out plans to reform planning rules in England, 'to deliver more high-quality, well-designed homes, and beautiful and greener communities for people to live in'. It said that the proposals would 'cut out bureaucracy to get Britain building, while protecting high standards. Developers will still need to adhere to Building Regulations'.

Housing Secretary Robert Jenrick said: 'We are reforming the planning system and cutting out unnecessary bureaucracy to give small business owners the freedom they need to adapt and evolve, and to renew our town centres with new enterprises and more housing.

'[The changes] mean families can add up to two storeys to their home, providing much needed additional space for children or elderly relatives.' However, pubs, takeaways, libraries, village shops and other buildings 'essential to communities' will not be covered because of the role these buildings and businesses play in local areas.

There is much criticism of the proposals, with RIBA claiming 'a fundamental contradiction' between the government's professed commitment to quality and its plans to further expand permitted development'. RICS has noted the contradiction between the proposals and the net-zero carbon legal target, saying it is 'bizarre' that the government is proposing to make it easier to demolish existing buildings instead of retrofitting'.

"Only 22% of PDR dwellings meet nationally described space standards, compared with 73% of those granted planning permission"

Detailed research for the communities department by researchers from UCL and Liverpool University, published in July without announcement, notes little difference in energy performance or council tax banding of PDR-consented schemes and those granted planning permission (PP), and little difference in access to local services. Much more significant differences are evident internally, however.

Only 22% of PDR dwellings meet nationally described space standards, compared with 73% of PP units. Most PP units that fall short are only 'slightly below the suggested standard', whereas many PDR units fall significantly below. In addition, 72% of dwellings created through PDRs have single-aspect windows, as against 30% for PP, with only 27% having dual or triple-aspect windows, compared with 67% for PP. Ten PDR units (in 138 schemes studied) have no windows, while no PP unit was without access to external light. PDR units appear to have worse access to natural daylight and sunlight, and may be more difficult to ventilate, so are at greater risk of overheating.

It is a huge concern that ensuring access to daylight and good ventilation are seen as 'red tape'. It is very likely that such units will need adaptation in future to remedy these failings – costing money and consuming resources and carbon – creating a further building-quality problem.

CIBSE is working with others to respond to these proposals; readers are invited to review the consultation and contribute views to **technical@cibse.org**.

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

References:

1 New laws to extend homes upwards and revitalise town centres **bit.ly/CJSept20HD** and The Town and Country Planning (General Permitted Development) (England) (Amendment) (No. 3) Order 2020 **bit.ly/CJSept20HD2**
2 Launch of 'Planning for the future' consultation to reform the planning system **bit.ly/CJSept20HD3** and Planning for the future **bit.ly/CJSept20HD4**
3 Affordable Housing Commission **bit.ly/CJSept20HD5**
4 *Research into the quality standard of homes delivered through change of use permitted development rights* **bit.ly/CJSept20HD6**

Research Q&As live at Technical Symposium

This year's virtual CIBSE ASHRAE Technical Symposium on 14-15 September will give people the chance to watch up to 60 presentations before putting questions to authors in live Q&As

The 2020 online Technical Symposium will feature live Q&A sessions for all the presentations, as well six keynote addresses from leading figures within industry and academia.

The two-day live event takes place on 14 and 15 September, but a dedicated symposium app will give access to all the presentations from 8 September, to allow users to prepare questions ahead of the live Q&As.

The opening address on Monday 14 September is by Star Refrigeration group managing director Dr Andy Pearson, whose keynote *Taming the energy tiger – how can I make a difference* looks at the decarbonisation of energy (page 69).

This will be followed by Q&As for on-demand sessions, which will address the use of building data, decarbonisation of heat, the performance gap, and net-zero strategies.

A midday keynote by CIBSE President Stuart MacPherson will look at *Net zero in practice*, while, at 2pm, ASHRAE president Chuck Gulledge will give a keynote entitled *The Ashrae Digital Lighthouse and Industry 4.0*.

Afternoon live Q&As will focus on sessions on modelling moisture, overheating, controls, and digital techniques to optimisation building operation. At 4pm, there will be a series of quick-fire presentations promoting speakers' posters. Each presenter will have four minutes to share their research and applications.

Subjects tackled in these compendiary sessions include: parametric modelling for climate-based daylight analysis; designing for seismic and blast forces; designing net-zero skyscrapers; ventilation dynamics in an underground station; and acoustic properties of alternative ventilation ducts.

The 10am keynote on day two will address the challenges of Covid-19 in the built environment and, at 11.20am, there will be a live Q&A session for the participants of the compendiary sessions. There are two more keynotes on Tuesday; the Cyclone Group's Ben Skelton will look at net-zero buildings from a US perspective at midday, and CIBSE past-president Lynne Jack will present at 2pm.

Tuesday's Q&As will discuss the on-demand sessions covering refurbishment, standardisation of data, health and wellbeing in schools, modelling of smoke and simulation of environmental systems, and lighting design using novel intelligence. The day will finish at 4pm with awards for the best presentations, which will include a Scotland Poster Prize presented by ASHRAE past president Darryl Boyce.

- For more information and to download the 2020 programme, visit **www.cibse.org/symposium**

Rethinking buildings to make them net positive

The net zero challenge focuses on cutting energy and carbon, but buildings could have a positive impact on the environment, says Aecom's Dave Cheshire

The basic concept of sustainability is that the needs of the present must be met without compromising the ability of future generations to provide for themselves. Population growth and dwindling resources, however, mean this definition is no longer valid. At the present rate of use, resources will run out.

We must design and construct structures that make a positive contribution to the planet. We can no longer think of buildings as consumers of resources. Groups are already looking at how buildings can make a net-positive contribution to the planet. Two ambitious initiatives stand out: the Living Building Challenge,[1] which promotes buildings that generate more energy than they consume; and Cradle to Cradle,[2] , which prescribes design solutions for the elimination of waste.

Both initiatives advocate reimagining buildings as components that contribute to the planet, in terms of energy or regenerative architecture that renews nature. Whether it's cleaning the air and releasing clean water, or adding to the biodiversity and providing sustenance to the biosphere, the ideas take inspiration from nature, where waste from one system becomes a nutrient for another.

"We need to reach beyond our defined roles and understand the wider implications of design decisions"

CIBSE has produced a guide on how to respond to the sustainability agenda, for which I was a principal author, along with CIBSE's Julie Godefroy. CIBSE *Guide L: Sustainability*[3] includes sections on incorporating ecosystems into design. It redefines waste as a resource and takes a whole-system approach to design that considers the wider impacts on infrastructure.

Implementing net-positive buildings requires new principles. These include:

- Systemic thinking, with buildings as part of ecosystems
- Mapping resource flows and determining how waste from one system becomes a resource for another
- A holistic approach to environmental and social topics that avoids the trap of considering each topic in isolation
- Designing out complexity and using solutions that do not require layers of technology.

With this new perspective and these principles, let's consider two examples of systems that are used in the majority of our buildings – the disposal of effluent and the provision of breathable air – and see what could be done differently.

Resource capture

The principles of toilets have not changed in more than 150 years, except that they have become more water-efficient. Looking at them afresh raises many questions. We collect, store, treat and distribute water to a level that it is so clean that it can be drunk and accessed in virtually every building in the UK – but we only drink 10% of the supply.

More than 40% of water (in a typical office) is mixed with faeces, urine, bleach and paper, and flushed down the drains, where it is often combined with freshly fallen rainwater. This warm, nutrient-rich effluent is transported to sewage works, where it is filtered and treated so it can be released back into the biosphere.

To make a positive contribution from our built environment, we need to redesign the system to avoid water use and capture nutrients. Composting toilets have been around for a long time, but they conjure up images of music festivals and isolated long drops in Canadian forests.

In a radical move, the Bullitt Center building[4] in Seattle installed composting toilets in an office building as part of an objective to achieve the Living Building Challenge. They look like any other toilet, yet use virtually no water and result in nutrient-rich compost.

Sewage treatment plants are an efficient way of treating effluent and this makes sewage treatment in buildings hard to justify. However, the ability to avoid using water in toilets and to capture the nutrients from waste – and use them locally – may just tip the balance. It is possible to collect urine from (waterless) urinals and use urine separation in WCs, turning a waste product into a valuable resource. Urine is an excellent source of nitrogen, phosphorous, potassium and trace elements for plants[5] and could even be used to make new materials and generate electricity.

Another key resource flow in our buildings is air. We pump our air full of particulates, nitrogen oxides, sulphur dioxide and many other pollutants that cause respiratory diseases, lung cancer, heart disease and more. We drag this

DAVE CHESHIRE is regional director at Aecom, and a principal author of *Guide L: Sustainability*

polluted air into our buildings, force it through filters and around tight bends. We heat it up and cool it down, then push it through pinch-points and labyrinths of ductwork. The internal environment is loaded with volatile organic compounds that further pollute the air. This CO_2-rich, warm air is recirculated via dusty ceiling voids before being expelled back into the environment. Fans use huge amounts of energy forcing the air around the building.

How could we do better? For starters, we could be more conscious about the air we breathe. The radical reduction in air pollution in our cities during the Covid-19 pandemic has given us a glimpse of how a future of sustainable transport could look. To clean up the city air we need to put an end to polluting fuels – from petrol and diesel-powered transport to diesel generators and wood-burning stoves.

Liberated from concerns about noise and air pollution, designers and buildings operators could consider other forms of ventilation, such as windows and mixed-mode ventilation. Where mechanical ventilation is necessary, we could design the building around the ductwork, creating generous voids for efficient, effective airflow – we did this for the University of Nottingham's Centre for Sustainable Chemistry to create a net-zero carbon laboratory building. We would design out indoor air pollutants by selecting better materials and finishes. Finally, we could think of uses for the warm, moist, CO_2-laden air we expel from buildings, such as the ICTA Rooftop Greenhouse Lab in Spain.[6] This uses CO_2 from the building it sits on to boost crop yields. In return, plants reduce the CO_2 content of the air, which could be fed back into the building.

Of course, using plants to clean the air is not new. Because of security concerns, little natural light enters New York's Public Safety Answering Center,[7] where workers take emergency calls 24 hours a day. Aecom installed a green wall that cleans the air. It uses phytoremediation to trap particulates, VOCs and CO_2, releasing clean, oxygenated air back into the building. Perhaps, in future, plantrooms will be full of plants!

A new paradigm

Net-positive buildings can only be achieved by changing our perspective. Instead of individual structures, we should be thinking in terms of whole systems. The aim should be to optimise the overall efficiency of the whole system, instead of treating one part in isolation. We should be looking for opportunities to turn what is treated as waste in one system into a nutrient or resource for another.

We need to reach beyond our defined roles and understand the wider context and implications of design decisions. We have a lot to learn from nature, which can teach us how to restore some of the symbiotic relationships that we have with the biosphere.

References:

1 Living Building Challenge **bit.ly/CJSept20lbc**

2 William McDonough and Michael Braungart, *Cradle to Cradle: remaking the way we make things* **bit.ly/CJSept20CtC**

3 CIBSE *Guide L: Sustainability* **cibse.org/knowledge**

4 Bullitt Center **www.bullittcenter.org**

5 Urine: the ultimate 'organic' fertiliser? *Ecologist* **bit.ly/CJSept20uri**

6 The water exchange between the greenhouse and the building of the RTG-Lab **bit.ly/CJSept20Lab**

7 This living wall cleans the air inside New York's new emergency center, *Fast Company* **bit.ly/CJSept20wall**

PERFORMANCE AS DESIGNED

The success of Agar Grove at the CIBSE Building Performance Awards was in part due to the focus on controlling overheating and minimising plant heat losses. Andy Pearson finds out how the Passivhaus approach helped tackle fuel poverty

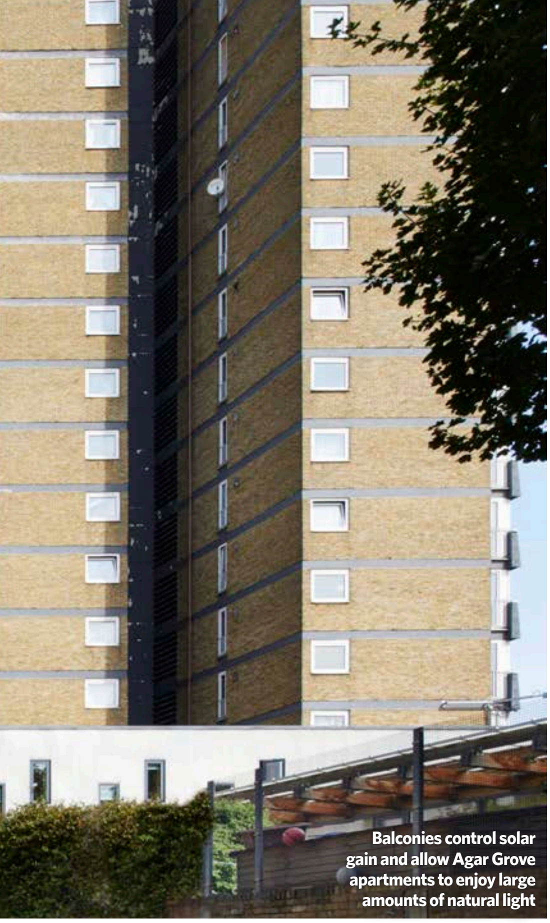
‘If all residential projects were like this, people would be very happy!’ That was the verdict of the judges at this year’s CIBSE Building Performance Awards, where the Agar Grove Estate Regeneration Phase 1A won Project of the Year – Residential. ‘The M&E design is great, the architectural design excellent, and the pre- and post-occupancy evaluation very thorough,’ said the judges, who might also have added that, when completed, the redevelopment will be one of the largest residential Passivhaus schemes in the UK.

Agar Grove Estate Regeneration is the redevelopment of a 1960s North London housing estate in the borough of Camden. It is a project in Camden Council’s Community Investment Programmme, designed by Hawkins\Brown and Mae architects in consultation with the tenants, with Max Fordham providing M&E and Passivhaus services. The architects’ masterplan is based on a layout designed to reinstate the area’s established street pattern, with the addition of community spaces and gardens. To help fund the metamorphosis, the masterplan has increased the development’s density. This has involved demolishing tired, low-rise buildings and replacing them with new energy-efficient council homes, plus the sale of new-build and refurbished flats on the open market.

The scheme will be redeveloped in six phases, to enable the smooth decant of existing residents; allowing residents to move in when a new block is completed, releasing their old block for demolition. When the project is complete, it will provide 507 new homes, of which 359 are set to be built to Passivhaus standards.

Passivhaus is a fabric-first approach to delivering energy-efficient homes. For a building to be classed as Passivhaus, one of the key targets is that it must have an annual heating and cooling demand of less than $15kWh{\cdot}m^{-2}$. The design-check-improve process is central to certification – the building’s design, construction, components used and commissioning process must all be certified, which is why Passivhaus schemes perform as designed. ‘The rigour associated with Passivhaus is a good way of closing the performance gap,’ says Katie Clemence, senior engineer at Max Fordham, the project’s building services engineer.

The assured performance was a big



Balconies control solar gain and allow Agar Grove apartments to enjoy large amounts of natural light

attraction for the London Borough of Camden in its redevelopment of Agar Grove. The energy efficient construction associated with the standard would ensure residents' fuel bills are kept to a minimum – helping tackle fuel poverty and carbon emissions – while the fabric first approach reduces the need for complex technical solutions, and the enhanced build quality should reduce long-term maintenance costs.

At the time the masterplan was being developed (2013), Passivhaus had not been applied to an inner city scheme of this scale in the UK, so Max Fordham set out to analyse its feasibility. One of the biggest challenges faced by the firm was that the development was subject to planning rules that were not always compatible with Passivhaus principles. For example, the Greater London Authority (GLA) was pushing for the scheme to have a CHP engine connected to a district heat network, which linked together all buildings on the development. The problem with this approach is that heat losses from the district heating's distribution pipework would have increased the scheme's primary energy demand beyond what is acceptable under Passivhaus.

'We determined that this option would result in high distribution losses from the unavoidable need for longer heating pipe routes, resulting in a system with low efficiency,' says Clemence.

As an energy efficient alternative, Max Fordham developed a scheme based on Passivhaus with communal heating provided by gas-fired boilers on a block-by-block basis. When it compared the block-based scheme with one based on CHP and district heating, the comparison showed life-cycle costs to be broadly comparable; while the Passivhaus option had a higher initial capital cost, it worked out to be better value over the scheme's anticipated 60-year lifespan.

When the engineer compared the carbon emissions associated with the two options, the benefits of abandoning CHP and district heating in favour of Passivhaus and communal heating became starkly apparent.

Planning policy in London requires a scheme to meet challenging carbon targets, and compliance is assessed using SAP methodology. At the time, SAP included an assumption that heat losses from a district heating network were 5% of the network's total generated heat. Max Fordham was sceptical about this, so looked at a number of actual district heating case studies for Passivhaus and non-Passivhaus developments. These indicated average network losses to be around 50% of the total generated heat – 10 times more than the figure used in SAP. 'SAP's 5% heat loss assumption was a significant factor in making district heating look a more favourable option,' explains Clemence. When the scheme was modelled using more realistic heat losses, Max Fordham found the Passivhaus option used less energy and emitted less carbon. As a result of the detailed analysis, the GLA gave the Passivhaus option the go-ahead.

The first block to be completed was Phase 1A, an £11.5m development of 38 social rented Passivhaus homes. Architect Hawkins\Brown optimised the building's form to help minimise heat losses. The window-to-wall ratio was set at around 35% to limit summer solar »

PROJECT TEAM

Architects: Hawkins Brown; Mae; (Architype)
Main contractor: Hill
Structural engineer: Peter Brett Associates
Services engineer: Max Fordham (Robinson Associates)
Passivhaus consultant (designer): Max Fordham (Architype/Elemental Solutions)
Passivhaus certifier: Warm
Landscape architect: Grant Associates
Project manager & QS: Arcadia

> "Resident feedback on summer temperatures was mixed, prompting Camden to educate some residents on the benefits of lowering window blinds and keeping windows closed during the heat of the day"

» gains without the need for solar control glass. Architype, the delivery architect for main contractor Hill, worked with Max Fordham and Warm, the project's Passivhaus Certifier, to simplify construction detailing to make it easier to build to Passivhaus.

The block, comprising a ground floor and six storeys, is supported on a concrete frame, with an infill of brickwork chosen to blend in with the local vernacular. On the roof is the communal plantroom complete with four gas-fired cascade boilers supplying several flow and return risers. Each dwelling contains a heat interface unit (HIU), which connects directly to the riser by short pipework legs on each landing.

The traditional solution for riser distribution at the time would have been to use a single heating flow and return pipework riser per block, connected to the HIU in each apartment via pipework legs snaking out above each of the block's communal landings. Max Fordham proposed an alternate solution involving a number of vertical risers next to apartments (three per block) to reduce the heat losses associated with

Table below: Passivhaus is a fabric-first approach to delivering energy-efficient homes

How Agar Grove met Passivhaus criteria

	Phase 1A	Criteria
Heating demand $kWh \cdot m^{-2}$ per year	13	15
Heating load W/m^2	9	20
Cooling: frequency of overheating (>25°C) %	6	10
Airtightness: pressurisation test results (n50) 1/h	0.6	0.6
Non-renewable primary energy (PE) PE Demand $kWh \cdot m^{-2}$ per year	118	120

External balconies have been integrated into the design to help control solar gain

Heating plant room with four cascade-controlled gas-fired boilers

lateral pipework. When Warm came on board, it expressed concerns that heat losses from Max Fordham's rationalised communal heat-distribution pipework would still be too high for Passivhaus. 'We were nervous about the communal heating system meeting the primary energy requirement of Passivhaus,' says Sally Godber, a director at Warm.

Warm worked with Max Fordham to model the risers in Passivhaus Planning Package (PHPP). This showed the distribution pipes were responsible for 45% of the system's heat loss, while the HIU was responsible for 33%. 'A key driver for us was to cut down on distribution losses of the system by reducing pipe lengths, reduce losses from the HIUs to get the flow and return temperatures down,' says Godber.

To reduce the connection lengths, Warm proposed further reconfiguring both the riser and the apartment layouts. 'We were fortunate that we were involved early enough in the design to be able to suggest changes to the floor layouts,' says Godber.

The final distribution strategy meant that the majority of pipework was vertical, rather than horizontal, and the apartment layouts were adapted so the HIU in each dwelling was adjacent to a riser. 'These changes served to cut the effective length of pipework and its corresponding heat loss in half,' says Godber. (See panel, 'Distribution heat losses'.)

Max Fordham selected HIUs with the minimum heat losses. Direct HIUs were chosen to eliminate the flow temperature drop associated with a heat exchanger, which allowed the entire system to run at a lower flow and return temperature. The HIUs provide space heating to the apartments via a single radiator in the living room and a heated towel rail in the bathroom.


Fresh air is provided to the bedrooms and living room, with stale air extracted from the kitchen and bathroom

OCCUPANT FEEDBACK

Occupant feedback questionnaires were used throughout the first year of occupation. Overall, respondents said air quality was good. Resident feedback on summer temperatures was mixed, prompting Camden to educate some residents on the benefits of lowering window blinds, opening internal doors for cross-ventilation and keeping windows closed during the heat of the day.

The design team also undertook post-occupancy evaluations. These included the detailed monitoring of three flats, anonymised heat metering, spot checks on electricity meters by Camden, and AHU monitoring.

Communal MVHR

The fabric-first approach results in a building envelope that is extremely well insulated and airtight. As a consequence, the apartments require an efficient mechanical ventilation system with heat recovery (MVHR) to ensure good air quality in the flats. Fresh air is provided to the bedrooms and living room, with stale air extracted from the kitchen and bathroom.

Agar Grove Phase 1A is one of the very few schemes to make use of a communal MVHR system based on roof-mounted air handling units. There are many pros and cons of central and decentralised ventilation. Godber says the most significant plus for centralised ventilation is the access for maintenance by Camden: 'Filter changes are a real problem for decentralised systems because access is required to each dwelling. In comparison, Agar 1A has only two AHUs, so only two filters to change; it also helps that those two filters are very large, so they last longer and, because they are fitted with pressure sensors, they send an alarm when they need changing.'

The system offers enhanced air quality in the flats because it enables less polluted air to be drawn from the roof rather than through the façades closer to the street. The arrangement also ensures the ventilation unit cannot be switched off by residents, so it will always operate as designed; and it can be maintained without access to the flats.

The downside of communal MVHR is that it places additional constraints on the layout because ducts must drop vertically down the building. Because apartment walls are generally part of its fire compartmentation, ducts also need to be fitted with fire dampers at this intersection. The ventilation system operates continuously, so Robinsons, the contractor's MEP consultant, took great care over the design to minimise system pressure loss. Godber says design static pressure was 101Pa, and the system's measured static pressure was close, at 115Pa. 'This is low, especially for a VAV system where commissioning engineers often ramp up the static pressure to about 400Pa to make it easier to set the controls,' says Godber. 'We were pleased with the result being so close to the design, which demonstrates a great installation and shows the value of the quality assurance Passivhaus certification brings.'

A major challenge of any new development in urban environments is the control of solar gain and overheating. The masterplan was developed to stitch the scheme into the neighbourhood streetscape, so »

Agar Grove is one of the few Passivhaus schemes to use a communal MVHR system

Distribution heat losses

The total amount of heat going into the system (primary) was compared with the sum of the amount of heat going into each HIU. This was done at four moments in time, which were then averaged to obtain one figure.

Time	13:15	13:30	13:45	14:00
Primary - HIUs	1.54kW	4.47kW	2.21kW	5.24kW
Primary - HIUs average	3.37kW			

The average of 3.37kW was compared to the total distribution heat losses in the PHPP, which – according to Warm – were 4.23kW (sum of the instantaneous heat losses through each piece of circulation pipe). So, the measured figure showed better results than the modelled figures.

» the blocks are not always orientated in the optimum direction for solar control. Fortunately, Phase 1A was orientated north-south, which helped the designers manage solar gains in the most economical manner.

At the time Phase 1A was being designed, there was no specific methodology on how to analyse overheating in housing, so Max Fordham created a strategy to appraise the risk and ensure the design could adapt. Modelling was carried out using the Islington 2030 DSY from the Prometheus probabilistic weather data website. The results were compared against CIBSE TM52's adaptive overheating criteria.

The modelling determined that living rooms would not overheat providing the windows could be opened during occupied hours. On noisier façades, large openings flush heat from the spaces quickly, preventing the need for windows to remain open for long. Control of overheating was also helped by the majority of apartments being dual aspect, allowing the cross-flow of air. In addition, external balconies have been integrated into the design to help control solar gain. 'In mid-summer, the balconies block out the high sun, but heat from lower-angle sunlight can enter the dwellings in winter,' says Clemence. It is a solution that enables the flats to enjoy high levels of natural light while avoiding overheating.

Phase 1A was completed in April 2018. To help residents adapt to their new low-energy homes, the contractor, council and their design teams created guides to explain how their Passivhaus home operated, including guidance on the use of ventilation three-speed control. As part of Camden's ongoing support to residents, occupant feedback enabled Camden Council to identify how residents could make their homes more comfortable (see panel, 'Occupant feedback').

Future phases

The CIBSE Award was for Phase 1A, and the design team adopted a similar approach to ensure Passivhaus compliance for Phase 1B. Detailed design of Phase 1C is about to start; its design has evolved significantly in response to changes to the carbon factors for gas and grid electricity. 'The carbon factors have changed, so the energy strategy of having communal boilers in the blocks will shift to one based on a heat pump solution,' says Scott Crease, senior partner at Max Fordham.

The design team is looking at an installation based on an ambient loop system, such as Dimplex's Zeroth or Daikin's Altherma Geo3. The ambient loop will have a flow temperature of about 25°C. A water source heat pump in each apartment will draw heat from the ambient loop for space heating and domestic hot water. 'It's a more expensive solution, but – in carbon and energy terms – it is completely the right solution,' says Crease.

Phase 1A of Agar Grove proved that Passivhaus principles can be applied successfully to large-scale residential developments. Phase 1C is set to take large-scale low energy housing to a new level. **CJ**

■ The CIBSE Building Performance Awards 2021 are now open for entries. Visit **cibse.org/bpa**

The Importance of Delivering Hot Water with Temperature Control

By Dan Madagwa, MEng

Introduction

The supply & use of hot water is vital to the efficient function of almost all industries. From NHS Healthcare to Care Homes to food production, hot water is critical yet often an overlooked integral part of the system design is the overall ability to accurately control hot water temperature. This capability can allow you to pre-emptively tackle or avoid issues arising from poor hygiene regimes or bacteria. The significance of hot water temperature control itself is being given a lot more attention, as seen in a CIBSE journal article entitled “Taking the temperature – domestic hot water” which looked at the potential of reducing carbon and providing modern, safer low energy solutions simply by focusing more on temperature and revising guidance (CIBSE, 2020). The importance of being able to accurately control hot water temperature will be explored in this paper.

How is precise temperature control achieved?

Temperature control is the procedure where the change of temperature of a space or substance is measured and the movement of heat energy into or out of said space or substance is adjusted to achieve a desired set temperature. In the case of hot water heaters, this process is governed by a temperature controller. This instrument simply calculates the difference between a set-point and a measured temperature by taking an input from a sensor and giving an output signal for the connected heat element.

Venturing into system design, another way to ensure the desired temperature is provided at the outlet is by using thermostatic mixing valves (TMV's). A TMV uses an internal thermostat that blends hot and cold water to achieve this result.

Hot Water Delivery units and systems

The two main forms of supplying hot water are the conventional storage tank water heater and the continuous flow (instantaneous) water heater. The main differences are outlined below.

Storage water heaters:

- Have a limited amount store of water.
- When store depleted takes time & fuel to reheat before use.
- Require greater plant room space.
- Materials handling issues, heavy and cumbersome.
- Standing losses.

Continuous flow heaters:

- Hot water is heated and provided solely upon demand.
- Evidence and data that they are mechanically and operationally more efficient.
- Limitless supply of hot water provided constant gas and water connections exist.
- Lighter and require less space.
- Advanced models can supply very precise temperature accurate hot water.

Table 1 opposite shows a comparative analysis between a continuous flow and storage water heater. As you can see from the data, the storage tank option tends to be less efficient and consume more energy. Once you factor in replacement costs, a continuous flow hot water heater is the more cost and energy efficient option as well as being better at reducing the carbon footprint.

However the most important feature with regards to temperature control and what makes continuous flow the preferred option for this application is the ability of some continuous flow water heater models to constantly provide temperature accurate hot water with a precision of up to ±1°C.

Temperature control in practise - Legionella & ACOP L8

ACOP L8 is the Health and Safety Executive Approved Code of Practise that governs the control of Legionella in water systems. Legionella – full name Legionella pneumophila – is a bacteria that causes, amongst other less serious conditions, Legionnaires disease, a potentially fatal form of pneumonia. Legionella bacteria are common in natural water sources but the conditions are rarely conducive to people catching the disease. This usually occurs in purpose-built water systems and the risk of being exposed to Legionella increases in warm, stagnant water, passed to humans via breathing in miniscule, aerosol-like droplets of water. Specific guidance for the control of L pneumophila in water systems is provided in ACOPL8 and its associated regulations, HSG274 Part 2.

When it comes to combating Legionella, precise temperature control is one of the strongest weapons available. The bacteria begins to die in temperatures above 50°C and cannot survive above 60°C Certain conditions support the growth of bacteria, such as a temperature range of 25°C to 45°C as well as the presence of certain deposits such as lime-scale, rust, sludge

	Continuous flow	Storage W/H
Max Heat Input (kW)	58.3	79
Max heat output (kW)	56	65
Efficiency (Gross)	96%	82%
1st hour flow rate @ 50°C rise (l/hr)	960	1411
Storage/Cylinder (L)	0	300
Continuous flow rate (l/hr)	960	1111
Peak usage periods (hr)	1	1
Number of peak usage periods	3	3
Heating consumption (kW)	58.3	79
Storage recovery time (mins)	0.0	16.2
Storage recovery (kW)	0.0	21.3
Storage loss (kWh)	0	9.29
Secondary return system heat loss per hour (kW)	10	10
Efficiency (efficiency curve of appliance)	95%	82%
Appliance input for secondary system (kW)	10.5	12.2
Secondary system operating time (hr)	21	21
Reheat of secondary return (kWh/day)	221.1	256.1
Consumption per peak period (kWh)	58.3	79
Total consumption per day (kWh)	396.0	566.4
Consumption per week (kWh)	2771.7	3964.7
Annual consumption (kWh)	144522.7	206730.1
Annual CO2 carbon emissions (kgCO2e)	26,570.5	38,007.3

Table 1: Example running cost comparison between continuous flow water heater and storage tank water heater.

and organic matter can also increase this risk. This is why it is important to control the risk of exposure and do all you can to minimise it by introducing measures that restrict the growth of bacteria and reduce exposure. Traditionally this is done via temperature control, keeping stored water at least at 60°C and ensuring distributed water is supplied with 50°C water (55°C for healthcare) at outlets within 1 minute.

Scalding

When discussing temperature control of water the risk of scalding should always be considered, especially in the health and social care sector. According to the Health and Safety Executive (HSE), high temperatures over 44°C can create a scalding risk and as such water temperatures discharged from outlets accessible to those vulnerable or where there is the potential for full body immersion must not exceed this temperature. Engineering controls can be put in place in order to ensure this. These include using the aforementioned thermostatic mixing valves which should be placed as close to the outlet as possible, temperature-restricted or temperature accurate instantaneous water heaters.

This would allow water of a safe temperature to be provided continuously and reliably at the outlet. For example there could be a scenario where a water heater was set using the controller to provide water of 43°C directly to the outlets. In this case, the use of thermostatic mixing valves would not be required though there could be legionella concerns. However regimes could be put in place to help control this.

One method that could be used in addition to normal operation is a pasteurization regime. This would consist of raising the water temperature very high to over 70°C, the point at which legionella bacteria are killed instantly, and flushing the system. This could be done when the building in question is not occupied, the water is returned to a safe temperature prior to occupancy and it could potentially allow for water to be supplied as low as 43°C during regular use, reducing consumption immensely.

Hygiene regimes

The temperature of hot water is critical for many hygiene regimes across a variety of industries such as laundry for hotels, care homes and healthcare, particularly with regards to the cleaning and disinfectant processes. Being able to reliably provide water at these temperatures not only serves to properly disinfect the items in question every time but gives the end-user peace of mind.

According to the Health & Safety Executive's HSG (95)18 Hospital Laundry Arrangements for Used and Infected Linens, "The washing process should have a disinfection cycle in which the temperature in the load is maintained at 65°C (150°F) for not less than 10 minutes or, preferably, at 71°C (160°F) for not less than 3 minutes". This is especially important as there are a number of harmful bacteria that can survive temperatures of over 50°C degrees such as Staphylococcus aureus, a well-known pathogen that if allowed to invade the skin deeply can cause a plethora of diseases, ranging from superficial skin infections that cause boils to more systematic issues like pneumonia and blood infections. Maintaining high temperatures ensures that such bacteria are killed before they have a chance to become a problem.

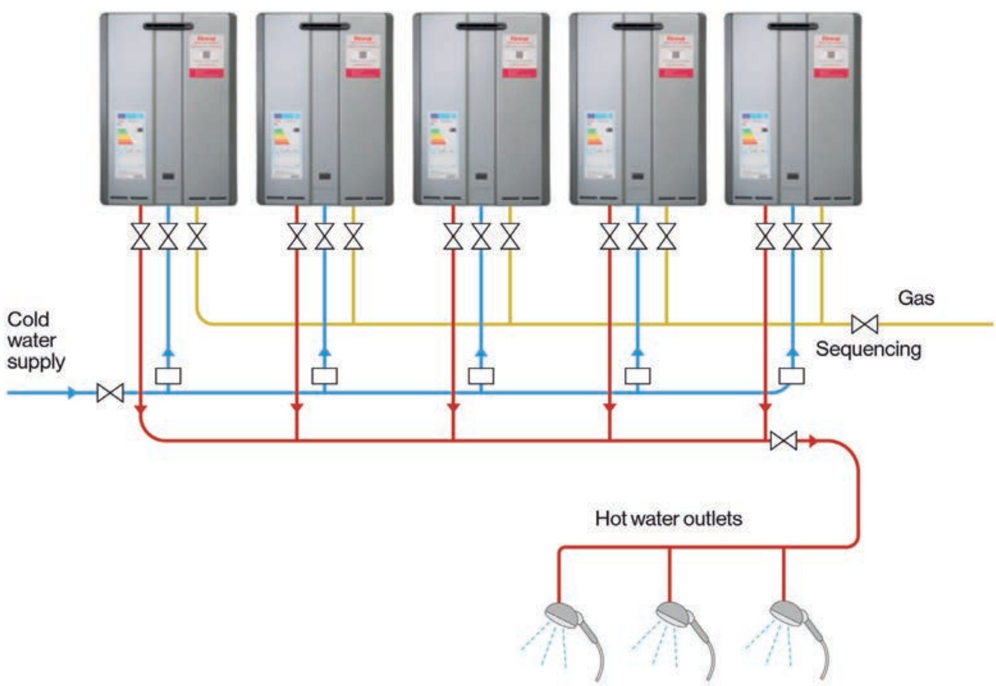
Food Processing

The need of hot, potable water is essential in any food processing operation as it is a major component of the cleaning process. To reduce the risk from hazards, comply with legislation, presenting a hygienic visual image or to ensure the variety of bacteria and residue left behind during production is removed, having clean equipment is of paramount importance.

Hot water (thermal energy) plays an integral role in the effectiveness and rate of the cleaning method. Increasing the temperature generally increases the rate of the chemical reactions involved in the cleaning and so make it more effective and take less time. In the same vein, higher temperature of water may require the use of less detergent, allowing money to be saved. The goal is often to find the perfect balance between cost, efficacy and food safety and so the ability to precisely provide water of specific temperatures is hugely beneficial and allows great control.

Conclusion

It is clear to see that implementing temperature precision and control in the specification and installation of hot water systems is vital and will only continue to grow in importance, particularly in the current pandemic and the aftermath. Being able to choose between providing water hot enough to combat Legionella and disinfect laundry or low enough to prevent scalding is a useful tool and if it is more widely incorporated as one of the first steps in the design process, a plethora of issues can be avoided and effectively design-engineered out of the equation.



CLEAR GUIDANCE

The risk of death and illness because of exposure to hazardous substances in the workplace can be cut by following the best practice guidance in ILEVE and BESA's new TR40 publication. **Alex Smith** summarises the guidance aimed at the safe design and installation of local exhaust ventilation

A LEV system prevents fumes from entering a worker's breathing zone

Every year, around 12,000 people in the UK die from occupational lung disease, according to the HSE, and there are around 18,000 new cases of individuals with breathing and lung problems.

HSE investigations reveal the human cost of exposure to hazardous substances – in the form of dusts, mists and fumes – which can lead to respiratory illnesses, cancer and chronic obstructive pulmonary disease. One school cook developed breathing problems after working with flour in a school kitchen that was small and had no ventilation or controls for the dust flour. The 46-year-old retired early with severe asthma and was awarded £200,000 damages .

Another worker developed occupational asthma after inhaling solder fumes at a company in Gloucester. The company failed to install fume-extraction equipment to remove dangerous rosin-based fumes from the workroom air and, as a result, was fined £100,000 with £30,000 costs. The employers were prosecuted under Control of Substances Hazardous to Health 2002 (COSHH), which requires employers to control substances that are hazardous to health.

Many cases of occupational illness could have been avoided if proper measures had been taken to reduce workers' exposure to hazardous substances. Local exhaust ventilation (LEV) equipment is designed to reduce the exposure of workers to these deadly hazards, which can accumulate in the body for many years before an illness is diagnosed.

Best-practice guidance

To ensure best practice in the design, installation, operation and maintenance of LEV systems, BESA and the Institute of Local Exhaust Ventilation Engineers (ILEVE) – a division of CIBSE – have produced *TR40: A guide to good practice for local exhaust ventilation.*

TR40 is aimed at everyone in the supply chain involved in the design, installation, operation and maintenance of local exhaust ventilation systems. These include employers, designers, suppliers, project managers, LEV commissioning engineers, employer-appointed LEV responsible people, LEV trainers and all other employees who design, commission, operate and maintain LEV systems.

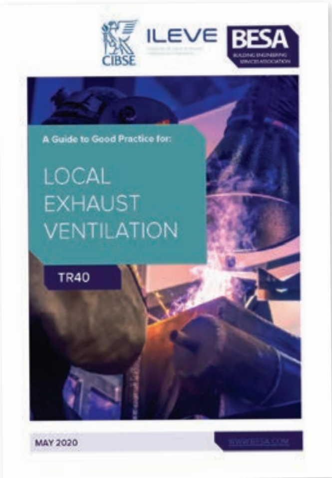
There is information on the various LEV roles and associated legal and statutory responsibilities. The document outlines what people should do and when they should do it, to ensure the LEV process – from start to finish – provides effective solutions to control exposure to hazardous substances. Roles and responsibilities are detailed in a diagrammatic form at the start of TR40 (Figure 1).

The guide describes the components of a LEV system, which includes hoods, ducting, filters, air mover and a discharger. LEV systems all work in the same way; airflow into hoods carries the dust or fumes away to a filter, which removes them. They may be portable or fixed, and include microbiological safety cabinets, dust-extraction units, spray booths, fume extraction, fume cupboards, down-draught tables, and on-tool extraction units.

There is a detailed section in TR40 on identifying competency, which explains what skills, experience and knowledge and training to look for. It also highlights the importance of keeping records and makes clear »

GUIDE SECTIONS

- Roles and responsibilities
- How to identify LEV competency
- Employer brief and design parameters
- LEV system specification
- Evaluating LEV tenders and quotations
- Installation programme
- Operating and maintenance manual
- Commissioning
- Training
- Log book
- Handover documents
- Thorough examination and testing (TExT)



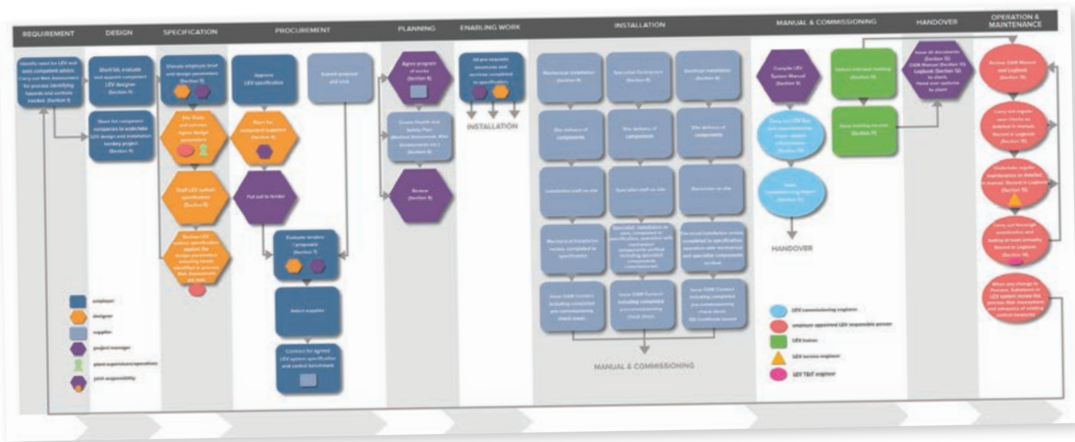


Figure 1: The TR40 guidance has a clear, diagrammatic description of the roles and responsibilities of those involved in delivering LEV

> "The designer should have proven competencies in the fields of occupational hygiene and LEV engineering design"

» what to ask when evaluating LEV tenders and quotations. It explains that the employer must ensure their advisers, and those they employ for specific roles to undertake works associated with LEV systems, are competent.

The guidance outlines the competencies required for LEV designers suppliers, commissioning engineers, maintenance engineers, installation contractors (mechanical, electrical and specialist), and the thorough examination and test engineer. For example, the designer should be able to demonstrate competence in designing effective LEV systems. They should be a member of a relevant professional body and have proven competencies in the fields of occupational hygiene and LEV engineering design.

It also explains the role of the occupational hygienist if a risk assessment is deemed necessary to monitor employees' exposure to hazards and evaluate the performance of control measures in place.

There are questions employers should ask members of the supply chain. For example, how did the designer show that the LEV provided adequate control, and have there been any operational issues since installation.

Section 4 features the employer brief and design parameters. The brief for the designer contains the requirements for the system. The designer should visit the site to observe the operation of the process if possible and this may influence the control options available.

Section 5 features a checklist for the LEV system specification. There are 26 items, including: details of the processes and hazardous substances to be controlled; the agreed controlled benchmark to be achieved, with the relevant occupational exposure limits; and information about hoods, ductwork, test points, filter, air mover and motor, controls, make-up air and maintenance access.

Evaluating LEV tenders and quotations is in section 6. The key guarantee required is that the LEV will adequately control the hazardous substance to an agreed benchmark. Other areas to check are the competency of the LEV supplier, specification and installation compliance, essential documentation, and whole-life system costs.

There are sections on installing, commissioning and maintenance, and TR40 explains how LEV commissioning differs from normal plant commissioning, as it has to ensure the operator's safe use of the system.

Section 7 describes the installation programme, and states that an outline project programme should be developed to identify key tasks, critical dates and milestones.

Best practice for an operations and maintenance manual is described in Section 8, while Section 9 focuses on how commissioning should be carried out. It says the report should include measured exposures from the breathing zone of the operator to identify whether the LEV: is controlling exposure to the hazardous substance adequately; is matching the specification; has been correctly installed; and is being used correctly. The final four sections discuss training, the log book, handover documents and thorough examination and testing.

TR40 should be read in conjunction with the HSE publication *HSG258 – Controlling airborne contaminants at work – A guide to local exhaust ventilation*, which offers employers further guidance on the design of new local exhaust ventilation (LEV) equipment.

TR40: A guide to good practice for local exhaust ventilation is available from the CIBSE Knowledge Portal at **bit.ly/CJSep20Lev** CJ

'PEOPLE DIE IF YOU DON'T GET THE DESIGN RIGHT'

Adrian Sims is passionate about raising the profile of local exhaust ventilation. As an expert witness in HSE prosecutions, he has seen the devastating effects on people's health when organisations fail to provide adequate protection from the inhalation of hazardous substances.

In a recent case, a former soldier inhaled oil mist while at work on one occasion, resulting in a serious respiratory condition that led to him losing his flat and girlfriend. 'That's how serious this is – it destroys lives,' says Sims.

TR40 is designed for people in the LEV contract chain. HSE already has a guidance document, HSG258, aimed at the owner of the system; TR40 looks at how designers, installers and commissioning engineers protect the person at risk.

'When you look at occupational exposures and who gets hurt, it tends to be the low-skilled worker, who doesn't know that wood dust gives you cancer,' says Sims. 'A huge education piece has to be done, from top to bottom. It needs to be treated with care. If we don't get the design right, people die.'

Sims says he is asked by contractors to design LEV systems without being told exactly what is having to be extracted from the space. 'They say it's just an extraction system, just get on with it. They don't appreciate the issues. Wood dust gives people cancer – it's an asthmagen and a carcinogen.'

■ **ADRIAN SIMS is managing director at Vent-Tech and director at WorkSafe Design**


Vaillant
aroTHERM plus

CALCULATED RISK

A group of UK researchers has attempted to quantify the transmission risk of airborne Covid-19 infection according to activity and type of indoor space. **Dr Chris Iddon** describes the methodology and how the risk of infection falls as ventilation rates are increased

Although the near field (<2m) transmission risk is well established via droplet transmission, many scientists have warned about the possibility of indoor far field (>2m) transmission of the SARS-CoV-2 virus encapsulated in small respiratory aerosols that can remain airborne for several hours.[1] Building services engineering bodies, such as CIBSE, have responded by encouraging improved ventilation strategies to reduce transmission risk.

Poorly ventilated indoor spaces are at an increased risk of SARS-CoV-2 transmission, and several methods have been proposed to assess the risk indoors. One challenge in developing a transmission-risk methodology is that the required dose of SARS-CoV-2 to produce an infection is unknown, and the amount of virus per millilitre of respiratory fluid that an infected individual may shed ranges over several orders of magnitude.[2,3]

The methodology is described in the pre-print paper *Modelling uncertainty in the relative risk of exposure to the SARS-CoV-2 virus by airborne aerosol transmission in buildings* by Benjamin Jones, Patrick Sharpe, Chris Iddon, Abigail Hathway and Shaun Fitzgerald. In the paper, a dose risk for a reference space is established and the dose risk of another space can then be compared to generate a relative risk index (RRI) for aerosol transmission, such that any uncertainty in the viral load of infector – or on the viral load required for infection – cancel out.[4] The method establishes how risky a space/activity is compared with the reference case. It can be used to establish the effectiveness of mitigation measures in reducing RRI.

It is important to appreciate that this model only considers the far-field transmission of SARS-CoV-2 by aerosol in a well-mixed space, and does not consider the near field (<2m) or fomite transmission. The concentration of SARS-CoV-2-laden aerosols from an infected individual will be greater within the exhaled puff than in the well-mixed room.[5] Social distancing is, therefore, still required and, if you are close to an individual and the infectious material has not become well mixed, transmission risk will be higher. In spaces where social distancing is not possible, consideration of droplet spread and appropriate PPE is required.

The model imagines an infected individual emitting viral-laden aerosols (VLA) as a pollution source and assumes a well-mixed space. With no dilution mechanisms, the number of VLA in the space would increase linearly over time. However, there are several ways in which the VLA are removed from a space – or rendered inactive (see Figure 1):

- Ventilation
- Ballistic and momentum-induced deposition removes VLA as they become adsorbed onto surfaces
- Biological decay of the entrained virus, becoming inactive over time
- Removal by filtration
- Inhalation by other occupants.

It is challenging to establish how many viral particles (virions) may be emitted by infected individuals. However, it is possible to measure the genetic material of the virus using the laboratory method quantitative reverse transcriptase polymerase chain reaction (RT-PCR), where fragments of the viral genome in a sample are amplified via a biological

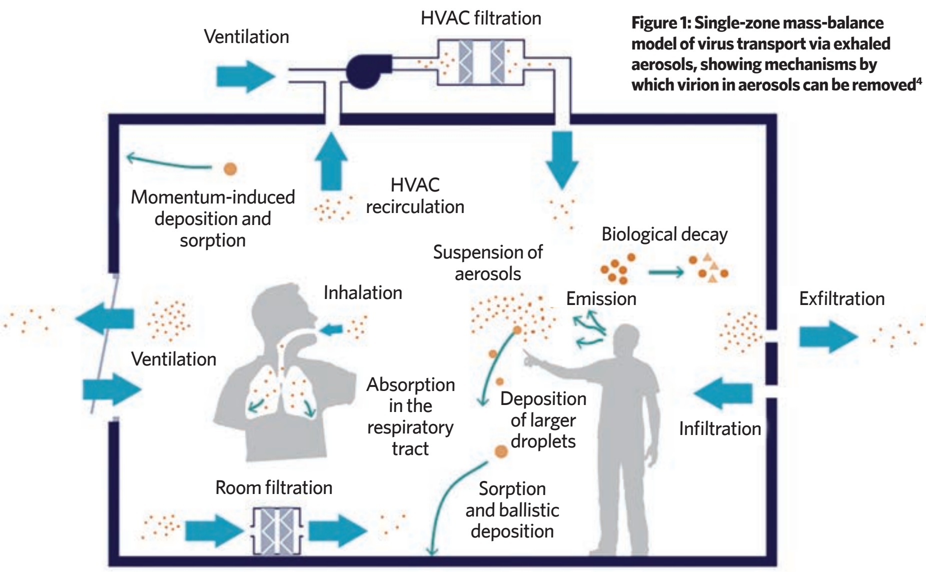


Figure 1: Single-zone mass-balance model of virus transport via exhaled aerosols, showing mechanisms by which virion in aerosols can be removed[4]

SHARING KNOWLEDGE

'Unprecedented times call for unprecedented measures' is an oft-heard rallying call during the Covid-19 pandemic response, and this remains true in academia. Preparing research findings for academic consumption requires careful thought and rigour; ordinarily, one would ensure that results and findings are thoroughly written before submitting them for peer review and publication. A team of academics and researchers has recently made this work in progress available publicly while it is being prepared for formal publication, because of the perceived benefit of sharing the RRI assessment method. The analysis shown here is under peer review, and readers should check the DOI for the latest version: bit.ly/CJSep20CI1

The risk of transmission will be affected by the ventilation rate and the type of respiratory activity, as well as exposure time

replication method and then quantified.

These genomic fragments of RNA do not give a value for the number of infective virion present – merely a measure of genomic material, much of which may be fragments of decayed virion. Other respiratory viruses studies suggest the ratio of infective virion to RNA copies is in the order of 1:100 and 1:1000.[6]

There are published measures of the SARS-CoV-2 genomic material in the respiratory fluid of infected individuals and the air of rooms housing infected patients. Therefore, this method has used 'copies of RNA' emitted by an infector, on the basis that an unknown portion of this genomic material is likely to be infective virion.

The number of RNA copies emitted by an infected individual into the space – G – is diluted by a number of mechanisms, described above, that can be normalised by the volume of the space – V (m^3) – and combined into a single dilution rate – ϕ (s^{-1}) – by addition.

The equations for the number of RNA copies inhaled by a susceptible individual in a scenario where an infector enters the room at time = 0 (novel), or if a susceptible person enters a room where an infector has been present for sufficient time that the number of RNA copies within the space has reached steady state, are then derived (see 'Equations for number of copies of RNA inhaled' panel).

There are ranges of uncertainty for many of the inputs and, in the paper, a statistical »

"Ventilation plays a key role in dilution – poorly ventilated spaces increase RRI, although there is a diminishing law of returns in increasing the ventilation rate; the potential benefits of increasing ventilation to a poorly ventilated space are greater than increasing a well-ventilated space by the same amount"

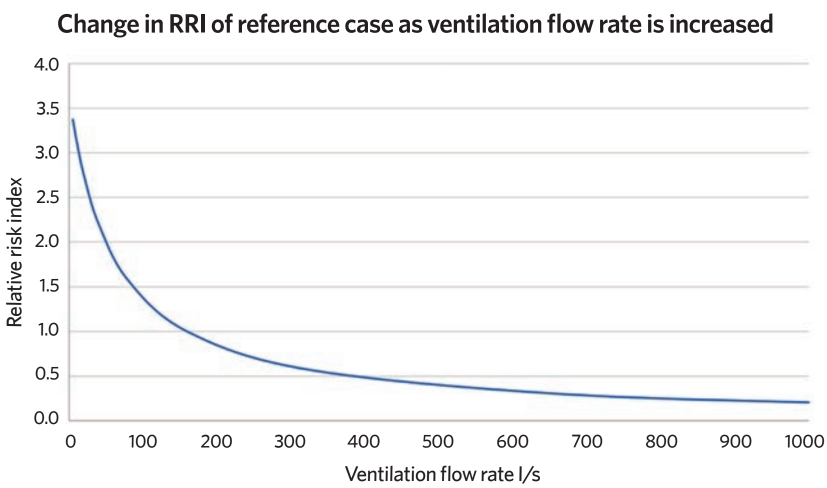


Figure 2: Demonstrating the law of diminishing returns for the reference case, a 32-person junior classroom occupied for seven hours. The RRI decreases as the ventilation flow in the space increases, the potential benefits of increasing ventilation to a poorly ventilated space are greater than increasing a well-ventilated space by the same amount

» framework to estimate uncertainty of the number of SARS-CoV-2 RNA copies inhaled is employed. The reference space is a junior classroom occupied for seven hours with a ventilation rate of $5\ L{\cdot}s^{-1}$ per person; the form and ventilation rates for these spaces are well defined in current Department for Education (DfE) guidelines and the paper describes the reference case and assumptions fully.[7,8]

In 2009, Morawska *et al* undertook several experiments to establish the amount of aerosols produced by an individual under various respiratory activities (for example, breathing, talking and vocalisation), so it is possible to derive a volume of respiratory fluid released per m^3 of exhaled breath for various respiratory activities.[9]

The total number of RNA copies released into the air by an infected individual is a function of the breathing rate, respiratory activity and the concentration of RNA copies per ml of respiratory fluid of the infected individual, providing the emission rate $kq_{sus}\,G$. The analysis suggests that the volume of respiratory fluid released as aerosols is roughly 1:5:30 for breathing, speaking and vocalisation respectively.

The mathematics of the model demonstrate that the RRI for aerosol transmission is most sensitive to the emission rate (G), so steps to reduce G should be considered (respiratory activities that produce more aerosols – such as vocalisation – should be minimised unless there are elevated levels of ventilation per person; face coverings to reduce G should be encouraged).

Ventilation plays a key role in dilution – poorly ventilated spaces (for example, infiltration only) increase RRI, although there is a diminishing law of returns in increasing the ventilation rate (see Figure 2); the potential benefits of increasing ventilation to a poorly ventilated space are greater than increasing a well-ventilated space by the same amount.

Vocalisation activities should be minimised unless there are elevated levels of ventilation per person

The model only considers the far-field risk of infection in a well-mixed room, and helps engineers reduce this risk. Social distancing and hand washing are still essential. **CJ**

■ For more analysis and a spreadsheet tool see the preprint at ResearchGate via **bit.ly/CJSep20CI1** or email **naturalventilation@cibse.org**

■ **CHRIS IDDON** is chair of the CIBSE Natural Ventilation Group

EQUATIONS FOR NUMBER OF COPIES OF RNA INHALED

Steady state equation

$$\sum n_{ss} = \frac{k q_{sus} G T}{\phi V}$$

Novel source equation

$$\sum n = \frac{k q_{sus} G}{\phi^2 V} \left(T\phi + e^{-\phi T} - 1\right)$$

Where:

k = the ratio of the number of aerosol particles that are absorbed by the respiratory tract to the total number of aerosol particles that are passed through it
q_{sus} = respiratory rate, ($m^3\ s^{-1}$)
G = emission rate (RNA copies s^{-1})
ϕ = dilution rate (s^{-1})
V = space volume (m^3)
T = exposure time (s)

Dilution $$\phi = \psi + \gamma + \lambda + \zeta + \omega$$

ψ = dilution rate due to ventilation (s^{-1})
γ = dilution rate due to surface deposition (s^{-1})
λ = dilution rate due to biological decay (s^{-1})
ζ = dilution rate due to absorption in the respiratory tract (s^{-1})
ω = dilution rate due to filtration and ultraviolet denaturing (s^{-1})

Full derivation of the equations are detailed in the preprint paper[4]

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MODEL HOUSING

To minimise overheating in homes it is important to produce accurate models to understand where risks might lie. To test the accuracy of modellers' predictions, researchers – led by **Ben Roberts** – compared four models with real-life temperatures in two homes

The 1930s test houses in the East Midlands

Reducing the risk of summertime overheating in UK homes is important because of the health implications of high indoor temperatures, and the increase in electricity demand if more air conditioning is used. The Committee on Climate Change has identified dynamic thermal modelling (DTM) programs and CIBSE Technical Memoranda TM52 and TM59 as potential enablers of new standards or regulation to reduce overheating risk. To be viable, DTM programs must steer designers towards low-risk designs by predicting correctly the relative overheating experienced by alternative design proposals.

The 2020 Carter Bronze medal-winning research paper *Predictions of summertime overheating: comparison of dynamic thermal models and measurements in synthetically occupied test houses*[1] compared DTM program predictions of summertime temperatures with those measured in the matched pair test houses at Loughborough University. It was a collaborative empirical validation and inter-model comparison between four modellers and a monitoring and validation team.

The four modellers were all employed in professional organisations and none was involved in the experimental work, or had prior knowledge or experience of the test houses. Each chose a CIBSE AM11-compliant DTM program that they use regularly in their work and which is widely used in industry. Two modellers selected versions of one program, while the other two selected versions of a different one.

The test houses are two nominally identical, semi-detached homes, built in the 1930s in the East Midlands, UK. They are south facing, with windows on the east and west façades covered and insulated so that solar gains are consistent. The houses have the same uninsulated cavity-wall construction, a suspended timber ground floor with a ventilated void below, and ventilated roof space. Both were retrofitted with 300mm of insulation above the first-floor ceiling and double glazing to all doors and windows, with identical operable elements.

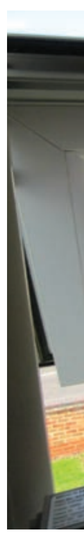
The facility is fully instrumented, with calibrated sensors inside and out. 'Synthetic occupants' – systems for the automation and control of internal heat gains (electrical heaters), internal doors, windows, blinds and curtains – allow accurate and repeatable side-by-side experiments to be carried out. The houses have been used in numerous research projects on topics including mitigation of summertime overheating, model validation, thermal performance evaluation, thermal comfort, ventilation, energy-saving performance, and energy flexibility.

A side-by-side overheating experiment was carried out in the houses from 16 June to 6 July 2017. There was a spell of hot weather during this period, which caused overheating and tested the models' reliability for making accurate predictions. Heat-gain profiles in each house were set to mimic those recommended in TM59. Blinds and curtains were opened in accordance with the TM59 sleeping schedule.

Windows stayed closed in the East house but were opened in the West house if the room air temperature exceeded 22°C and it was occupied (according to TM59 occupancy profiles) and closed if the air temperature fell below 22°C or the room was unoccupied.

Peak temperatures of the East house reached 28.9°C in the living room and 31.9°C in the front double bedroom. With operable windows, peak temperatures in the West house were only slighter cooler, at 28.5°C (living room) and 30.9°C (front bedroom).

Predictions were made in two phases: blind and open. In the blind phase, modellers were given only information on the house construction, geometry, synthetic occupancy, heat-gain profiles and weather, and asked to make predictions of indoor temperature without knowing the measured indoor temperatures. In the open phase, the modellers were given indoor temperature data, revised their models, and made new



predictions. In each phase, they predicted:

1. Indoor operative temperature during the test-house experiments for the empirical validation using weather measured locally
2. Annual overheating hours following TM59 methodology for inter-model comparison using the CIBSE DSY1 file for the 2020s, high emissions, 50% percentile scenario for the nearest location to the test houses.

Empirical validation

The model predictions deviated most from measurements on the warmest days – precisely when predictive accuracy is most needed. On these days, the peak temperatures predicted by all four models were higher than measured in both houses (see Figure 1). For example, on the warmest day, and with windows open, the predicted peak temperatures exceeded measured temperatures by 1.4°C to 3.3°C in the front double bedroom, and 2.2°C to 4.6°C in the living room. As a result, in both houses, the overheating threshold exceedance hours during occupied hours in living rooms were predicted higher than measured.

The models also tended to over-predict the diurnal swing in indoor temperature. Consequently, in the house with windows closed, all the models predicted fewer sleeping hours in the bedroom over 26°C than measured. For the house with windows open,

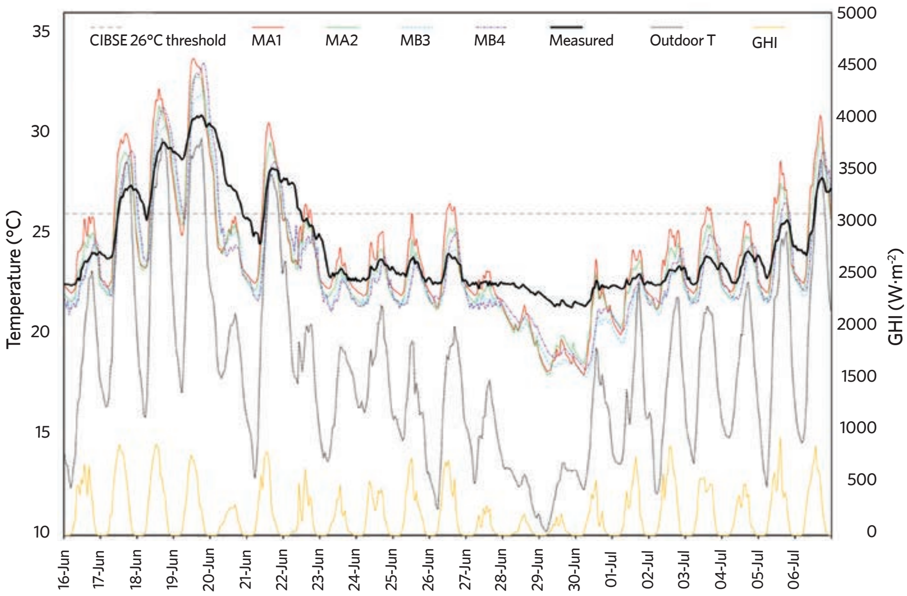


Figure 1: Operative temperatures measured in the front double bedroom of the house with operable windows and the temperatures predicted by each model, outdoor air temperature and global horizontal irradiance (GHI), compared with the CIBSE static threshold for bedrooms. MA1 = modeller 1 using software program A; MA2 = modeller 2 using software program B; MB3 = modeller 3 using software program B; MB4 = modeller 4 using software program B.

modelled and measured sleeping hours in the bedrooms over 26°C were similar for two of the bedrooms. In the open phase, all four modellers improved the prediction of hourly room temperatures during warm weather, suppressing – but not eliminating – the over-prediction of peak temperatures and diurnal swing. The prediction of overheating hours in the living rooms improved, but the differences between modelled and measured overheating hours in the bedrooms were largely unchanged.

“The model predictions deviated most on the warmest days – precisely when accuracy is most needed”

Inter-model comparison

It is often important to know whether the difference in overheating as a result of a design change is reliably predicted. Comparing annual predictions of indoor temperature with windows opening, following the TM59 protocol, with indoor temperatures with windows always closed showed that all models were consistent in their prediction that overheating in the bedroom would decrease with windows open.

There was variability in the predicted decrease in overheating hours, however. Quantifying the inter-model variability revealed that the predicted hours over the threshold might change if a different model or modeller were used to undertake the same analysis. So, when predictions are close to the overheating threshold, assessment of whether the overheating criteria are passed or failed is unreliable.

It is important that the uncertainty in predictions is accommodated if overheating risk assessment using dynamic thermal models becomes a regulatory requirement.

Further research is required to understand the causes of variation between model predictions of overheating and the reason for the differences from the measured temperatures. The test-house plans, modelling guidance, weather and temperature data used by the modellers in this study are publicly available (Roberts *et al*, 2019b).[2] CJ

This article is a summary version of ‘Predictions of summertime overheating: comparison of dynamic thermal models and measurements in synthetically occupied test houses’, published in CIBSE’s *Building Services Engineering Research and Technology* journal in July 2019. The paper was awarded the 2020 Carter Bronze medal for most highly rated paper relating to application and development.

Inside of the test houses, showing the automated window opening

References:

1 Roberts, B M, Allinson, D, Diamond, S, Abel, B, Das Bhaumik, C, Khatami, N and Lomas, K J, (2019a). Predictions of summertime overheating: comparison of dynamic thermal models and measurements in synthetically occupied test houses. *BSERT,* 40(4), pp.512-552.

2 Roberts, B M, Allinson, D and Lomas, K (2019b): *Prediction of overheating in synthetically occupied UK homes: dataset for validating dynamic thermal models of buildings.* Loughborough University Figshare Dataset. **doi.org/10.17028/rd.lboro.8094575.v1**

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Updated guidance on heat-recovery systems

In heating season, CIBSE says thermal wheels can remain on if properly configured and balanced

CIBSE says poorly configured or balanced systems must be remedied or bypassed

CIBSE and REHVA have updated their guidance on the use of heat-recovery systems during the Covid-19 pandemic.

CIBSE says there is no risk of spreading the Covid-19 virus in heat-recovery systems that have physically separated supply and extract airstreams – such as twin coil units or plate heat exchangers.

However, the advice for rotary heat exchangers (enthalpy/thermal wheels) is more complicated, because they may be liable to air leakage and moisture transfer between the supply and exhaust streams.

Version three of CIBSE *Covid-19 Ventilation Guidance* says leakage rates are very low for properly configured rotary heat exchangers fitted with purging sectors. Version three of REHVA's Covid-19 guidance document echoes this, saying that properly constructed, installed and maintained rotary heat exchangers have almost zero transfer of particle-bound pollutants. There is no evidence, it adds, that virus-laden particles larger than about 0.2µm would be transferred across the wheel. Because the leakage rate does not depend on the rotation speed of the rotor, there is no need to switch off rotors, REHVA's document says. The carry-over leakage is highest at low airflow, so higher ventilation rates should be used.

However, CIBSE says that poorly configured or balanced systems must be remedied or bypassed. Where this is not possible, the rotor should be turned off and ventilation rates increased as much as reasonably possible.

REHVA's document states the most common fault is fans being mounted in such a way as to create a higher pressure on the exhaust-air side. 'This will cause leakage from the extract air into the supply air.'

In the heating season, CIBSE advises turning on the rotor to ensure maximum reasonable outdoor airflows dilute any indoor viral contaminant: 'The expected reduction in dilution of any potential indoor viral source with lower flow rates is considered to be a greater risk for viral transmission than the potential for viral transfer across the thermal wheel. Turning the rotor on has the added benefits of maintaining the energy efficiency of the system and assisting (in the case of enthalpy wheels) with maintaining higher humidity levels in the building.'

Both bodies recommend a competent engineer inspects heat-recovery equipment, measuring the pressure difference and estimating leakage based on temperature measurement (see panel, 'Limiting air leaks').

LIMITING AIR LEAKS

REHVA's *Limiting internal air leakages across the rotary heat exchanger* guidance outlines measures that can be taken to reduce internal air leakage in ventilation systems.

It says the correct positioning of fans is important; the most recommended configuration includes both fans located downstream of the exchanger.

The next step is to set the correct pressure difference between the supply air side downstream of the exchanger and the extract air side upstream of the exchanger, ensuring the extract pressure is at least 20Pa less than the supply pressure.

The purge sector is a device that can practically eliminate the leakage resulting from the rotation of wheel (carry-over), REHVA says. Its location and setting (angle) must be arranged according to manufacturer guidance depending on the configuration of fans and pressure relations. Finally, the condition of perimeter and middle beam seals should be checked during periodic inspection and, if necessary, restored to its original state.

Read REHVA's specific guidance at bit.ly/CJSept20RHE

MVHR offers comfort in luxury home

Vent-Axia's High Flow mechanical ventilation with heat recovery (MVHR) units have been specified in a 1,300m^2 new-build home in Kingswood, Surrey. The system was combined with geothermal intake ducts, which harness ground energy to remove the extremes of outside temperatures. As fresh filtered air is drawn through polymer ducts – laid at a depth of 1.5-2.5m below ground – renewable geothermal energy is transferred to the intake air, providing natural warmth when it's very cold outside, and natural cooling when it's hot.

White paper focuses on HVAC maintenance

Daikin has published a white paper on indoor air quality that includes the latest information on standards, regulations and guidance. *Delivering Good Indoor Air Quality* also has a section on ductwork cleaning and maintenance.

The company also advises that further guidance, BS EN 15780: 2011: *Ventilation for Buildings. Ductwork. Cleanliness of Ventilation Systems*, specifies the required cleanliness levels for supply, recirculation and extract air, grouped into three classes – low, medium and high – depending on building use.

Boiler and heat pump hybrid SAP-approved

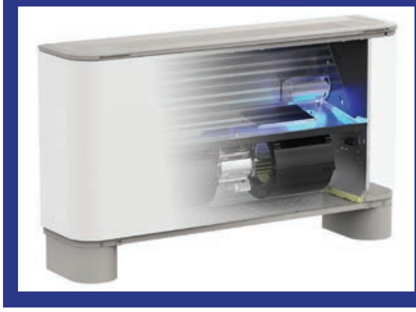
The first integrated boiler and heat pump hybrid has received SAP recognition. Sime's Murelle Revolution uses a 30kW boiler and factory-sealed 4kW output air source heat pump, and complies with Part L of the Building Regulations. Phil Birchenough, Sime product manager, said: 'Harnessing the benefits of air source heat pump and boiler technology in the same casing allowed us to incorporate a flue gas heat-recovery device as part of the heat-pump circuit. This plays a major role in the efficiency of the appliance.'

UV fan coils installed

More than 90 Aermec UV fan coil units have been sold for a major London office development, and used in several hospital projects.

The FCZ-H unit incorporates an ultraviolet C (UVC) germicidal lamp with a titanium dioxide (TiO_2) surface. When radiated by the lamp, Aermec says any pollutants in the airflow are broken down into harmless substances by free radicals created by the UVC and the TiO_2 surface. The UVC lamp is shielded, so the device is harmless and has no effect on people in the room, the manufacturer says.

Aermec is planning to roll out UV lamps across its heat recovery ranges.



Environmental group campaigns for propane

The EIA wants HFCs in single-split air con units to be banned

An environmental pressure group is calling for HFC refrigerants to be banned from use in single-split air conditioning units across Europe.

The Environmental Investigation Agency (EIA) issued the demand as part of its submission to the review of the European F-Gas regulation. It recommended more propane gas – also known as the hydrocarbon refrigerant R290 – be used in its place, and for an increase in the amount of propane allowed in residential air conditioning.

The agency quoted research carried out by the German institution Öko-Recherche, which concluded that switching to propane in Europe could save up to 62Mt of CO_2 equivalent emissions by 2050 – the same climate benefit as running up to 13,385 wind turbines for a year. A worldwide ban from 2025 could result in savings of 5.6Gt CO_2e, it estimated.

Öko-Recherche looked at the climate impact of a revised product standard, together with an EU ban on HFCs in split air con units from 2025, and examined the climate impacts if a similar policy was rolled out globally.

EIA climate campaigner Sophie Geoghegan said the proposed changes would 'enable more climate-friendly and efficient cooling appliances to come to the marketplace, and will build confidence in flammable refrigerants for installers and consumers'.

The European Commission's consultation on the review of F-Gas regulations closes on 7 September. There will then be a public consultation with changes finalised late next year.

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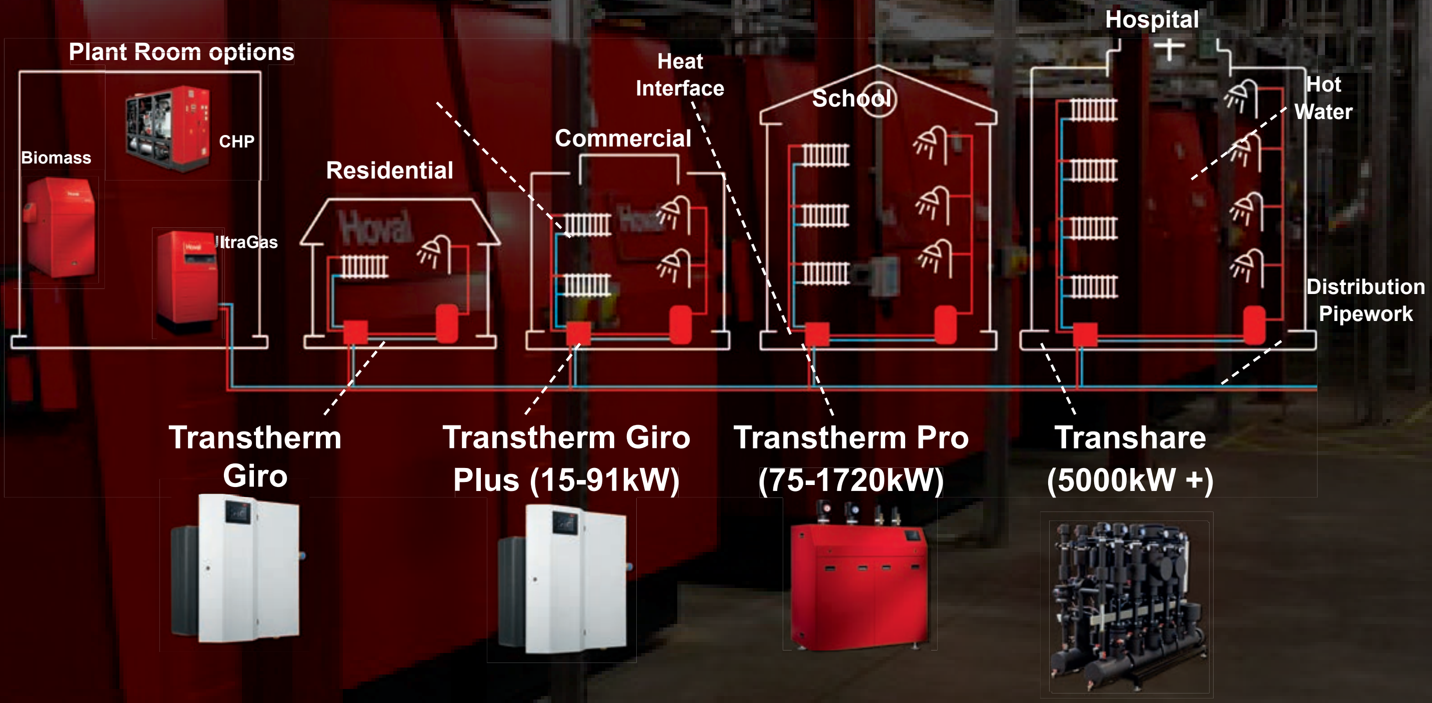

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An appropriately specified Hepa filter can be used in mechanically ventilated spaces and recirculating systems to practically remove small airborne particulates. *CIBSE Journal* technical editor **Tim Dwyer** looks at what must be considered when integrating them into HVAC systems

UNDERSTANDING HEPA FILTERS

As the world returns to work, the loading of particulates in the outdoor air is rising to pre-pandemic levels and, in many areas, is reported as already above 2019 levels.

The range of particle sizes is vast (see 'The filtering challenge' panel). Larger dust particles may be readily removed from an airstream with low cost, low air pressure drop, panel and bag filters specified to standard EN ISO 16890:2016 'Air filters for general ventilation'.

However, as particles become smaller, it is more challenging to capture them while maintaining a workable pressure drop and reasonable filter longevity. It is these smaller particles – particularly those categorised as PM 2.5, PM 1.0 and ultrafine – that have been identified as having significant detrimental impacts on health.

An appropriately specified and installed high efficiency particulate air (Hepa) filter may be used in mechanically ventilated spaces and in recirculating systems to practically remove these smaller, airborne particulates.

Hepa filters, such as the simplified example in Figure 2, are used routinely in laboratories and operating theatres to protect against infection from airborne virus and bacteria and are capable of filtering ambient particulates from vehicles and combustion processes (such as wood burning).

In CIBSE's current Covid-19 guidance, it is noted that for poorly ventilated spaces with a high occupancy and where it is difficult to increase outdoor ventilation rates it may be appropriate to consider using air cleaning and disinfection devices known as (recirculating) room air cleaners. To be effective, air cleaners need to have at least Hepa filter efficiency (and/or potentially use germicidal UV (GUV) radiation) and to have a substantial part of room air pass through them.[1, 2]

Standards

There are several national standards for Hepa filters that have evolved over the past 80 years, however, ISO 29463 'High efficiency filters and filter media for removing particles from air' – derived from EN 1822 'High efficiency air filters (EPA, Hepa and Ulpa)' – provides the appropriate benchmark for all global applications by defining 13 different filter classes ranging from ISO 15 E to ISO 75. (The ISO was designed to accommodate the practices of other national standards including those from the US and Japan.)

In Europe, ISO 29463 co-exists with a revised EN 1822 standard that maintains its own equivalent classification system for air filters so retaining the designations of Hepa filter classes that are familiar to many – H13 and H14 – and having test methods that are in accordance with ISO 29463 Parts 2-5.

Hepa is designated in ISO 29463 in the range ISO 35 H-ISO 45 H and sits between efficient particulate air (EPA) and ultra-low penetration air (Ulpa) filters. A key difference between ISO 29463 and various national standards is that, instead of testing mass relationships or total concentrations, the assessment of filter efficiency is based on particle counting at the most penetrating

THE FILTERING CHALLENGE

CIBSE Guide B2 'Ventilation and ductwork' section 2.3.3 notes that particles are not generally referred to as 'dust' unless they are smaller than 80µm (adult human hair is around 100µm in diameter).

Construction activity can add significant particulates to the air, such as concrete dust, typically from 3µm up to 100µm and clay 0.1µm to 50µm. Smoke particles vary considerably in size from about 0.3µm downwards, with fumes being formed of solid particles, predominantly smaller than 1.0µm (PM 1), formed by the condensation of vapours.

Ambient radioactive particles, as discovered in the vicinity of nuclear incidents, are typically measured as small as 0.2µm. Particulates from diesel combustion are most numerous at sizes less that 0.1µm (PM 0.1 or 'ultrafine'), and viruses such as the coronavirus species are thought to be in a similar range, from 0.06 to 0.2µm – several hundred times smaller than a human hair.

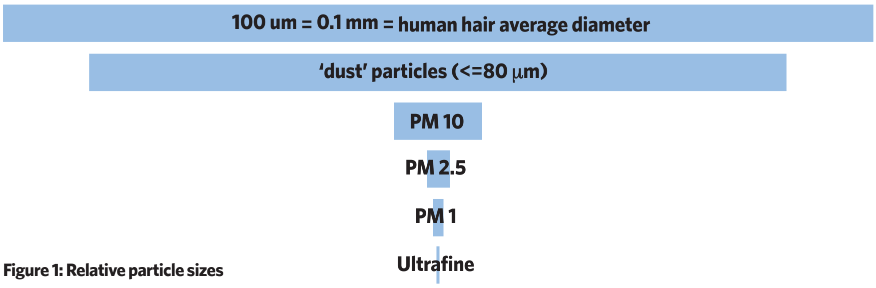


Figure 1: Relative particle sizes

> "The integrity of a leak-proof, properly designed, accessible, serviceable housing for the filter is essential as, otherwise, at least some of the airstream will bypass it"

particle size (MPPS), using a standard aerosol, which will depend on the particular filter media and construction.

MPPS identifies the worst-case size for particle capture and, by virtue of the multimodal Hepa filtering mechanisms, smaller and larger particle sizes will be removed with a greater effectiveness.

There is a widespread misunderstanding that particles smaller than the MPPS will pass through the filter – this is not the case (see panel 'Mechanisms of filtration').

For example, micro-glass filter mediums (such as pleated borosilicate glass fibre media) or polymeric media (mixed fibre media that can provide enhanced consistent performance characteristics) would – as shown in the example in Figure 3 – typically have a MPPS in the range of 0.12µm to 0.25µm. However, for larger, and smaller, particles the capturing efficiency will rise.

So as to meet the H13 and H14 requirements, the Hepa filter must, on average, remove at least 99.95% and 99.995% of particles respectively at the specific MPPS for that filter (the size of the most penetrating particle is discovered in a media pre-test prior to determining the final efficiency.)

The US Department of Energy (DOE) »

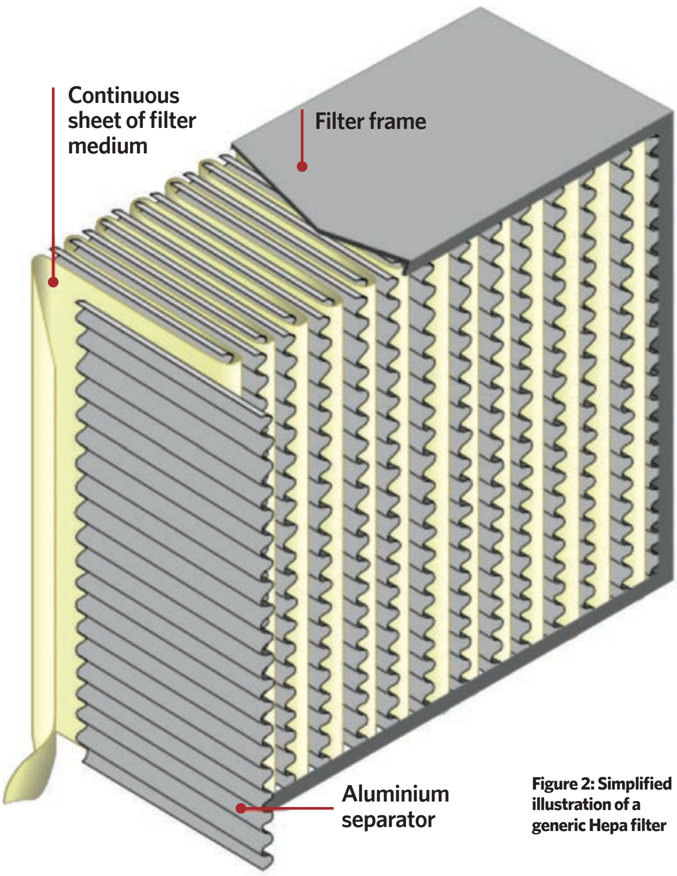


Figure 2: Simplified illustration of a generic Hepa filter

» standard, adopted by many US-originated products, requires a Hepa filter to remove at least 99.97% of airborne particles specifically at 0.3µm in diameter. An example of a commercially available H14 class Hepa filter tested to EN 1822:2019 with an airflow of 0.944$m^3 \cdot s^{-1}$ has a clean overall airside pressure drop of 250Pa to give approximately a minimum 99.995% overall efficiency at MPPS. (The economic point for this filter to be replaced is considered to be when air pressure drop is approximately 510Pa).

The EN1822:2019 test standard (as per part 3 of ISO 29463) requires that the Hepa filter media to be tested as a flat sheet for MPPS before manufacture, since batches of the same media, from the same manufacturer, can vary.

Air filters should be tested to a recognised and current performance standard – there are many products that use the term 'Hepa' without an appropriately certified test. Hepa filters that are marketed where MPPS is simply 'believed to be 0.3µm' is not appropriate for today's Hepa applications. All UK/European Hepa filters should be individually tested and certified to EN 1822:2019.

MECHANISMS OF HEPA FILTRATION

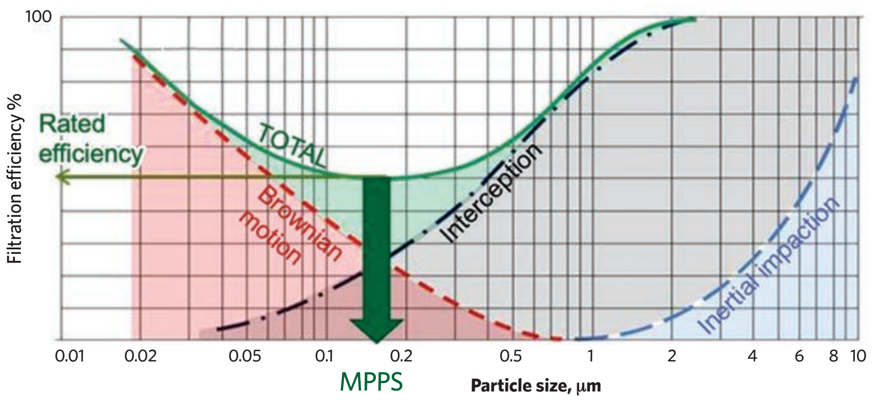
Inertial impaction occurs when large particles are unable to quickly adjust to changes in the flow stream around the fibres, so they impact with a fibre and are captured.

Interception is where a particle comes within one particle radius of a fibre and is trapped by the fibre.

Brownian motion is where very fine particles create a random path through the media that increases the probability of the particle contacting a fibre and being captured.

There will also be an electrostatic effect as a result of the inherent static charge as air moves across the filter media, although in most cases this is not a dominant effect.

Figure 3: Key modes of particle capture in an example Hepa filter with a MPPS of 0.16µm (based on diagram provided by Camfil)



BS EN 1822-1 2019			ISO 29463-1 2017		
Filter class and group	Overall value Efficiency (%)	Overall value Penetration (%)	Filter class and group	Overall value Efficiency (%)	Overall value Penetration (%)
E10	≥ 85	≤ 15			
E11	≥ 95	≤ 5	ISO 15E	≥ 95	≤ 5
			ISO 20E	≥ 99	≤ 1
E12	≥ 99.5	≤ 0.5	ISO 25E	≥ 99.5	≤ 0.5
			ISO 30E	≥ 99.9	≤ 0.1
H13	≥ 99.95	≤ 0.05	ISO 35H	≥ 99.95	≤ 0.05
			ISO 40H	≥ 99.99	≤ 0.01
H14	≥ 99.995	≤ 0.005	ISO 45H	≥ 99.995	≤ 0.005
			ISO 50U	≥ 99.999	≤ 0.001
U15	≥ 99.9995	≤ 0.0005	ISO 55U	≥ 99.9995	≤ 0.0005
			ISO 60U	≥ 99.9999	≤ 0.0001
U16	≥ 99.99995	≤ 0.00005	ISO 65U	≥ 99.99995	≤ 0.00005
			ISO 70U	≥ 99.99999	≤ 0.00001
U17	≥ 99.999995	≤ 0.000005	ISO 75U	≥ 99.999995	≤ 0.000005

Filter efficiency is for most penetrating particle size (MPPS)

Table 1: Hepa filter classification comparison – European and global

AHU integration

It is unusual to retrofit Hepa filters directly into an existing AHU. However, if a need arises, it would be more likely to mount the Hepa filters into a ducted housing downstream of the AHU.

The integrity of a 'leak proof', properly designed, accessible, serviceable housing for the filter is essential as, otherwise, at least some of the airstream will bypass it.

The air pressure drop across a Hepa filter is likely to be two or three times that of a general purpose panel filter – it is important to select Hepa with the lowest pressure drop as well as having a long serviceable life. (For example, 50Pa added to the pressure drop through a filter passing 1$m^3 \cdot s^{-1}$ will consume an additional 1.2kWh of fan power every 24 hours that, taking fan and motor efficiency into account, will likely cost in the order of £75 per year (at UK electricity prices).

Since Hepa filters usually have very fine pleated paper media that can be easily clogged by coarse dust, pre-filtration is used to remove most of the larger particulate matter and PM10s from the airstream – this will prolong the life of the Hepa and is likely to cut the total life-cycle cost of the total filtration installation.

The specific selection of the filter pair will benefit from some modelling of individual cases (as simple as a spreadsheet model) since it will be dependent on the contaminant load in the air, the cost of fan power and the capital and maintenance costs of the filters.

As a result of capital and operational cost, it is unlikely that Hepa filters will be fitted in general HVAC AHUs in the near future, however, their selective application can allow systems to provide safer environments when challenged with air that is otherwise gravely contaminated with fine particulate matter. **CJ**

References:

1 Covid-19 – Emerging from lockdown – safely re-occupying buildings v3, CIBSE, 19 May 2020.
2 Covid-19 Ventilation guidance v3, CIBSE, 15 July 2020. Up-to-date editions of the CIBSE covid guides are freely available at **bit.ly/CJSep20Hepa1**

With thanks to **PETER DYMENT**, technical manager at Camfil

PLANT ROOM

By using thermal storage in buildings with cooling and heating requirements, designers can cut energy use, reduce HVAC plant and, potentially, free up space for rooftop gardens. **Joshua Martoo** reports

Millennium Bridge House has a prime position overlooking the River Thames. Thermal storage means freeing up space for a rooftop garden, designed by Andy Sturgeon

In a world reliant on rechargeable batteries, storing energy can improve the viability of renewable technologies as we strive to deliver greener buildings in healthier cities. Thermal-storage vessels are, essentially, batteries – used to heat and cool buildings – and the opportunity to integrate this concept into new and existing building designs should not be overlooked.

While thermal-storage systems are not new, the focus, generally, has been on using them for heating and cooling purposes or large industrial processes. However, they are also being used in commercial office and residential developments for heating and cooling – and, therefore, heat recovery.

The need to improve air quality and decrease the carbon impact

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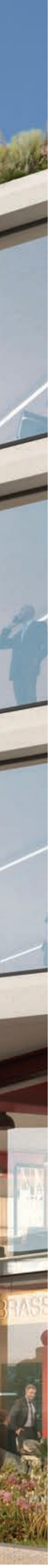

buildings have on the environment is essential to help combat the current climate emergency. Recently proposed carbon factors have led to the use of gas within London seemingly being phased out, with 'all electric' buildings being favoured.

All-electric heating, particularly in colder climates, can be challenging to implement with ever decreasing rooftop plant space and limited electrical infrastructure. Air source heat pumps, for example, do not perform well in very low ambient conditions – when they are needed most – but are very efficient at high ambient temperatures.

This inherent problem can be solved with thermal storage, by producing and storing heat when ambient conditions are more favourable and using the stored heat when it's required. Storage systems can shift loads from peak to non-peak times, reducing operating costs and improving plant efficiency. Similarities can be drawn with the daily usage cycle of a mobile phone: charging the device overnight when not in use and discharging it throughout the day as required.

Thermal storage opportunities

A thermal store is essentially a large thermal-energy battery – or, more specifically, a device to absorb or give up heat over time to heat or cool buildings. Typically, water is contained in insulated storage tanks filled with stratified chilled or low-temperature hot water. The sizing of these systems can be designed to meet a portion of short-term peak, daily, or even weekly cooling or heating loads.

The opportunity for heat recovery becomes available when chilled and hot water thermal-storage systems are linked. Cooling systems normally reject heat to atmosphere, but with hot-water thermal storage, it can be captured, and used at another time for domestic hot water and space heating.

The design and size of the tanks can allow peak loads, usually seen at the primary plant, to be reduced, allowing significant reductions in plant size. Traditionally, a building's plant is designed to deal with peak loads that may exist for a very small portion of the year, if ever. This means the full capacity of these systems is rarely – if ever – used. Optimising plant size by using thermal-storage systems will reduce capital expenditure and make more frequent use of its available capacity.

The thermal-load profile of the building is decoupled from the operation of the heating and cooling systems, providing increased flexibility, reliability and efficiency. For a cooling-dominant building, heat-generation plant may not be required. Charging of tanks can be done during off-peak electricity tariffs, further reducing overall energy costs and payback periods.

The rooftop terrace is visible from Tate Modern

Typical thermal-storage tanks use thermal stratification, where warmer and less dense water floats atop cooler water. Chilled water is drawn from the bottom of the store and returned to the top. This is done at a very low velocity, to prevent any induced inertial effects that may mix the water and disrupt the temperature differentials. As the load from the building is decoupled from the cooling plant, chillers or heat pumps can operate at their most efficient, and may not be affected by non-favourable external conditions or the normal variable building loads. The chillers can be turned off during the warmest part of the day, despite this coinciding with the peak cooling loads.

With thermal storage, a nominal peak day can result in cooling plant operating continuously over 24 hours to charge the tank and support the peak demand. A nominal peak cooling load of a building of more than 2,000kW can be met by 1,000kW in primary cooling plant if sized appropriately. The storage system in this example will be full before the building's normal operating hours and discharged at the end of the working day.

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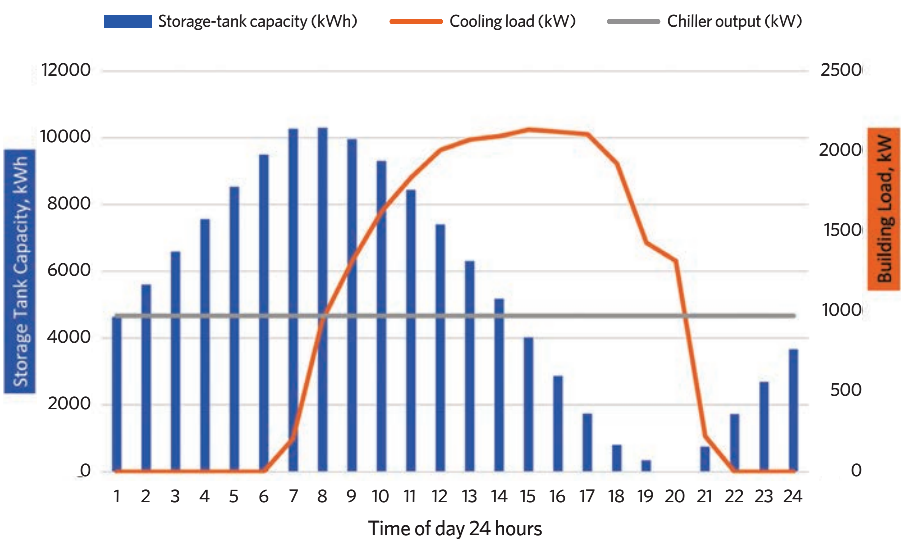
"As the load from the building is decoupled from the cooling plant, chillers or heat pumps may not be affected by non-favourable external conditions"



Thermal storage tank capacity and building load

» Water-side free cooling may be appropriate in very cold climates at normal chilled water temperatures (6°C) and in temperate climates where there is a use for chilled water at a supply temperature of 10°C or higher. Manufacturers of free cooling air cooled chillers advise that some free cooling is available once the ambient temperature falls to 3K below return chilled water temperature.

Challenges and benefits in refurb and new-builds

For efficient, high-density energy storage, large temperature differentials are required; at least 10K is desirable. Most air source heat pumps and air or water-cooled chillers cannot generate large enough temperature ranges for storage systems unless cascade arrangements are used. There is currently a very small selection of suitable products on the market that can produce efficiently the required water temperatures for storage, so refrigeration technology must adapt to support these conditions if thermal storage is to be a common solution for buildings in the future.

Phase-change materials can offer denser energy storage, but are limited and, historically, operationally unreliable. Further, very large volumes and usable space for the storage tanks are required. The spatial requirements can be challenging; usually, these tank installations require very tall tanks and huge volumes of water.

An obvious benefit of integrating thermal storage into a building's design is that primary heating and cooling plant capacity can be reduced, thereby also reducing plant area and electrical infrastructure. Buildings can change their peak electrical demands to be more diversified, and make use of off-peak tariffs.

Reducing plant areas can enable more flexible rooftop designs. Take, for example, the recently approved refurbishment of Millennium Bridge House in London. Norman Disney & Young's (NDY's) thermal-storage design negates the need for heating or cooling plant to be roof-mounted, so allowing more than 2,500m² of roof space to be used by the public, retail and office building tenants. The existing building's roof offered no rooftop amenities, and all usable space was dedicated to HVAC plant. This Breeam excellent scheme – developed with Piercy&Company Architects for Angelo Gordon and Beltane Asset Management – uses large chilled and low-temperature hot-water storage tanks, located in the existing basement, with water-cooled chillers to transfer and recover heat. Using chilled and low-temperature hot-water tanks in this way allows for full heat recovery, so no primary heating plant is required.

The dry air coolers, located on the level 2 façade, reject heat from the water cooled plant in the basement when the heating storage systems are full. We have, therefore, avoided excessive pipework routes to roof level, reducing pumping energy and riser space while keeping the rooftop free of HVAC plant.

Thermal-storage systems offer engineers an opportunity to challenge how new and existing buildings are designed. There could be a more sustainable future in which primary heating plant isn't needed in office buildings as we push towards net-zero carbon design. CJ

JOSHUA MARTOO is a senior project engineer at Norman Disney & Young

TAKING THE HEAT OUT OF THE CLASSROOM

Increased use of computing in schools is causing a rise in cooling loads that can result in air conditioning being in conflict with heating. Science teacher **Chris Baker** looks at four methods of reducing cooling requirements at Parrs Wood High School

Gas consumption has decreased in schools because of improved building fabric, but electricity consumption has increased, and is generally attributed to greater use of information and communications technology (ICT) equipment[1] and associated comfort cooling. For new build schools, ADL2A gives guidance on measures to avoid cooling fighting heating.[2] However, this is often not possible in existing builds, where air conditioning is retrofitted into computer rooms sited in larger, wet central heating zones.

This report considers four methods available to existing schools to minimise increased energy consumption resulting from cooling fighting heating. It shows that, with careful planning, significant savings can be made at little or no cost and that, for schools, low energy hybrid thermal mixing (HTM) units are currently not a financially viable retrofit alternative to a traditional air conditioning unit. Research for the report was carried out at Parrs Wood High, a large state school in Manchester, and much of the data was collected by the student sustainability CO_2 team.

Simultaneous cooling and heating occurred in 12 (7.5%) classrooms, each of which has a split air conditioning unit under full occupant control (in total, 30kW of electrical power). The building is divided into heating zones, each with seven rooms, a zone-thermostat in one of them. Typically, one or two of these rooms have been converted into computer rooms, increasing each room's peak cooling loads by around 1.6kW. This has caused them to overheat not only in summer, but also in winter, when the heating was on and occupants turned on the air conditioning.

Turning the heating down wasn't an option, as the other rooms in that zone would be underheated. Thermostatic radiator valves seem an obvious solution, but they are easily tampered with and, to date, we have not found any that are robust enough to survive in a school environment.

Method 1: Improve control of air con units

Cooling fighting heating was minimised in two ways. First, occupants were stopped from using excessively low air-conditioning setpoints. As the heating was set at 20°C, the cooling setpoint was limited to no lower than 21°C.

Second, the operating times of air conditioning were minimised. An analysis of the main-school computer rooms showed that, during occupancy hours, they were empty for 25% of the time because of 'free periods' and lunchtimes. Use of a run-on timer reduced waste operation caused by units running when rooms were empty. The run-on time and set point were limited by using the password-protected features of the room controllers – although, in a few instances, older controllers did not have these features, so the units were time-limited by installing an occupation sensor in the room, at a cost of about £100.

The operating times of the air conditioning units were monitored using low-cost data loggers, and the operating times during occupancy were found to be reduced by 47% (400 hours) over the heating season – considerably greater than the target reduction of 25%. (There were further savings from the avoidance of overrun outside of occupancy hours, but these are not included here.) This equates to around 7,200kWh of electricity, giving annual savings of £792 and $3tCO_2$. A thermal comfort survey and monitoring of room temperatures showed no marked change in thermal comfort levels.

Greater use of ICT equipment in schools accounts for their increased electricity consumption

Parrs Wood High School in Manchester has nearly 2,000 pupils

Method 2: Locate computer suites in rooms with lowest heat gains

Heating distribution pipe and solar gains vary considerably between rooms, and a significant reduction in cooling load can be achieved by simply siting computer suites in rooms with low heat gains.

Rooms at the start of a zone have higher uncontrollable heat gains from higher-temperature distribution pipes with a larger bore and, typically, have only one radiator. Rooms at the end of a run have smaller-bore, cooler pipes and two radiators. So, a larger percentage of the heat – two radiators instead of one – can be turned off at the end of a zone run, offering a greater reduction in cooling load. (Note, this is not the case with self-balancing systems, where there are flow and return pipes at both ends of a zone.)

The distribution pipe heat gains at the start of a zone were found to be 1.8kW, but only 0.6kW at the end of a zone, a reduction of 1.2kW.

Total gains from ICT equipment were around 1.6kW, and can almost be offset by locating computer rooms at the end of a heating zone run. This assumes radiators can be turned off; if they cannot, because of broken or missing knobs (common in classrooms), it's worth repairing them. Avoiding rooms with circulation pipes for DHW also helps, as these were found to emit about 1kW of heat all year round.

"A significant reduction in cooling load can be achieved by simply siting computer suites in rooms with low heat gains"

Additionally, north-facing rooms have less solar gain. CIBSE heat gain data was used to compare typical gains in classrooms at our location.

Solar gain is particularly high in the spring and autumn, and was found to be as high as 2.8kW in a south-facing room, but only 0.4kW in a north-facing one, so 2.4kW lower than the south-facing room. This means combined avoidable heat gains can reach 3.6kW. From the heat-gain model, the total average room gains were around 10kW, so the avoidable gains represent a significant proportion of the cooling load.

By siting computer suites in north-facing rooms at the end of a zone run, the need for comfort cooling can be reduced significantly, if not eliminated. In some instances, this simply means relocating the computer room to the opposite side of the corridor, so key services – such as intranet and power cables – are still available.

Some methods of reducing heat gains proved unviable at Parrs Wood (see panel, 'Unviable methods of reducing heat gain').

Method 3: Cluster IT classrooms into a single heating zone

If all rooms in a single heating zone are computer rooms, the heating in that zone can be reduced significantly, cutting the heat gain by, typically, 2.5kW. This has worked well in one heating zone, where cookery and computer rooms are clustered together. The heating warms the »

UNVIABLE METHODS OF REDUCING HEAT GAIN

The following methods would not work in Parrs Wood's classrooms:

i. Thermostatic radiator valves: not robust enough for school use
ii. Reroute heating distribution and DHW circulation pipes to avoid computer rooms: prohibitively expensive (based on contractor quotes)
iii. Insulate exposed central heating and DHW pipes: insulation would need protecting with wood or plastic cladding, which is inexpensive, but installation would be time-consuming because of the layout of the pipes and other obstructions
iv. Increase ventilation from windows: not an option as most computer rooms are on the first floor for security, so have window restrictors. HSE advises a maximum opening of 100mm,[3] which limits ventilation.

An ICT room at Parrs Wood High School with a split air conditioning unit

COST OF RETROFITTING HTM UNITS

Quotes were taken from two leading HTM and two air conditioning contractors (early 2019 prices):

- **Ground-floor room (easy access for installation): total installed cost of HTM unit £5,585 v split air conditioning unit £2,533. At more than twice the cost, we calculated it would take the lower energy HTM unit more than 50 years to pay for itself**
- **First-floor room (more difficult access for installation): at £7,789 v £2,533, it would take the HTM unit around 100 years to pay for itself.**

» rooms on a cold morning, but the zone-thermostat shuts it off once other heat gains become significant.

Clustering all computer classrooms together does pose difficulties: each of the 10 subject faculties requires one or two such rooms in their area of the school. There would also be increased installation costs, as the majority of heating zones do not have enough spare fuse ways to support the additional 32A ring main required for each computer room. An additional distribution board would have to be installed and wired back to the main incomer.

Method 4: Provide comfort cooling with HTM ventilation units

After the launch of the Priority Schools Building Programme, the guidelines for thermal comfort in schools were reviewed in 2016[4] and the adaptive thermal comfort criteria of TM52 were adopted. The new guidelines aim to avoid overheating using low-energy solutions – a combination of natural and mechanical ventilation instead of mechanical *cooling*. Additionally, outside air should be premixed with room air to avoid draughts.[5]

As a result, several companies have developed hybrid thermal mixing (HTM) units that cool classrooms by mixing in outside air. Cooling results from increased air velocities and, as there's no compressor to power, they are cheaper to run than traditional air conditioning. Unlike air conditioning, they are also intended for use with open windows. The guidelines apply to new schools, but a comparison was carried out to see if HTM units offer a viable, low-energy alternative in existing schools.

The costs of installing both types of cooling were assessed in two computer rooms: one on the ground floor, with easy access and a working height of less than three metres, and one on the first floor, requiring scaffolding or a hydraulic lift. HTM units channel large quantities of outside air into a room and need an air duct through the external wall that is considerably larger than the refrigerant feed pipes of a split air conditioning unit – in this case, 900mm by 300mm. Forming the opening and installing the outer cowling increases installation cost, especially at heights above three metres (see panel, 'Cost of retrofitting HTM units').

Compared with an air conditioning unit, the payback times are far longer than the 20-year life expectancy of the HTM unit. Additionally, for energy efficiency Salix funding, the payback times exceed the maximum of eight years and, at £338 per lifetime tonne CO_2 saved, it exceeds the Salix criteria of £200 per tonne.

National trials of HTM units confirmed improved thermal comfort levels and reduced CO_2 levels compared with natural ventilation and identified a 'potential' to lower capital costs. However, this was based on the reduction in building costs from avoidance of central AHU ventilation feeding large numbers of rooms,[5] as opposed to the cost of retrofitting a single air conditioning unit. The trial report also expected maintenance costs to be lower for HTM units.[5] However, maintenance contracts offered in this study were about the same price as for standard air conditioning. Some of our air conditioning units are 15 years old and have not required any mechanical repairs, only the annual service.

HTM units also work out expensive in rooms without wet central heating, such as new-build extensions. A heater in the HTM unit would need to be powered by electricity – which would be more expensive to run than a heat pump, as it would not benefit from a coefficient of performance – or it could be heated by a heat pump, which could be used on its own to condition the space, so would be the cheapest option.

Conclusions

When converting classrooms into computer suites in existing wet heating zones, the most cost-effective way of minimising comfort cooling costs is to use rooms with low heat gains. Use of a run-on timer and setpoint control is also good practice and can reduce the running cost of a 2.5kW unit by about 47% (£66) a year. Avoiding cooling fighting heating by clustering computer rooms into one heating zone is effective, but generally impractical because of other logistical considerations.

HTM units have several benefits and offer an excellent solution in new-build schools. However, the capital cost is currently prohibitively high and they incur greater installation costs when retrofitting.

The low-cost solutions outlined above are set to become more effective as computers become more energy efficient and are run increasingly by power over ethernet fed from solar PV installations, further reducing heat gains. **CJ**

CHRIS BAKER is a science teacher and coordinator of the student CO_2 sustainability team. **c.baker@parrswood.manchester.sch.uk**

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SAFE RETURN

As children across the UK return to the classroom, schools have had to devise Covid-secure services strategies to safeguard pupils and staff. **Chris Baker** details the plan for safe air conditioning at Parrs Wood High School

Parrs Wood High School in Manchester has devised an air conditioning strategy to mitigate the risk of airborne transmission of Covid-19. The planned operation of air conditioning units and air handling units (AHUs) is based on CIBSE and REHVA guidance.

Air conditioning units

The school has 40 split air conditioning units and heat pumps and, at the start of the pandemic, there was uncertainty over their use because they don't introduce fresh air into a room, but recirculate air within it. Such units are increasingly common in UK schools; they are often retrofitted in computer rooms for comfort cooling, or used in new-build classrooms instead of wet central heating.

We initially isolated our units after guidance from REHVA, to turn off local recirculation units in spring to avoid resuspension of virus particles at room level, and because of concerns after an outbreak associated with air conditioning in a restaurant in China. However, the guidance on local recirculation units – such as fan coils and splits – has now been updated by REHVA.[1] It says units can be left on as long as the levels of ventilation are increased during occupation, either by mechanical systems or by openable windows.

CIBSE also gives a clear explanation of how it could have a beneficial effect by helping to better mix fresh air with room air.[2] Its advice states: 'If a local recirculation unit enhances air disturbance and, hence, helps reduce the risk of stagnant air, then this should be considered when developing a strategy.'

We noted from the guidance that air speed is a critical factor in the spread of the virus. Stronger air currents could carry particles further, increasing the inhaled viral load at a distance. It seemed sensible to minimise this by running our units at low fan speed and adjusting the louvre angle to direct air across the ceiling, not down at surfaces or occupants. Unfortunately, our older room controllers do not allow us to lock these settings, so we will have to publicise these instructions to staff.

One concern raised by REHVA regarding air conditioning is that it allows occupants to achieve thermal comfort without the use of windows, so rooms may not be ventilated properly.[1] We shall, therefore, make it clear that windows should be open at all times.

Recirculation of indoor air was prevented in AHU crossover heat exchangers

"A soft-button was added to the BEMS control page to ensure the unit would remain on 100% fresh air, even in cooler weather"

REHVA and CIBSE recommend that the units are operated continuously, as the pressure shock at switch on could dislodge viral particles from room surfaces and internal air filters, resuspending them in the air. For us, however, this is unlikely to be successful, as our air conditioning temperature controls exhibit a large degree of hysteresis, and occupants revert to on/off control to achieve thermal comfort.

Finally, the effectiveness of window ventilation depends on weather conditions,[2] and most of our classrooms do not have air conditioning to help mix fresh and room air. If we find any rooms are not ventilated sufficiently by open windows, we will consider using a low-speed desktop fan or freestanding HEPA filter unit.

Air handling units

Our AHUs, each with a cross-flow heat exchanger, allow some mixing of incoming and exhaust air because of the perforated design of the separating walls. The guidance warns of the risk of virus particles being carried from the exhaust to the supply air via heat-recovery systems. To stop this, a soft-button was added to the BEMS control page to disable heat recuperation and ensure the unit remains on 100% fresh air, even in cooler weather. To prevent this setting being turned off accidentally, the actuators have been removed from the fresh air dampers on the AHUs. We visually inspected the damper first to ensure it was in the correct position. The running time will also be increased to two hours either side of occupancy.[1] **CJ**

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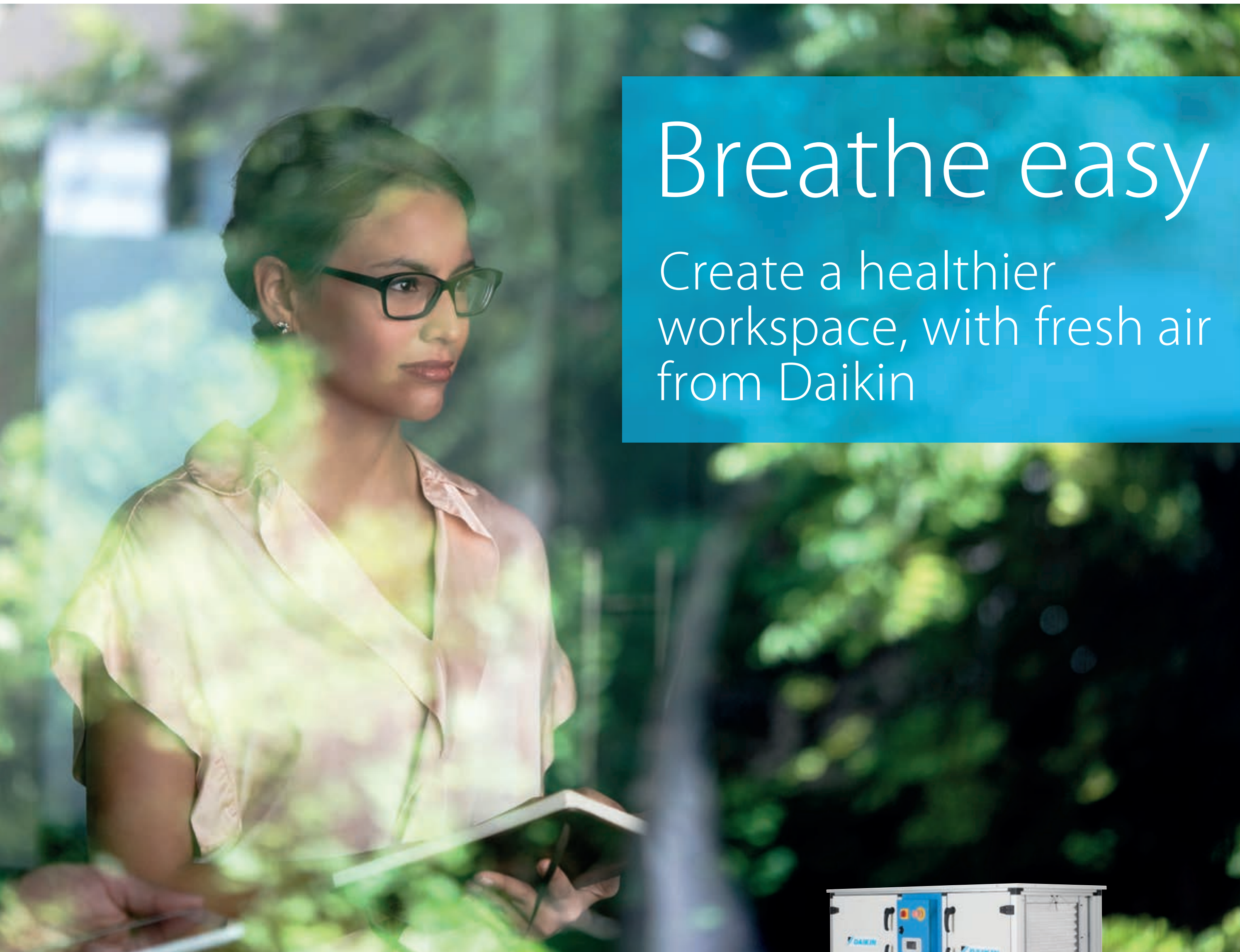
Indoor Air Quality



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Airflow needs to be consistent throughout the whole cross-section of a range

STRAIGHT SHOOTING

A planned and tested ventilation strategy is vital in indoor shooting ranges, says **Roy Jones** of Gilberts Blackpool

With any indoor space, there are right and wrong ways to ventilate. In firing ranges, however, the consequences of poor ventilation can be explosive, so it is even more crucial to get it right.

Research in the USA has shown that it can take up to two hours for potentially harmful particulate concentrations to return to pre-shooting levels in an unventilated indoor range.[1]

Practical considerations

Ventilation in a firing range is not just a matter of controlling airflow so that it does not adversely affect the flight path of the projectile. It also has to address the build-up of pollutants resulting from the bullets – primarily lead particles, but barium, copper and arsenic can also be found depending on the bullets used. In addition, unburnt propellant needs to be removed, while carbon monoxide from the action of shooting, and carbon dioxide from the shooters' breathing, also has to be dealt with.

In the UK, the primary guidelines to follow are set out in the Ministry of Defence and Defence Safety Authority's Joint Service Publication (JSP) 403 – specifically, volume 2 of the handbook, which explains the design and construction of ranges for military small arms and infantry weapon systems.

It lays down specifications for the control of hazardous substances in indoor ranges. In particular, it identifies that enclosed/indoor ranges ought to be ventilated – mechanically or naturally – to address the potential hazards of lead (under the Control of Lead at Work Regulations), unburnt propellant, dust, and carbon monoxide (see panel, 'Ventilation guidance for shooting ranges').

The design concept

Air needs to be changed to ensure appropriate indoor air quality for the shooters, while minimising air turbulence; potentially harmful particles are removed as far as practically possible; and that the shooter is not exposed to draughts (velocities exceeding $0.5 m \cdot s^{-1}$).

Airflow needs to be consistent throughout the whole cross-section of the range, to accommodate differing firing positions and stances: prone, kneeling and standing. These are typically measured and checked on the range at 0.3m, 0.8m and 1.5m from finished floor level.

Laminar flow is the choice for such steady airflows; air travels smoothly in regular paths to avoid irregular fluctuations and unwanted air mixing. This pulls air down the range from behind the shooting position, with extract rated around 10% greater than the inlet supply air provided, to produce a negative pressure down range, at the opposite end, in the bullet-catching areas.

In a small range that is infrequently used (less than daily), a simple fan input at the firing end and fan extract at the shooting end may suffice, again ensuring negative pressure within the range. This must still be controlled carefully to ensure contaminants are drawn away from the shooter.

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> "Venting through the wall, rather than the ceiling, prevents any potential downforce – something to be avoided if there is to be no turbulent air at any of the shooting points"

A bank of adjustable deflection wall grilles with plenum chambers is an efficient solution

Venting through the wall

In most commercial ranges, the most efficient and effective solution is to provide a bank of adjustable deflection wall grilles with plenum chambers across the entire wall behind the shooters. The plenum chamber equalises the pressure for a more even distribution of air, handling large volumes at low velocity.

Venting through the wall, rather than the ceiling, prevents any potential downforce – something to be avoided if there is to be no turbulent air at any of the shooting points within the range.

This combination should deliver airflow of between 0.1m·s^{-1} and 0.5m·s^{-1}, consistent from floor to ceiling, as the JSP403 parameters require. Air speeds of less than 0.1m·s^{-1} do not provide sufficient fresh air within the range, while air speeds above 0.3m·s^{-1} may need to be heated.

A double-deflection aerofoil bladed grille allows finite control, to give an equal air movement across the bank of grilles. Each blade can be precisely adjusted to avoid potential 'dead zones'. There are usually viewing windows from a control room, and a series of doors for entrance and storage, which will not allow the whole wall to be active. By using adjustable high flow-rate grilles, air can be directed into these blank areas and, within a few metres, even out the airflow to attain stable velocities across the whole of the range cross-sectional area.

Within the plenums housing the double-deflection grilles, there must be a series of reduction plates, tested to ensure initial laminar flow across the whole height of the laminar wall.

Computational fluid dynamic (CFD) modelling is advised to validate any design before manufacture, but pre-delivery testing is critical to confirm laminar effect across the whole panel height. This will ensure that site commissioning can be undertaken and performed from the correct starting point. Full testing of each section of vertical duct is a necessity, otherwise it would be almost impossible to spot potential problems when trying to validate the system once installed. No matter how much CFD is done, a system is only as good as the installation

Test and test again

Once the ventilation system is installed on site, additional testing should be done to determine even airflow and to equalise air volumes.[2] JSP403 requires a ventilation system to operate 20 minutes before and 30 minutes after range use, so any residual dust is removed from the system and general isothermal conditions are provided for the even air temperature required for the range.

This is probably the most important factor in this design – that the temperature cannot be elevated or decreased below a few degrees while the range is in use, as the air needs to maintain a laminar flow, both down the range and across the depth of the range. Any increase in temperature will elevate the air upwards and out of the shooting area and will bypass the shooters.

A small decrease in air temperature is acceptable, as air will keep within the occupied zone but increase slightly in velocity. Care should be taken to keep this within a very small limit of around -2 degrees to ensure the warmer air in the range can be part of the laminar flow and not try to stratify at high level away from the incoming clean air.

"Airflow needs to be consistent throughout the whole cross-section of the range, to accommodate differing firing positions and stances: prone, kneeling and standing"

The basic concept has been successfully applied in several high-profile indoor ranges around the UK, where live and blank ammunition is fired from weapons such as assault rifles, pistols, shotguns and sports rifles by military personnel and private individuals, and where range sizes have varied from 20m to 100m deep, up to 20m wide and 4m high.

The overall concept is simple; achieving it, not so much. It proves the benefits of using an air movement specialist, who has the physical understanding and technical expertise and capability to work alongside the building services consultant and engineers to develop a strategy that hits the target in every aspect. **CJ**

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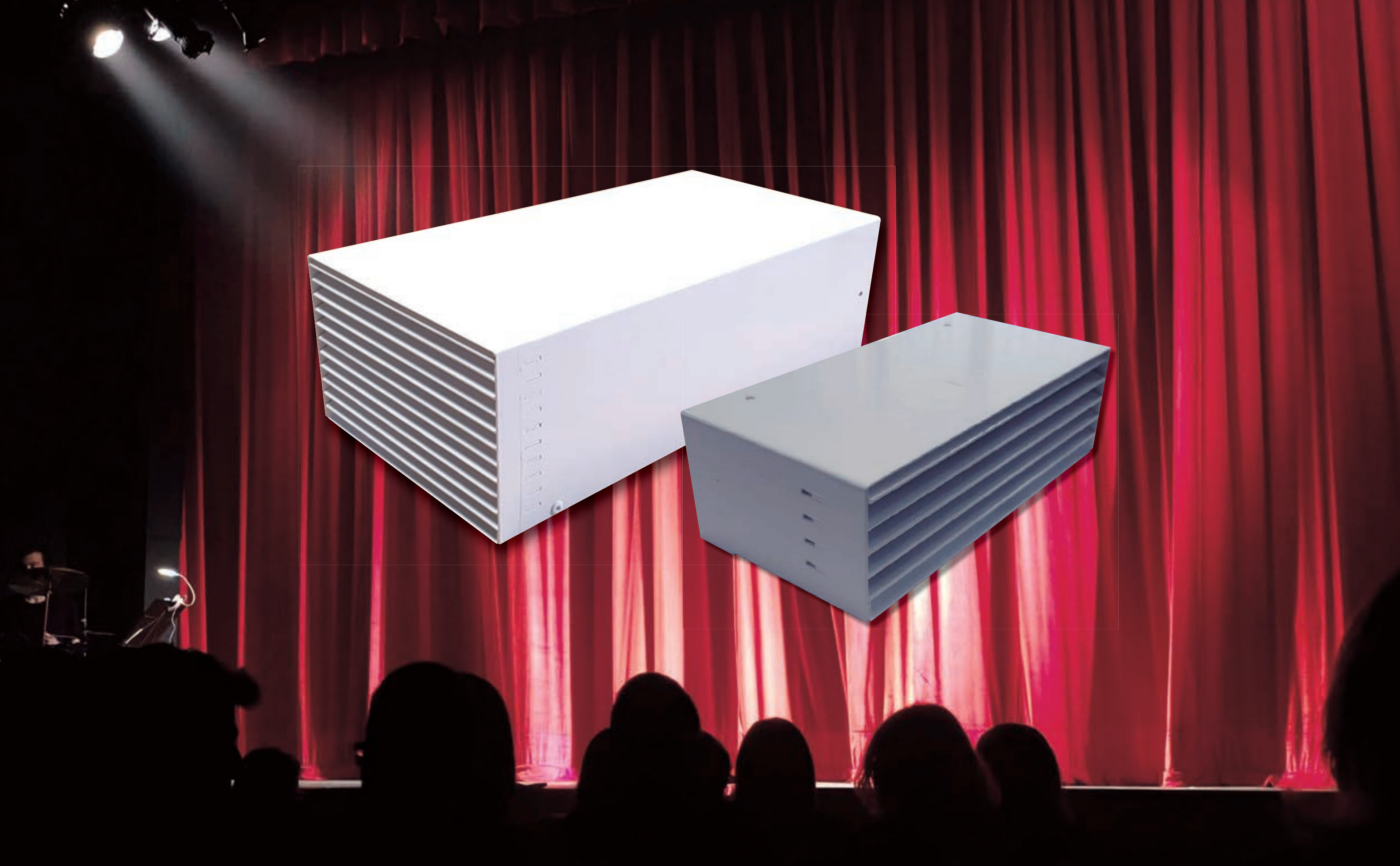
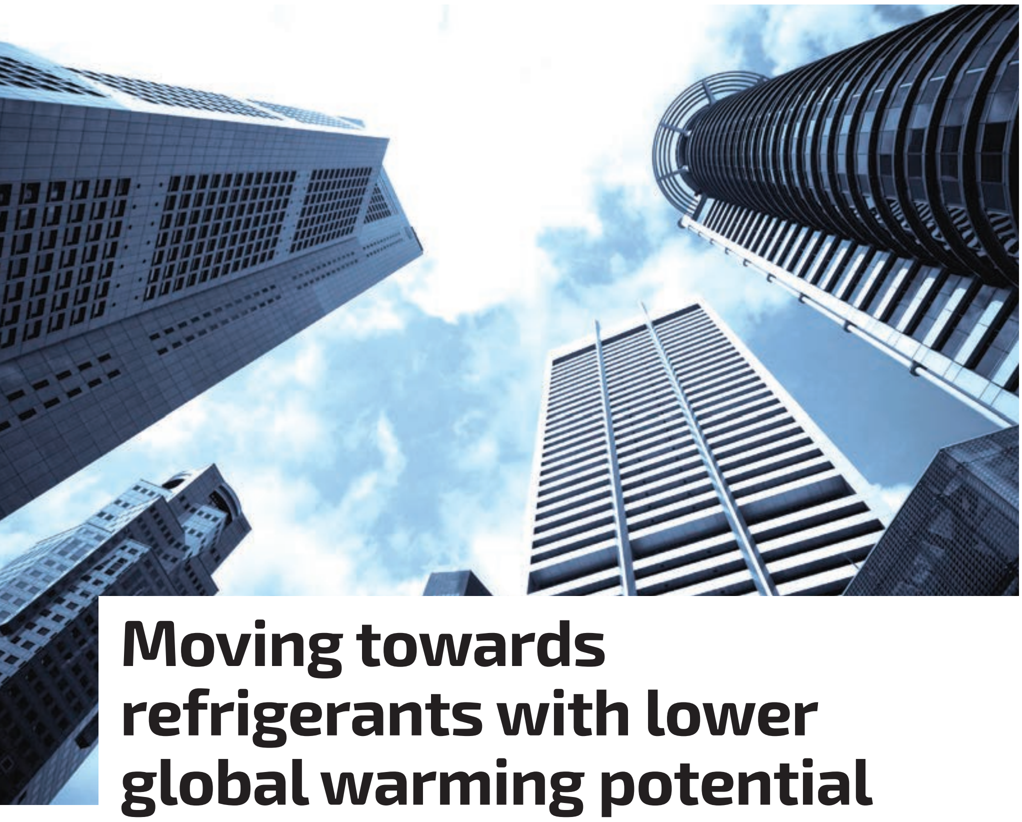
ROY JONES is technical director at Gilberts Blackpool

VENTILATION GUIDANCE FOR SHOOTING RANGES

Guidance for shooting ranges is covered in the Defence and Defence Safety Authority's Joint Service Publication JSP403. It states: 'The aim is to ensure that exposure to emissions from service weapons in indoor ranges and ranges with enclosed or semi-enclosed firing point do not generate a hazard to those who enter. The aim of the design should be to provide sufficient fresh air onto the range to ensure that the contaminants at the firing point(s) are all taken clear of the breathing zone. The range envelope should be designed in such a way to minimise air turbulence and provide a smooth air path from supply to exhaust points. It is expected that, for most ranges, between 6-10 air changes per hour will deliver adequate dilution [to establish comfortable conditions]'.





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Moving towards refrigerants with lower global warming potential

This module considers the growing use of lower global warming potential refrigerants for chillers, air conditioning and rooftop units

Buildings and the construction sectors combined are responsible for 36% of global final energy consumption, and nearly 40% of total direct and indirect CO_2 emissions. Energy demand from buildings and the construction of buildings continues to rise, driven by improved access to energy in developing countries, greater ownership, and use of energy-consuming devices, plus rapid growth in global buildings' floor area of nearly 3% per year. Some of the fastest-growing end uses are space cooling, with a year-on-year continued rise in global energy intensity per floor area.[1]

The environmental impact from refrigeration that provides the cooling for HVAC systems results from direct and indirect emissions. Direct emissions occur because of refrigerant escaping from systems that might be a result of faults and breakages, or during maintenance and repair procedures. Indirect emissions result from the generation of power that is consumed by the refrigeration machine. This is likely to release CO_2 – as well as other environmentally deleterious gases and particulates – into the atmosphere from the power-generation plant. The environmental impact will depend on: the thermodynamic effectiveness of the refrigerant; the efficiencies of the refrigeration system and the associated systems; the energy losses in the power-distribution systems; and the primary energy source at the power plant. So, for example, if the primary energy source was deemed as 'renewable', this impact may be reduced. The unknowns of a future supply scenario, however – as well as the benefits of lower operating costs –should always favour systems that require less power to operate, subject to an appropriate life-cycle analysis.

There was a step-change in the popular understanding of the impact of refrigeration on the global environment following the discovery of the Antarctic ozone hole in late 1985, which was linked to direct emissions. This highlighted the need for stronger measures to reduce the production and consumption of a number of chemicals, including commonly used refrigerants that were, principally, the halogenated hydrocarbons, which encompass the chlorofluorocarbons (CFCs), such as R12, and the hydrochlorofluorocarbons (HCFCs), such as R22. This culminated in the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer. This was subsequently adjusted to accelerate the phase-out schedules, and amended to introduce other kinds of control measures and to add new controlled substances to the list.

Using 2010 data, the US Department of Energy (DoE) estimates that the equivalent CO_2 emissions from the cooling component of air conditioning were as shown in Figure 1, with approximately 25% (or 175 million tonnes CO_{2e}) the result of direct emissions. For some perspective, the total UK emissions relating to all activities in 2018 were[2] 451.5 million tonnes CO_{2e}.

The direct emissions may be managed through operational procedures to minimise leakage and by employing systems that require reduced refrigerant charges. New technologies may assist in reducing environmental impact. This might include enhanced heat exchangers and 'smart' leak detection, more robust manufacturing processes, superior design, and alternative refrigerants.

Indirect emissions may be reduced by using more efficient – or alternative – refrigerating machines, by using otherwise 'wasted' energy to drive the refrigeration system, or by using » refrigerants that have thermodynamic properties that provide a more efficient refrigeration cycle. Unfortunately, refrigerants that have lower environmental impact are not always those that deliver good thermodynamic performance or overall life-cycle benefit.

The hydrofluorocarbons (HFCs), which have zero ozone depletion potential, rose in popularity for use in refrigeration, air conditioning and heat pump equipment as CFCs and HCFCs were phased out. Most of the HFCs are thousands of times more harmful to the climate as GWP gases (see 'Global warming' boxout), compared with the refrigerants they replaced. The UN identifies a variety of impacts from the resulting climate change, such as: soil erosion; more crop diseases; reduced water availability; hunger and malnutrition; heat-related illnesses; wildfires; shifting fish stocks; losses of habitat for wildlife; and the melting of ice and snow that is raising sea levels

In response to the rapid growth of HFC emissions, the Montreal Protocol adopted the Kigali Amendment in 2016 to gradually reduce the global production and consumption of HFCs. It is estimated that phasing out HFCs will avert global temperatures from rising by 0.5K by the end of the century and, if accompanied by better energy efficiency measures, will potentially avoid one-degree celsius of warming.[3]

Refrigeration is set to be one of the fastest-growing sources of warming emissions, as incomes rise in developing countries, temperatures increase, and global cooling demand soars. More than one billion people presently face immediate risks from a lack of cooling, and a warming planet means this number will only increase – and meeting that cooling demand will itself contribute to heating the planet. Left unchecked, direct and indirect emissions from air conditioning and refrigeration are projected to rise 90% above 2017 levels by 2050,[4] resulting in an increase in greenhouse gas emissions equivalent to one-third of all current emissions.

The Kigali Amendment was welcomed by many chemical and manufacturing companies in developed countries because it can endow them with green kudos and market advantage over inferior products. It was much harder for developing countries, as their companies have relied on old refrigeration and coolant technologies, and need to invest in research and development, and upgrade or replace factories and equipment.

The HFC phase-down provides an opportunity to combine other energy efficiency measures, alongside developing energy efficient and environmentally responsible refrigerants. The details of the agreed Kigali Amendment are quite complex, providing a different trajectory for substance phase-out that largely depends on a country's per capita consumption of 'controlled substances'. Developed countries, being larger per-capita consumers, have a shorter reduction timetable compared with the developing nations (as defined by Article 5 of the Montreal Protocol). Non-Article 5 countries, including the US, Japan and in Europe, formally started phasing out HFCs in 2019. China will start in 2024, and India and other more challenged countries in 2028. Non-Article 5 countries have agreed to cut the use of HFCs to 15%, against an agreed baseline, by the mid-2030s, and Article 5 countries to similar levels by the late-2040s.

Until the 1980s, there had been only gradual change in refrigerant choices over the previous half-century. In the past 40 years, however, there has been a steady change in the application of refrigerants, as shown in Table 1. (The categories 'synthetic' and 'natural' can be somewhat misleading, as manufacturing processes are likely to be required for both types of refrigerants.)

The majority of HFC consumption is in the cooling sector, comprising refrigeration, air conditioning and heat pumps, and more than half of that total HFC consumption is thought to come from emissions resulting from the servicing of installed equipment.[7] As a result of the Kigali Amendment and, in Europe, the

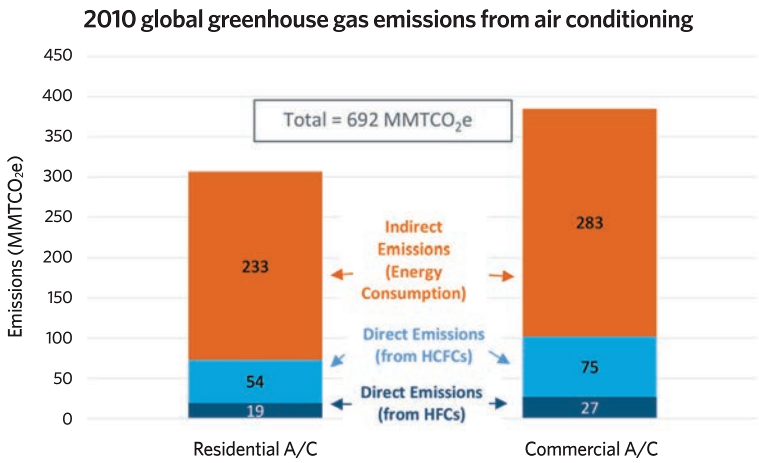

Figure 1: The global emissions, in million tonnes CO_2 equivalent, from the cooling component of air conditioning systems from direct and indirect emissions, based on 2010 data (Source: US Dept of Energy, *The future of air conditioning for buildings* (2016))

GLOBAL WARMING

Global warming potential (GWP) is a measure of the relative global warming effects of different gases. It assigns a value to the amount of heat absorbed by the gas relative to that of a similar mass of carbon dioxide over a specific period. Carbon dioxide was chosen as a convenient benchmark gas by the Intergovernmental Panel on Climate Change (IPCC), and its GWP is taken as 1.

As shown in Figure 2, 2019 was characterised by warmer-than-average conditions across most of the global land and ocean surfaces, with record high annual temperatures being experienced across many parts of the world. At current rates of growth, by 2024/25 levels of atmospheric CO_2 will be higher than at any point in the past 3.3 million years (since the Mid-Piacenzian Warm Period), when mean global temperatures were 2K to 3K higher than today.[5]

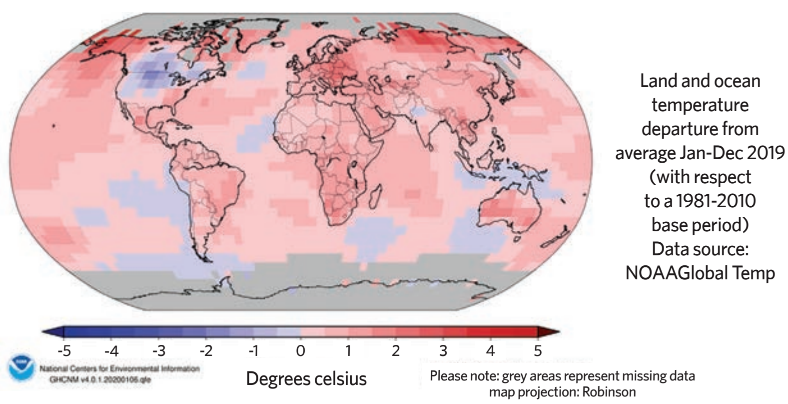

Figure 2: Comparative average global temperatures for 2019 (Source: www.ncdc.noaa.gov/sotc/global/201913)

	Synthetic refrigerants	Natural refrigerants (most still require manufacturing)
1980s	CFC and HCFC	NH_3 and HC
1990s	HCFC and HFC	NH_3 and CO_2 and HC
2000s	HFC and HCFC	NH_3 and CO_2 and HC
2010s	HFC and HFO	NH_3 and CO_2 and HC and H_2O
2020s	HFO and HFC	NH_3 and CO_2 and HC and H_2O
2030s	? HFO ?	? NH_3 and CO_2 and HC and H_2O ?
Grey indicates disappearing from general use and orange shows that general use is increasing (HC = hydrocarbon, HFO = hydrofluoroolefin, NH_3 = ammonia)		

Table 1: Approximate refrigerant timeline[6]

F-Gas Regulation, long-term refrigerant and system solutions need to have low GWP. Alternative refrigerants that have very low or zero GWP – such as new applications of extant substances, mixes of refrigerants, hydrocarbons (HCs), ammonia and CO_2 – are increasingly available and approved for use in many markets.

CIBSE Journal CPD Module 146 (June 2019) discusses the main criteria that determine whether a potential substance is likely to provide a safe, environmentally sensitive refrigerant for building services applications, including the flammability/toxicity 'safety group' designations (A1... B3). The F-Gas Regulation, EC 517/2014, focuses on reducing emissions and the responsible end-of-life, recovery and destruction of gases, and, in Europe, these are most commonly the A1 HFCs R134a (GWP=1,430), R404A (GWP=3,922) and R410A (GWP=2,088).

The low-GWP candidates can be categorised as either single-component fluids or refrigerant blends. Single-component fluids include R32 (safety group A2L, GWP=675), the HFOs R1234ze(E) and R1234yf (both A2L, GWP<=1), R717, ammonia (B2L, GWP=0), R744, carbon dioxide (A1) and the HCs, such as R290, propane and R600a, isobutane (both A3, GWP=3). There are many blended refrigerants designed to meet the demands of lower-temperature, higher-displacement applications – including R454B (mix of R32 and R1234yf – A2L, GWP=466), R513A (mix of R1234yf and R134a – A1, GWP=573) and R515B (mix of R1234ze(E) and high-GWP R227a – A1, GWP=293) – that attempt to provide the best compromise to deliver a set of desirable refrigerant qualities.

When assessing the performance of a refrigerant alternative, the 'total equivalent warming impact of a system' (TEWI,[8] measured in MT CO_2e) accounts for both the direct (from leaks, servicing and end-of-life disposal) and indirect emissions. When evaluating TEWI, the energy efficiency of the refrigeration system is a significant element because, as seen in Figure 1, the indirect emissions are likely to dominate. This may mean that a low-GWP, but low-performance refrigerant may actually have a higher TEWI when compared with a higher-GWP refrigerant. Practically, the majority of the replacement refrigerants will require significant modifications – or, more likely, complete replacement – of the refrigeration system.

So, for example, HFOs such as R1234ze(E), with GWP <= 1, are already being successfully used for space cooling and heat-pump applications, and are more energy efficient than the 'natural' refrigerants (as well as the R134a that it commonly displaces), so resulting in a lower TEWI. (Considerations on the safe application of HFOs, classed as A2L refrigerants, are discussed in CPD Module 146.) For large chillers currently employing R134a, it is possible to retrofit the system with R1234ze(E) – this requires expert advice.

Single-component fluids make it simpler to charge systems, and are readily available from refrigerant distributors. R32 has been widely used for air conditioning and heat-pump applications, displacing R410A systems and providing energy efficiency gains of up to 10% compared with R410A. R1234ze(E) has been adopted broadly, with more than 1,000 HFO chillers installed in Europe, providing a TEWI reduction of around 15% compared with similar systems employing R134a. By applying the lower-GWP refrigerants and system designs that employ new technologies to reduce refrigeration charge and motor energy consumption (such as in the air-cooled chiller illustrated in Figure 4), the overall TEWI can be reduced significantly in commercial chillers and heat pumps, compared with the previous generation. Both R32 and R1234ze(E) are A2L refrigerants, but with appropriate design – including external siting of active refrigeration components – they have proved, so far, not to present any significant flammability issues. The blend R454B has been applied successfully to succeed R410A, particularly in North American ducted residential and package unitary commercial products using scroll compressors.

The refrigerant marketplace for large chillers and heat pumps is, similarly, undergoing a revolution in optimised design and lower-GWP refrigerants. Most commonly, these will employ blended refrigerants, including R513A on water-cooled centrifugal chillers and R515B on water-cooled screw chillers.

The technological transformation is a challenge for the whole supply chain, not just the scientists, and will probably result in more refrigerants being developed, but with narrower operating envelopes targeted at specific applications and markets. As recent global events have proved, the future – even in the short term – is impossible to predict. However, as prices become more competitive, and the impacts of global heating become more evident, it is likely that the future generations of synthetic refrigerants are likely to be dominated by the HFOs and increasingly ingenious technical solutions.

Turn to page 66 for references.

Figure 4: A commercial air-cooled HFO chiller (up to 1,200kW cooling) available with fixed- or variable-speed screw compressor, with permanent magnet motor technology. An aluminum microchannel condenser reduces refrigerant charge by 40%, the flooded evaporator includes turbulators to increase the tube-side heat transfer, and the condenser fan is driven by an inverter speed-controlled EC motor

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Module 167

September 2020

1. **What proportion of equivalent CO_2 emissions from the cooling components of air conditioning have been shown to be because of indirect emissions?**

- ☐ A Approximately 5%
- ☐ B Approximately 25%
- ☐ C Approximately 50%
- ☐ D Approximately 75%
- ☐ E Approximately 90%

2. **With no intervention, what is the projected rise above 2017 levels of direct and indirect emissions from air conditioning and refrigeration by 2050?**

- ☐ A Approximately 5%
- ☐ B Approximately 25%
- ☐ C Approximately 50%
- ☐ D Approximately 75%
- ☐ E Approximately 90%

3. **At what point in the past was the atmospheric level of CO_2 thought to be same as it would reach in 2025 at current rates of growth?**

- ☐ A 1930s
- ☐ B Mid-13th century
- ☐ C During 3rd century
- ☐ D Around 3AD
- ☐ E Approximately 3.3 million years ago

4. **Which single-component refrigerant has been widely used for air conditioning and heat pump applications to displace R410A systems?**

- ☐ A R1234ze(E)
- ☐ B R134a
- ☐ C R22
- ☐ D R32
- ☐ E R744

5. **Which of these refrigerants does not have flammability/ toxicity 'safety group' designation A2L?**

- ☐ A R1234yf
- ☐ B R1234ze(E)
- ☐ C R32
- ☐ D R454B
- ☐ E R717

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References:

1 *2019 Global status report for buildings and construction – towards a zero-emissions, efficient and resilient buildings and construction sector*, IEA/UNEP 2019.

2 2018 UK greenhouse gas emissions, final figures, BEIS – **assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/862887/2018_Final_greenhouse_gas_emissions_statistical_release.pdf** – accessed 3 August 2020.

3 *In support of climate action, Cool Coalition partners announce huge push on efficient, climate-friendly cooling*, UN Environment Programme – **www.unenvironment.org/news-and-stories/press-release/support-climate-action-cool-coalition-partners-announce-huge-push** – accessed 3 August 2020.

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5 De la Vega, E, Chalk, T B, Wilson, P A *et al*, Atmospheric CO_2 during the Mid-Piacenzian Warm Period and the M2 glaciation, *Sci Rep* 10, 11002 (2020), **doi.org/10.1038/s41598-020-67154-8**.

6 Pearson, A, *Refrigerant choices*, CIBSE ASHRAE Group, 2017 – **www.cibseashrae.org/#RefChoice0217** – accessed 3 August 2020.

7 *UNEP Ozone Secretariat workshop on HFC management: Technical issues, Fact Sheet 2: Overview of HFC market sectors*. UNEP Bangkok 2015.

8 *Methods of calculating total equivalent warming impact (TEWI) 2012*, AIRAH 2012, **www.airah.org.au/Content_Files/BestPracticeGuides/Best_Practice_Tewi_June2012.pdf** – accessed 3 August 2020.

Product of the month

AET Flexible Space underfloor air conditioning helps restore historic building

System uses void beneath existing raised-access floor to create the ventilation path, cutting need for ceiling services

The restoration of London's historic Pennybank Chambers has used AET Flexible Space's unique underfloor air conditioning system to enable contemporary office space to be built into the building's original brick façade. The system means that the new upper office floors can benefit from the fantastic natural light from full height ceilings and the building's original windows, which are curved around the building.

The system provided by AET makes use of the void beneath the existing raised-access floor to create the air ventilation path, eliminating the need for high level, ceiling-based services and the associated duct and pipework. This enables floor-ceiling heights to be maximised, and also works extremely well in older buildings, like Pennybank Chambers, where a lowered ceiling would partially obscure the original windows and reduce natural light levels.

The floor supply high-level return conditioned air module (CAM-V) units used at Pennybank Chambers distribute

"The system means the upper office floors can benefit from natural light"

conditioned air into the space via the fantiles, which are recessed into the raised-access floor. AET was able to use its specially designed TU350 slimline fantiles to accommodate the very shallow existing 170mm floor void. The used room air is returned back to the CAM unit at high level where it is re-conditioned.

The slimline fantiles were installed in the new metal tiled floor fitted throughout Pennybank Chambers' office space.

There is considerable flexibility in where these fan terminals can be placed, allowing for easy reconfiguration depending on the particular needs or layout of an office. Fantile units are modular in design and, therefore, offer huge CAT-B savings when reconfiguring the workspace compared with ceiling-based systems. The modular and flexible design also minimises waste and energy consumption.

For maximum flexibility, each fan terminal is supplied with onboard 'Fatronic' controllers that allow for personal, end-user fan speed and temperature set point adjustment. Meeting rooms and cellular spaces can be managed via AET's Flextouch wall-mounted controllers allowing end-users to adjust the fan speed and temperature, and also monitor and control CO_2 and humidity levels.

■ **Call +44(0)1342 310400, visit www.linkedin.com/company/1089152/ or www.flexiblespace.com**

ASHRAE humidity guidelines for reopening schools and universities

The ASHRAE Epidemic Task Force has published guidance on the operation of HVAC systems in schools and universities, to mitigate the airborne transmission of SARS-CoV-2 in preparation for the new academic year. The ASHRAE recommended winter classroom design condition specifies 40-50% RH through proactive humidification. Dave Marshall-George, UK sales manager at Condair, said: 'It is very reassuring to see guidance including a recommendation for 40% RH as a minimum level of indoor humidity.'

■ **Visit www.condair.co.uk**

Gilberts adds BIM portfolio

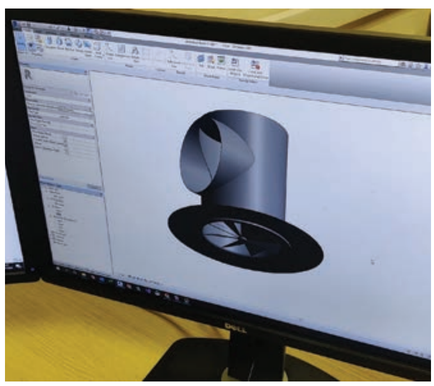
Building services BIM design and validation is simplified thanks to Gilberts Blackpool.

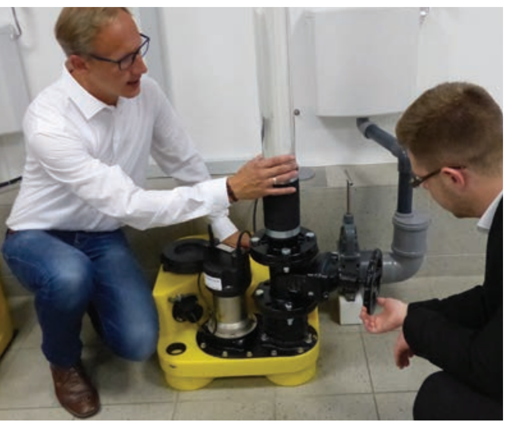
The independent air movement specialist has invested significant time and effort to ensure that Revit files for its entire range of most popular grilles, diffusers and louvres are now accessible.

The catalogue is available for free download upon registration via its dedicated BIM portal

Gilberts sales director Ian Rogers said: 'Every one of our popular standard ranges is now included on the portal.'

■ **Visit www.gilbertsblackpool.com**





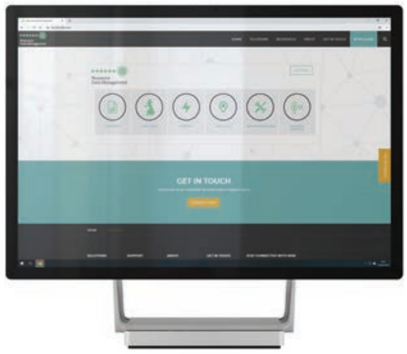
No 1 for Jung Pumpen

For the latest Jung Pumpen products, training and news, visit the UK's authorised distributor, Pump Technology.

See the new Compli 3D BIM library, and access details of webinars, seminars and specific factory training visits for public health engineers (planned for 2021) in Germany.

For specification of Jung Pumpen floor-mounted, wastewater and sewage-pumping equipment please contact the experienced and knowledgeable Jung Pumpen team.

■ **Call 0118 9821 555, email support@pumptechnology.co.uk or visit www.jung-pumps.co.uk**



Remote monitoring software ActiveFM ›

Achieving optimal efficiency for any type of facility is essential to keep costs to a minimum. It requires having insight into operating data from HVACR and any other BMS devices, perform predictive maintenance and manage energy use.

Resource Data Management's remote monitoring software ActiveFM offers all of these in one platform. Any number of sites across the world can be monitored and compared, and the status of HVACR devices can be displayed to a fine level of detail, in as little as 15-second increments. The system can also be set up to predict system failures to help maintenance. Add-on software options include Kwheb, a cloud-based energy management dashboard and Live Maps, a real-time map view of HVACR assets across multiple sites worldwide.

■ **Call +44 (0)141 810 2828 or visit www.resourcedm.com**

Healthy outlook for hospital site

In 1729, a four-bed hospital opened on Quartermile in Edinburgh. It was the first voluntary hospital in Scotland. In 1879, the site was transformed into an architectural gem with a distinctive baronial style, when it metamorphosed into The Royal Infirmary.

It now enters a new era as home to the Edinburgh Futures Institute (EFI). Grundfos Pumps has taken up the M&E challenge to ensure that this historic location will continue to encourage yet more groundbreaking achievements. Grundfos says it is delighted to have been selected as the pump supplier of choice and has already supplied a range of pumps, pressurisation units and packaged boosting equipment for phase 1.

The £120m project will see the Lauriston Place building sensitively restored, extended and upgraded. Not only will it be ready to face the next 300 years, but with the help of many forward-thinking partners such as Grundfos Pumps, it will carry the momentum to forge new quests.

■ **Visit www.grundfos.co.uk**

New insect prevention air curtain

JS Air Curtains is launching a new air curtain, the Fly, specially designed for insect control. It is a hygienic alternative to plastic strip or chain link curtains, as it removes any potential for Covid-19 cross surface contamination.

By creating a high-velocity air barrier across a doorway, flying insects are prevented from entering food preparation areas in butcher shops, supermarkets, hospitals and nursing homes, as well as food production premises. This allows doors to remain open, further reducing the risk of surface contamination through staff or customers needing to touch doors or handles.

■ **Visit www.jsaircurtains.com**

New small and efficient humidifier from Condair ›

Condair is launching the Condair RM, a new low-capacity resistive steam humidifier that can provide up to 8kg of steam to a duct. This level of output is ideal for applications like CRAC units in data centres, MRI suites in hospitals and high-end residential humidification. It is also ideal for offering zonal humidity control in branch ducts of buildings, like galleries or multi-occupancy offices, where a specific area of the building requires an independently managed humidity level.

■ **Visit www.condair.co.uk**

› DIRECTORY Your guide to building services suppliers

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Andy Pearson received ASHRAE's Comfort Cooling award for project excellence in 2016 for a Norway district heating system

Andy Pearson

All systems go

CIBSE ASHRAE Technical Symposium 2020 speaker Dr Andy Pearson, group managing director at Star Refrigeration, explains what future heating systems might look like

At this year's Technical Symposium – taking place online on 14-15 September – Andy Pearson is giving a keynote on *Taming the energy tiger – how can I make a difference*. He says the UK has to switch wholeheartedly to electricity if it is to hit carbon reduction targets. He outlines three principles to mitigate against climate change: 'stop burning stuff', 'switch to electricity' and 'remember the negawatt' (the energy saved as a result of energy conservation).

Andy Pearson studied manufacturing science and engineering at the University of Strathclyde. He joined Star Refrigeration in Glasgow as a design engineer. He had short spells as a site manager and commissioning engineer before joining Star's sales department. In his current role, he is responsible for Star Refrigeration Group as a whole. He was president of the Institute of Refrigeration in 2010 and was elected a Fellow of ASHRAE in 2016. See the keynote at **cibse.org/technicalsymposium**

Why do heating systems need to switch to electricity?

There is a three-step process of thought required: first, burning fossil fuel and emitting carbon has to be curtailed and quickly. Second, moving to the combustion of other fuels – even carbon-free fuels – is not the answer because it fails to address other issues surrounding combustion, such as air quality. Third, although localised generation can provide some small-scale answers, when we look at heat demand on a national scale, it is clear that moving heating onto the grid is the only solution that answers all the independent, but simultaneous, challenges. It is clean, familiar, it doesn't depend on unproved technology and it can be done quickly. But this only works if centralised electricity generation is also clean.

What is the true measure of efficiency in building systems?

It's necessary to divide the assessment of efficiency into two complementary components; quantitative and qualitative. The calculable efficiency is the desired effect – whatever that may be – divided by the energy required (the measurable input) to achieve the effect. It is difficult to quantify the desired effect for a building. The true measure of good efficiency is when all qualitative objectives have been met and the measurable input (the quantitative part) has been minimised. For example, there's no point having an energy efficient chilled water system if everybody in the building is uncomfortable.

Can system data help save energy?

The key to getting energy use down is being able to make meaningful comparisons. This starts with the commissioning data; it should be possible to call up data on building performance when it was new and functioning as intended, and it should then be possible to maintain that level of performance throughout the building life. We now have the ability to record data at commissioning and provide ongoing comparison with current performance to highlight the areas requiring attention. The key is to make the output as simple as possible.

What refrigerants should the industry be considering?

On one hand, I wouldn't rule out anything but, on the other hand, I don't think building design specialists should have to worry about something as technically complex as the inner workings of the refrigeration or air conditioning system. What they need to do is to be completely honest about the order of precedence they place on the various competing factors that will apply to their project (for example capital cost, reliability, long-term security, ease of maintenance and efficiency) and choice of refrigerant will naturally follow. So, for example, if high energy efficiency is important, then ammonia should be considered but, if the overriding consideration is low capital cost, then it is unlikely to be a contender. It's important to realise that energy efficiency should not always be the number one priority – for example, in a system which only runs for a small percentage of the year, it doesn't really matter but, if the load is high 24/7, then efficiency has to be much more important.

Should we be moving to ambient heating/cooling networks?

This is an interesting question – we need to find better ways of enabling adjacent users with requirements for heating and cooling to cooperate with each other. One suggestion would be to provide a network of water at, say, 15°C, which can be used as the heat sink for chiller plant to reject heat efficiently all year round and, at the same time, provides a ready heat source for local heat pumps to tap into. This would make both the chillers and the heat pumps more efficient, free up a lot of valuable real estate currently used for heat rejection equipment and the network would be in thermal equilibrium with the soil so wouldn't even need to be insulated.

EVENTS

Event details are correct at the time of going to print, but please note, as a result of the ongoing coronavirus (Covid-19) situation, they may be subject to change. For updates, please check cibse.org/training for training and cibse.org/events for CIBSE groups and regional events. CIBSE has a range of online learning courses available to support your learning, visit cibse.org/online-learning

NATIONAL EVENTS AND CONFERENCES

CIBSE ASHRAE Technical Symposium 2020
14-15 September

The CIBSE ASHRAE Technical Symposium will be an online event this year. Taking place over two days, it will include a variety of live and on-demand presentations, alongside live Q&A and discussion sessions. The programme includes: real world sustainable development; digital techniques to optimise built environments; enhanced energy performance and wellbeing; grid decarbonisation; heat networks; fire safety and smoke control; applying BIM; design tools for lighting; and much more.
cibse.org/symposium

Young Engineers Awards
8 October

The annual Young Engineers Awards, bringing together the Graduate of the Year and Employer of the Year awards to celebrate the rising talent, as well as those who mentor, nurture and encourage people new to the industry. To mark the 25th edition of the awards, this year will also include the new Apprentice of the Year accolade, to recognise the invaluable contribution played by apprentices in our industry. This will be an online event.
cibse.org/yea

Build2Perform Live
24-25 November

Registration is now open for the 2020 Build2Perform Live event and exhibition. The free event will feature more than 80 hours of CPD, 160 speakers and 70 exhibitors. The programme will be released next month.
cibse.org/b2plive

CIBSE REGIONS AND GROUP EVENTS

For up-to-date information on regions and groups meetings, webinars and podcasts, visit **cibse.org/events**

CIBSE MEMBERSHIP WEBINARS

The CIBSE membership department continues to support members wishing to progress their membership. It is hosting free webinars to support members with applications for the Associate and Member grades, and registration with the Engineering Council at Incorporated Engineer and Chartered Engineer levels.

The series includes two separate webinars, with session one covering routes to membership and session two focusing on how to write the Engineering Practice Report. Each webinar features a presentation followed by a Q&A.

For further details and to register for the sessions, visit **cibse.org/webinars**

1 and 8 September
6 and 20 October
10 and 17 November

NEW LIVE ONLINE TRAINING COURSES

A full programme of live online training courses has been released through to the end of 2020. The training courses have been reformatted to work online, with a live trainer, so you can expect the same interaction and participation as you would in a classroom setting. For details and the full programme, visit **cibse.org/training**

Mechanical services explained
9-11 September

Low carbon consultant design
16-18 September

Building services explained
22-24 September

Overview of IET wiring regulations (18th edition)
22 September

Practical project management
24 September

Low carbon consultant building operations
28 September-1 October

Understanding smoke control
1 October

High-voltage (11kV) distribution and protection
6 October

Low carbon consultant design
7-9 October

Building services explained
7-9 October

ONLINE LEARNING

CIBSE has a portfolio of online learning courses, which contain interactive content, with quizzes and additional resources to support your learning. Choose from core engineering modules, digital engineering (basics of BIM) modules, and soft skills modules to enhance and support your development.

CIBSE #GrowYourKnowledge webinars

CIBSE's free webinar series continues in September. Taking place every Thursday at 11am, the webinars are designed to support the CIBSE community in maintaining their CPD remotely.

Each webinar features a 20-45-minute presentation, ending with an interactive Q&A. All previous webinars are available on the **#GrowYourKnowledge** GoToWebinar channel.

To register, visit **cibse.org/growyourknowledge**

Upcoming webinars:

Superhomes residential deep retrofit journey with heat pumps
3 September

To register for the webinars, visit cibse.org/growyourknowledge