CIBSE JOURNAL

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CIBSE PRESIDENT KEVIN KELLY ON INCREASING DIVERSITY

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Equal opportunities

CIBSE's new president Professor Kevin Kelly is not unusual in calling for more diversity in a professional organisation, but you don't often see evidence of a pledge being honoured on the first day of office.

In his inaugural address, Kelly called for CIBSE Groups and Societies to have steering groups made up of people who 'represent the full bandwidth of who is in society'. He has already backed up words with actions by coopting three women onto the CIBSE Board to increase the ratio of women to men from 3:9 to 6:9.

'I made it clear that I want to hear more female voices on the Board,' says Kelly in an interview on page 16. 'If everybody at the top level is male, there's something seriously wrong.' He is also keen to increase representation of minority groups at CIBSE and laments the few people from BAME communities who are at Board level.

Kelly says subconscious bias is preventing many from progressing in the industry. His former university, TU Dublin, had mandatory training in this area, and Kelly said it helped him become more self aware and question himself about how he treated those from a different background.

Like other Presidents before him, Kelly's route into the industry was through an apprenticeship. He is keen to offer 'ladders of opportunities' to school leavers and other apprentices to help them develop their engineering careers. He is particularly pleased to see that there will now be two categories in the 2021 Apprentice of the Year Awards – Technician (level 3-4) and Degree (level 5-7) (page 11).

In his inauguration speech, Kelly highlighted how building safety, climate change and Covid-19 are changing the way engineers are designing buildings. He says that while engineers are designing with good intentions, the performance gap is still undermining efforts to drive down carbon emissions from buildings.

A survey of engineers who have signed the Building Services Engineers Declare Climate and Biodiversity Emergency found that client priorities around financial, time and resourcing constraints were among the main challenges to achieving net-zero buildings (page 24).

Clients are often unwilling to pay for post-occupancy evaluations, but Kelly sees these as being crucial to understanding the performance gap. He believes this is where academia can step in. 'I tell engineers they have a data-rich environment and there are postgraduate students who don't have enough data for research,' says Kelly, who as both an engineer and academic, is especially keen to encourage more collaboration between industry and universities.

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CONTRIBUTORS

Hywel Davies
How the golden thread of information aims to ensure building safety from design to occupation

Eleanor Hoey
Why the climate emergency means engineers must share knowledge and tools with their clients

Mike Darby
Five issues with air handling units and how to resolve them by updating the BMS controls strategy

Tim Dwyer
CPD Module 181 looks at applying specific fan power for efficient ventilation and air conditioning

CIBSE

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UK'S LARGEST ENGINEERING CAMPUS CONSTRUCTION COMPLETED

MECD is part of a world-class research and innovation hub

Construction of the base build phase of the Manchester Engineering Campus Development (MECD) has been completed. Arup was the building services and fire engineer while BDP's Manchester education team provided detailed design during technical and construction stages. This was the first project in which the University of Manchester appointed a dedicated environmental sustainability adviser to develop and drive the university's sustainability targets.

IN BRIEF

Construction recovery gathers pace

The recovery in construction activity is gaining momentum, according to market analysts Glenigan who reported an 18% increase in project-starts during the three months to April and 39% rise in the value of main contract awards.

It said project starts remained below pre-pandemic levels, but the signs for the rest of the year were encouraging and the development pipeline was ahead of 2019 levels.

Glenigan said the value of projects starting on site averaged £5,212m per month during the three months to April; an 18% increase against the preceding three months and 37% higher than a year ago.

The rise was due to increases in both the value of major projects starting on site and in underlying market activity (under £100m).

Mead appointed MMC champion

The Construction Industry Council (CIC) has appointed former CIBSE President Nick Mead as its champion for Modern Methods of Construction (MMC).

Mead is technical director at Laing O'Rourke and has been on the CIC Board as a member-appointed director for the past five years.

Mead described MMC as a 'key initiative for construction' and pledged to ensure his work added value to the CIC and its members.

IEA report calls for gas boiler ban by 2025

No new fossil-fuel boilers should be sold, except those compatible with hydrogen

There should be no new gas boilers sold from 2025, according to the International Energy Agency (IEA).

The recommendation is one of 400 proposals included in a new report designed to help the world achieve net-zero emissions by the middle of this century.

As well as an end to the use of fossil-fuel heating, the report – designed to help preparations for the COP26 climate conference in Glasgow this November – proposes a ban on sales of new petrol and diesel vehicles by 2035 and an immediate end to new coal, oil and gas exploration. By 2050, the IEA envisions a global economy that is twice as big as today, with two billion extra people but with the demand for energy dropping by 8%.

Its path to net-zero says that in just four years' time, there should be no new fossil fuel boilers sold, except where they are compatible with hydrogen. It also says that, as well as greening the energy system, it will need to be expanded to provide electricity to the 785 million people in the world who currently have no access. To meet this challenge, the world will need to install four times the amount of wind and solar energy than it did in 2020.

Fatih Birol, the IEA executive director said: 'Moving the world on to that pathway requires strong and credible policy actions from governments, underpinned by much greater international co-operation.'

Read the report at **bit.ly/CJJun21IEA**

The IEA says fossil fuel boilers must be compatible with hydrogen

Scientists recommend air hygiene certificates for public spaces

Lack of rules on air hygiene helps spread disease

Air quality should be regulated in the same way as food, say scientists

A group of international experts says current ventilation regulations are helping to spread disease in buildings and must be overhauled urgently.

It compares the situation to early 19th-century Britain, in which thousands of deaths were linked to contaminated water supplies. The Covid-19 crisis has highlighted the problems of aerosols spreading infections in crowded indoor spaces, say the scientists, who claim the cost of improving ventilation to reduce airborne infections would add less than 1% to the cost of a typical building.

In an article for the journal *Science*, the group of 40 scientists and engineers says there is very little regulation of air hygiene in the UK, although there are strict safety controls in place for food, sanitation and drinking water. The problem is made worse, it adds, by building designs focusing on reducing energy use and maintaining comfortable temperatures, at the expense of ventilation rates.

'The way we design, operate and maintain buildings influences transmission,' says the group, which has called for a 'paradigm shift' on the same scale as changes to water-hygiene regulations almost 200 years ago.

A certification system for public buildings, such as the one used by the food industry, should also be introduced, it argues.

Catherine Noakes, professor of environmental engineering for buildings at the University of Leeds, and a member of SAGE, was one of the signatories. She says improving ventilation to reduce exposure to airborne pathogens would bring other benefits, including improved performance and wellbeing.

'We have neglected the role that air circulating inside a building plays in the way germs and viruses may spread between people,' says Noakes. 'The pandemic has exposed that deficiency in our understanding and the way we seek to make buildings safer.'

Pollution risk in poor-quality homes

Socially disadvantaged households are more likely to be exposed to higher levels of indoor air pollution, according to a report from University College London. It said air pollution was the greatest environmental health threat to people in the UK and high levels of outdoor pollution in areas with poor-quality housing put socially disadvantaged families at the worst risk.

In *Buildings and Cities*, researchers examined five factors explaining why lower socio-economic groups could be exposed to higher levels of indoor air pollution in their homes. They focused on London and the pollutants PM2.5, NO_x and CO, which are found in most households. The factors were: housing location and ambient outdoor levels of pollution; housing characteristics, including ventilation properties and internal sources of pollution; occupant behaviours; time spent indoors; and underlying health conditions.

While high-density dwellings often have lower ventilation levels, which can reduce the number of outdoor contaminants entering the home, this is not sufficient to offset living in an area of high outdoor pollution, the research found. Lower socio-economic groups also spend less time outdoors, according to the project, which was funded by Public Health England and the Engineering and Physical Sciences Research Council.

BSI to fast track IEQ standard

The British Standards Institute (BSI) is to speed up the development of a new standard for measuring indoor environmental quality (IEQ).

Publicly Available Specification (PAS) 3003 was championed by engineering firm EFT Consult, which has been working on it for six years. The BSI has now decided to accelerate that work into a full British Standard – BS 40101 Building Performance Evaluation – which is due to be published this year. It will closely follow the work EFT Consult and its partners have already completed in the development of PAS 3003, incorporating areas such as efficient and suitable lighting, heating, ventilation, and minimising the unwanted and harmful effects of air and noise pollution.

A PAS is a recommended code of best practice, but fast tracking this work to full British Standard status means the document will be able to direct how design, installation, operation, maintenance, and ongoing monitoring, measuring and reporting should be carried out.

It will also determine benchmarking parameters to develop a Wellbeing Performance Rating that could be applied to any building, according to EFT.

Buro Happold appoints new CEO

Buro Happold has appointed James Bruce as its new chief executive officer (CEO). He immediately announced plans to grow the business, which operates in 26 markets worldwide, and double the number of employees from 2,000 to 4,000 in six years.

'Expanding our international markets, where we believe there is the best potential for us to grow, will create significant opportunities for our people and our clients,' said Bruce, who added that the company would expand through acquisitions, joint ventures, and partnerships in key regions.

The consultancy, which had an annual turnover of £204.7m last year and increased profits by 6%, has also appointed New York-based Craig Schwitter as senior partner. His projects include Singapore's Jewel Changi, New York City's High Line, and Harvard University's Science and Engineering Complex.

James Bruce

IN BRIEF

Developers optimistic about future of offices

London office construction has grown by 20% over the past six months and developers are increasingly optimistic about prospects for the market, according to the latest Deloitte London Office Crane Survey.

The market collapsed by 50% from a peak of more than five million square feet during the first Covid lockdown but has now risen above three million again, with more than 80% of schemes going forward on a speculative basis.

New office construction has dropped by 9% since the last survey, but upgrades of existing office stock account for 56% of the new work pipeline.

The survey, carried out in March, found 85% of developers are still concerned about weak tenant demand for office space. However, no respondent said the leasing demand had worsened and more than half (57%) felt it had improved.

Cost inflation will be 'new normal' for projects

Lack of materials and specialist skills is pushing up prices as economy rebounds

With the construction rebound picking up speed, clients are being warned by a range of commentators to get used to sustained price inflation over the next two years.

The latest survey from IHS Markit/CIPS remained close to its six-year peak in April at above 60 (anything above 50 indicates growth), but this has created major supply and demand imbalances that have pushed the rate of product and labour cost inflation to its highest level since the survey began in April 1997.

Commercial work was the best performing sector in April, with civil engineering enjoying its fastest growth spurt since September 2014.

Cost consultant Arcadis advised clients to get projects moving quickly to avoid the full impact of long-term price rises, which are starting to be reflected in tenders. It forecast a major acceleration in inflation for infrastructure, and a slightly slower one for buildings from next year.

Infrastructure projects are feeling the heat owing to lack of materials and a shortage of specialist skills, with price increases of 3% and 5% being forecast for 2021 and 2022, respectively. Concerns about delays to project starts prompted Arcadis to warn of even steeper cost rises in future years, as high as 5% by 2025.

Grenfell families condemn 'grave injustice' in Fire Safety Bill

Group says leaseholders should not pay for replacing cladding

The families of the victims of the Grenfell Tower disaster believes the lack of financial protection for people living in flats blighted by unsafe cladding is 'indefensible' and that the new Fire Safety Act will perpetrate a 'grave injustice'.

The government was able to push through the new legislation in the face of a large rebellion by Tory MPs, who supported an amendment to give further financial protection to leaseholders facing huge bills to remove the cladding.

Home Secretary Priti Patel said the government was paying for remedial work to 'thousands of buildings around the country', but the Grenfell campaigners said the £5bn fund was not enough.

Patel said the act would 'actually help to save lives by changing some of these awful regulations and guidelines that existed previously'.

Ministers say a loan scheme will ensure costs are capped at £50 a month for safety works and that residents in the tallest tower blocks in England will not have to pay to have cladding removed. However, the Grenfell United group said leaseholders should be protected from all remediation costs because they were not responsible for the cladding and the government should recoup the cost from the developers. They said they were 'deeply disappointed that ministers have broken their promises to leaseholders who have done absolutely nothing wrong'.

Fire risk of Grenfell cladding systems well known

A cladding expert has told the Grenfell Tower Inquiry that manufacturers and contractors should have been less 'complacent' before the 2017 tragedy because of a number of widely reported fires in other countries in the years leading up to it.

Jonathan Sakula said the combustibility of building systems similar to that used at the west London tower block were well known. Sakula highlighted a number of fires that were propagated by aluminium composite material cladding with a polyethylene (PE) core. That same combination caused the fire to spread at Grenfell Tower, where 72 people were killed.

Sakula said: 'I would have expected them to have taken more serious steps, saying "we are concerned about the use of PE cores on high buildings and would recommend you used fire-resistant materials".'

Smoke detection system failed during east London tower fire

The failure of the smoke detection system in an east London tower block undermined its compartmentalisation strategy, leading to a full evacuation when it caught fire last month.

Two people were hospitalised and 42 treated for smoke inhalation and shock. According to *Inside Housing,* developer Ballymore told residents at New Providence Wharf that the smoke detection systems had failed meaning doors in the communal area did not close.

The building is covered in aluminium composite material cladding similar to that used at Grenfell Tower. However, early investigations found that it played no role in facilitating or spreading the fire.

Many residents said that they heard no alarm or air horn and were forced to evacuate the building themselves, despite paying £47,000 a month for a 'waking watch' fire-safety service.

IN BRIEF

Firms put value toolkit to the test

The Construction Innovation Hub has launched a 'Value Toolkit' designed to improve the social, environmental, and economic outcomes from building projects.

Construction Minister Anne-Marie Trevelyan welcomed the start of a six-month pilot phase, which will see the toolkit tested by more than 70 early adopters, including Arup, Mace, Mott MacDonald and Morgan Sindall, on live projects. The eight member bodies of the engineering services alliance Actuate UK have also put their weight behind the initiative.

The toolkit provides methods for measuring each stage of a project from design to construction and on through occupation. It also creates a data feedback loop to help project teams learn lessons for the future.

Training has 'even steeper hill to climb'

Meeting the government's new carbon emissions target will need an unprecedented surge in training and recruitment across the building services sector, according to the Building Engineering Services Association (BESA).

Heating buildings alone causes up to 31% of emissions, and there will need to be a rapid scaling up of recruitment into the industry to take on the challenge of decarbonising heat over the next two to five years, a webinar hosted by BESA heard.

The Construction Leadership Council (CLC) believes the industry's workforce will have to grow by 800,000 people by 2050 to achieve net-zero emissions, and this will include at least 70,000 new heat pump installers by 2030, according to the Heat Pump Association (HPA).

Professor Sandy Halliday made RIBA honorary fellow

Professor Sandy Halliday MCIBSE has been made an honorary fellow of RIBA.

Halliday is a director at the Gaia group and has worked in sustainable building design for 30 years. Last year, Halliday was named among the Women's Engineering Society's Top 50 Women Engineers in Sustainability.

She is author of the *Sustainability: RIBA Plan of Work 2013 Guide* and published *Sustainable Construction* in 2018.

LEV conference

The LEV 2021 Extracting the Best Practices Conference, organised by the Institute of Local Exhaust Ventilation Engineers (ILEVE) and the British Occupational Hygiene Society (BOHS), was held virtually in April. Mary Cameron, from BOHS, welcomed 140 attendees, before Dean Greer, of ILEVE, and Alison Margary, of BOHS, gave updates on the institutes' work in the past year.

Presentations were given by:

- Duncan Smith, of the Health and Safety Executive, on the decision-making process for issuing a LEV-related improvement notice and the Enforcement Management Model
- Mark Allen, of Thompsons Solicitors, on the life of an occupation case, from the onset of symptoms, evidence gathering, litigation and the effect on the claimant
- CIBSE's David Mitchell on exhaust stack design guidance, D1/H1 guidance and dispersion modelling requirements
- Carol Bladon and Claire Creed, from BOHS, on the working and requirements of CPD in the BOHS
- Dean Greer on the ILEVE Competency Card, the links to the BOHS Certificate of Control and the likely effects of the Grenfell tragedy on competence for all
- ILEVE's Adrian Sims on proportional balancing of LEV Systems and what happens when you alter the system
- Dougie Collin, of SK-IHS, on behalf of Dr Jarand Hindenes, giving a doctor's case study on welding fume and health surveillance.

The institute would like to thank Mary Cameron, Adrian Sims and the conference team for organising the event, as well as the presenters, sponsors and attendees. Slides will be available at **cibse.org/ileve**

ILEVE celebrates 10 years

Institute has developed many initiatives in the LEV industry since its inception

The Institute for Local Exhaust Ventilation Engineers (ILEVE) celebrates its 10-year anniversary this year, after being launched to the LEV industry in May 2011.

Ahead of this launch, the institute became a division of CIBSE in 2010, with Wally Gilder, James Wheeler, John Whitehead and Paul Ramsden among the driving forces.

There have been a number of changes to the steering committee in that time, with Gilder handing over the chair to Jane Bastow, who then passed the baton to Dean Greer.

Bastow instigated moves to work with other institutions, societies and industry bodies, and Greer has developed this further, working with a number of strategic partners to develop and support the institute's core aim.

ILEVE chair Dean Greer

ILEVE was established to promote air quality in the workplace and to reduce ill health and death caused by airborne contamination and hazardous substances in the working environment.

It exists to recognise competence in the practical application of local exhaust ventilation, and to raise awareness of the importance of good air quality and ventilation in workplaces.

ILEVE is recognised and supported by the Health and Safety Executive (HSE) and has developed a number of initiatives in the LEV industry since its inception. The ILEVE Competency Card was introduced to show that corporate members are competent in one or more of the five modules in which the institute grades them.

With the HSE and other stakeholders, the institute also initiated the Industry and Regulatory Forum in LEV. From this, it developed the Competency Matrix, which is reviewed regularly to ensure that it complies with current regulations and guidance.

In addition, ILEVE – in conjunction with others in the industry – has developed LEV Commissioning and Thorough Examination and Test (TExT) report templates, with guidance on their use, supported by the HSE.

The Competency Matrix and the Commissioning and TExT templates are on the ILEVE website, and are free to use.

Institute members have been heavily involved in producing other guidance, too, such as *A guide to good practice in local exhaust ventilation*, TR40. They are also working with other societies and trade bodies in the industry, and on many HSE initiatives.

'We look forward to the next 10 years,' the institute said.

- For more details, visit **cibse.org/ileve**

CIBSE increases focus on apprentices

Move recognises range of routes into industry and celebrates emerging talent

Above: Megan Whitbread was the first winner of the CIBSE Apprentice of the Year award in 2020

Underlining its commitment to encourage a diverse cohort of young engineers, CIBSE has introduced new categories for apprentices for its Young Engineers Awards 2021.

An apprenticeship category was included for the first time in 2020, but this year's awards include separate recognition for Apprentice of the Year – Technician (level 3-4) and Apprentice of the Year – Degree (level 5-7). The move supports CIBSE's strategy to improve recognition of the range of routes into the industry and to celebrate emerging talent.

Megan Whitbread, an apprentice electrical engineer at Troup Bywaters + Anders, was the first winner of the CIBSE Apprentice of the Year award. In her entry video, she described building services engineering as an exceptional career where you 'can make a difference in so many ways'.

The award, together with the Graduate of the Year and Employer of the Year awards, forms part of the CIBSE Young Engineers Awards, which are open for entry.

CIBSE President Kevin Kelly said: 'The future of our profession lies in the hands of new recruits. Creating safe, healthy, carbon-neutral and climate-supporting cities of tomorrow will only be possible if exceptional new talent is recognised and supported – and this talent will emerge from multiple routes and backgrounds that must be welcomed into an inclusive and diverse culture.'

With categories for small, medium and large companies, the Employer Award asks firms to demonstrate how they put young engineers at the centre of the business and invest in their career progression. The CIBSE ASHRAE Group Graduate Award challenges finalists to show their presentation skills in front of a panel of industry judges.

Any engineer who has graduated in a building services-related field in the past two years, either at undergraduate or postgraduate level, is eligible to take part.

The CIBSE Young Engineers Awards 2021 – delivered in partnership with CIBSE Patrons and sponsored by Ideal Heating, ACV and Swegon – will take place online on 14 October. Entries must be received by 30 July 2021. Visit **cibse.org/yea**

Pandemic is key symposium topic

The 2021 Technical Symposium – titled 'Engineering the built environment for a new "normal": delivering safe, healthy and versatile buildings' – will take place virtually on 13-14 July.

Planned before the government's roadmap for emerging from lockdown was released, this two-day online event features more than 60 peer-reviewed papers on a wide range of building performance-related topics. The response to the Covid-19 pandemic will be a key subject of discussion, with papers looking at: the use of ventilation to reduce exposure risk; the challenges of balancing ventilation and indoor air quality objectives with energy-demand reduction; and the likely impact of the pandemic on working practices and future requirements for building services.

Several papers consider the application of IT and artificial intelligence tools to building performance and air quality, and to modelling the performance of some building types. Distributed ledger technology continues to feature, too. Other papers look at what we can learn about the climate in our urban centres from the dramatic changes in work patterns during 2020, and the implications for dealing with heatwaves and overheating in schools and hospitals.

There will be a focus on how building simulation can help improve performance outcomes, and the use of building simulation tools to give insights into how buildings will behave. As we look to decarbonise heating, there are papers on the development of heat networks, and on future opportunities with low temperature and low carbon networks and the use of waste heat.

The provisional programme will be published in June, and there will be a mix of live sessions and pre-recorded presentations feeding into live discussion panels.

● For more information and to register, visit **cibse.org/symposium**

IN BRIEF

Energy efficiency in commercial kitchens revision

A revised edition of *TM50: Energy efficiency in commercial kitchens* is now available.

Commercial kitchens are significant water and energy users, and their carbon footprint can be considerable. This new edition of TM50 gives updated advice for designers, installers and operators on how to minimise the energy consumption of these facilities, thereby reducing emissions and operating costs. It has recommendations that can be applied to all commercial food-service facilities, whatever the size.

Copies can be downloaded at **cibse.org/knowledge**, with hard copies available for pre-order.

Sponsors required for member applications

Everyone applying for CIBSE membership must have a sponsor to provide support and guidance with the application process.

The sponsor will help check your application, ensuring it is accurate, complete and that you are applying for the appropriate level of membership. They must be confident that you meet the relevant criteria, so discussing your work and experience with them is essential.

Sponsors cannot be family members and should be someone applicants have known for at least a year. They must be either: a member of CIBSE at the level you are applying for or higher; registered CEng with any Engineering Council-nominated institution; or professionally registered with the construction industry. Visit **cibse.org/membership**

Updated training programme

CIBSE's 2021 training programme has been updated. It now includes the July-December schedule dates for live training, which is available to browse by building services topic area or in chronological order.

The new brochure offers an exclusive discount for live training and online learning. It also features the popular annual Avoiding Overheating training on 7 July, and other training opportunities for individuals and corporate.

To download the brochure, visit **cibse.org/training**

President's Prize open for entries

CIBSE Student members in their final year of BSc, BEng or MEng study are invited to enter the CIBSE Undergraduate Award to be in with a chance of winning £500.

The award encourages students to develop their potential and aim for excellence. The panel will be looking for evidence of excellent understanding and knowledge of building services engineering, science and design, as well as originality and high-quality visual information, and are particularly keen to encourage applicants whose final year projects share CIBSE's interest in sustainability.

Entrants need to submit a 2,000-word synopsis of their final-year project and a completed application form. The winner will receive a £500 cheque and trophy. Two runners-up will each receive £100. Entries must be submitted by 16 July. For full details and an application form visit **bit.ly/CJJun21Prize**

New members, fellows and associates

FELLOWS

Antonutto-Foi, Giulio Andrea
London, United Kingdom

Chan, Ping Ki
Tsuen Wan, Hong Kong

Noel, Peter Raymond
Coulsdon, United Kingdom

Rashid, Atif
Glasgow, United Kingdom

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Hong Kong, Hong Kong

Chan, Yau Chung
North Point, Hong Kong

Chi Chuen, Cheung
Hong Kong, Hong Kong

Chow, Chung Chi
Lai Chi Kok, Hong Kong

Christopoulou, Patroula
London, United Kingdom

Corpuz, Angel
Al Khobar, Saudi Arabia

Crippa, Tommaso
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Gudja, Malta

Ellis, Thomas Charles
Beckenham, United Kingdom

Georgitsi, Emmanouela
Brighton, United Kingdom

Hariharaputran, Vishwaraj
San Antonio, United States

Hunt, Josh
Okehampton, United Kingdom

Lam, Chi Yeung
NT, Hong Kong

Liu, Chung Ching Desmond
Hong Kong, Hong Kong

Man, Wing Hong
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Perrone, Manuel
London, United Kingdom

Routledge, Marc
Nottingham, United Kingdom

Siu Kee Marcus, Ng
Hong Kong, Hong Kong

Wong, Ching Ling
Hong Kong, Hong Kong

Wong, Wai Chung
Spalding, United Kingdom

Yan, Hung Wai
Hong Kong, Hong Kong

ASSOCIATE

Ward, Stephen
Brough, United Kingdom

LICENTIATE

Chadwick, David
Manfield, United Kingdom

Colcombe, Demi
Tonypandy, United Kingdom

Davie, Thomas
Romford, United Kingdom

Everitt, Shaun
Bolton, United Kingdom

Exton, Drew
Lincoln, United Kingdom

Fernandes, Michael
Hornchurch, United Kingdom

Gatchalian, Kenneth Lawrence
Singapore, Republic of Singapore

Georgiou, Konstantina
Cambridge, United Kingdom

Marner, Tom
Leeds, United Kingdom

McPhillips, Anthony Peter
Huddersfield, United Kingdom

Morrison, Keith
Craigavon, United Kingdom

Naylor, Simon Thomas James
Leeds, United Kingdom

Ruggeri, Francesca
London, United Kingdom

Serek, Anthony Richard
Mount Hawthorn, Australia

Standerwick, Samuel
Bristol, United Kingdom

Spinning the golden thread

With the Building Safety Bill due to be introduced into Parliament, one topic has been enthusiastically debated: the golden thread. Hywel Davies considers this fundamental component of the new regime

The *Independent Review of Building Regulations and Fire Safety* was published three years ago, just a month before the first anniversary of the Grenfell Tower tragedy. During the review, Dame Judith Hackitt heard 'almost unanimous concern surrounding the ineffective operation of the current rules around the creation, maintenance and handover of building and fire safety information'.

Where available, 'it is often incomplete or held in paper form and is not accessible to the people who need to see it'. She was quite clear that this lack of information poses many safety challenges. The 'golden thread' of information is the recommended remedy.

Chapter 8 of the report proposes a 'golden thread' of information for all higher-risk buildings (HRBs), so that the 'original design intent is preserved and changes managed through a formal review process.' Dame Judith was clear that access to up-to-date information is essential for 'effectively carrying out a fire risk assessment of a building and determining whether any action is required'.

The concept of the golden thread is the digital management of information throughout the life-cycle of a building. It underpins the new more stringent regime for higher-risk buildings, sometimes called buildings 'in scope'. It consists of the information that allows someone to understand a building and the steps needed to keep both the building and those in and around it safe, both now and in future.

It provides the data and documents and describes the information management processes needed to identify, understand, manage and mitigate building safety risks so that catastrophic risks of fire and structural failure can be reduced and their consequences minimised.

This process is to apply through the whole life-cycle of the building, through design, construction, refurbishment and management, so the golden thread needs to be maintained and retained and available to all those with responsibility for the safety of the building.

This information should be stored, managed, maintained and retained as structured digital information. It is anticipated that government will provide guidance on the relevant digital standards for information management and exchange, taking full account of the emerging framework of standards, such as the BS EN ISO 19650 series, the guidance in the UK BIM Framework, and the work already under way in the housing sector to prepare for the new safety regime.

"The greatest challenge is not defining the golden thread, but convincing a change-resistant industry that reform and a change of culture is essential"

The information needs to be accurate, reliable and secure, and accessible from a single source. It must be kept up to date and relevant to those using it, and retained securely. Above all, it should give residents confidence that the building they call home is being managed safely.

Responsibility for developing the golden thread policy rests with the Building Safety Programme in the Ministry of Housing, Communities and Local Government (MHCLG). It is working closely with the HSE, which will be home to the new Building Safety Regulator. The regulator will have wide-ranging new powers and be responsible for implementing the golden thread policy once the bill becomes law next year.

Heightened interest in the golden thread is prompted by the desire to understand what this drive for digital information management will require. Dame Judith is clear that industry must own the golden thread – 'it is the responsibility of the [building operator] to initiate, hold and maintain this information'. With industry ownership comes duty: a duty to reform and to embrace digital information management and information exchange.

And it is not just the Hackitt review; the government's *Construction Playbook* puts the UK BIM Framework at the forefront of modern construction practice. The industry must learn to deliver comprehensive information about buildings, not just the buildings themselves.

The golden thread supports wider changes in the regulatory regime intended to promote a culture of building safety. Legislation alone cannot embed reform. The greatest challenge is not defining the golden thread, but convincing a change-resistant industry that reform and a change of culture is not just possible, it is essential. As the fourth anniversary of Grenfell approaches, we must continue to do all we can to deliver that cultural change.

DR HYWEL DAVIES
is technical director at CIBSE
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Measured steps

Monitoring of air quality is paramount to making sure public buildings are Covid-safe, says Webb Yates Engineers' Andrew Lerpiniere

The guidance and discussion on how indoor ventilation can be used to minimise the risk of airborne transmission of the SARS-CoV-2 virus has focused on workplaces and schools. These spaces are, to some extent, controlled environments; for the most part, the occupants are known and know the building. Standards of behaviour are generally already set.

Now, public buildings, museums and galleries, are opening to the general public once again, with some, such as libraries, having been open since 12 April.

Conditions in these spaces are different because control is restricted to how many people can be in the building at any one time, and does not extend to who those people are or how they behave.

Many public buildings are run by teams used to dealing with these issues, and to having a level of responsibility for their visitors' wellbeing, but – like us all – they are still learning what to do during a pandemic.

"The critical point is to have some understanding of how 'safe' spaces are"

It seems an age ago, though it was only last summer, that museums began to emerge from the first lockdown, opening their doors to limited numbers of visitors. There was so much of which we were still unsure.

Version 3 of the CIBSE Covid-19 Ventilation Guidance noted that: 'Evidence continues to suggest that in poorly ventilated indoor spaces airborne aerosols are a possible transmission route and the precautionary advice remains valid.' The precautionary advice was to ventilate spaces as much as reasonably possible with outdoor air. It is simple in theory, though not always in practice.

The question that many museums, and similar organisations, were facing then – and again now – was exactly how to follow that guidance. In a practical sense, there is only so much that can be done with any space – whether naturally or mechanically ventilated – to introduce as much outdoor air as possible.

In summer 2020, we worked with the V&A estate team to assess the existing ventilation provision for all spaces in the museum, using the CIBSE Covid-19 Ventilation Guidance as the basis of the assessment. For each space, consideration was given to whether the existing ventilation provision:

- Met the guidance
- Could be adjusted to meet the guidance
- Could not be reconfigured to meet the guidance and the system should be turned off.

Those spaces that were in the final category were subject to further workplace-based risk assessment in relation to whether they could be used at all or, where limited access was required, how they could be used safely. These were not spaces that would be accessed by the public.

But had it worked? The museum had followed the guidance and done all possible to maximise outdoor air supplies, but had it made its spaces Covid-safe? We decided to monitor CO_2 levels in every space, initially two to three times a week. We set a target level of 600ppm CO_2 or less for all spaces that would be open to the public, and consistently met that target, in all public spaces, both before the museum reopened and when visitors returned.

It is not possible to say that 600ppm is a 100% Covid-safe guarantee, but it is, probably, as close as we can realistically get to outdoor air without being outdoors. The current CIBSE guidance notes that large volume spaces with low occupancy– a description that fits many museum spaces – should aim for 800ppm CO_2. The critical point, having done everything to introduce as much outdoor air as possible, is to have some understanding of how 'safe' those spaces are.

The same should apply to schools. The vast majority will be naturally ventilated. There will be a huge range in the effectiveness of ventilation, and certainly plenty of poorly ventilated classrooms, but I doubt we really know how well or badly ventilated most schools are.

Monitoring CO_2 levels, as a direct indication of air quality, is a simple way to measure how well ventilated a classroom is. Thought needs to be given to how this is done; not every classroom in every school needs to be monitored all the time. A standard, scientific approach to gathering data is important – as is an intelligent approach to analysing that data. Schools are full of people who, with a little guidance, would be able to undertake both, at relatively little cost.

It may be that there is a fundamental problem with the ventilation of our schools, and that limitations on ventilation systems in some public buildings make effective outdoor provision almost impossible, but without more extensive measurement we cannot be sure. Understanding the issue makes finding a pragmatic, cost effective solution much more likely.

Read about air quality sensors on page 38.

ANDREW LERPINIERE
is director at Webb Yates Engineers

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OPEN TO CHANGE

To rise to the challenge of delivering safe and healthy net zero carbon buildings, the building services engineering industry must embrace diversity and become more inclusive, says new CIBSE President **Kevin Kelly**. He talks to **Alex Smith** about plans for his year in office and how he's already taken action to get more women on the CIBSE Board

Lifelong learner Kevin Kelly is keen to provide 'ladders of opportunity' for all within the industry

Professor Kevin Kelly has taken on the Presidency of CIBSE during a time of profound change for the building services industry. In his inauguration speech last month, he described three external factors that were causing upheaval in the industry: the consequences of the Grenfell Tower fire, Covid-19 and climate change.

Kelly described Covid-19 as a hammer blow that had thrown up health challenges for engineers that they have never faced before. At the same time, climate change was forcing engineers to take urgent action to deliver net-zero buildings, while also having to prepare for a 'fundamental change in building safety' brought about by the response to the Grenfell fire.

Kelly believes engineers want to change, but, to do so, he feels they must pay more attention to the way their buildings actually perform.

'I'm not convinced that, the way people are building, they are doing things for the planet,' he says. 'The designs might be OK, but that performance gap exists after the building is occupied. What are we doing to close the gap?'

Kelly thinks engineers should be carrying out more research on their own buildings to understand the impact of their design and innovations on performance.

'There's no such thing as a research laboratory if you're a building services engineer,' he says. 'The lab is the building you have just created. You've got lots of data, which you can extract to see if the building performs as well as you expected.'

Describing himself as an academic and engineer, Kelly is keen to encourage collaboration between industry and universities. He says that engineers, short of time or resource to evaluate their buildings, could look to researchers in academia for help.

'When I talk to engineers, they ask, "how am I going to find time to evaluate performance?"; I tell them they have a data-rich environment and there are postgraduate students who don't have enough data for research.'

Lifelong learning

Kelly says he is a lifelong learner. He completed his primary building services

CURRICULUM VITAE

A professor emeritus and research fellow, Technological University (TU) Dublin, Kelly remains active in PhD research supervision and in editing research for the online *SDAR Journal*.

Career

Began in 1970, as a 15-year-old apprentice electrician. In 1978, he started training as an electrical services engineer and, in 1983, entered Dublin Institute of Technology (DIT) to teach electrical apprentices. Led the development of electrical services engineering programmes at degree level in the mid-1990s, which allowed advanced entry for electrical apprentices.

Retired as head of school of multidisciplinary technologies and was previously head of department of electrical services engineering at DIT/TU Dublin.

Education

First-class honours in building services engineering from Dublin University (Trinity College); MSc (education and management – Hons) from Dublin City University; doctoral degree in education from University of Sheffield. Conferred as professor by DIT.

CIBSE

Past chairman of CIBSE Ireland (2005-06); Past president SLL (2013-14); CIBSE Silver Medal awarded in 2015.

Kelly believes apprenticeships are a good way for young people to earn and learn and enter the industry

> "If you've got a changing external environment, your company needs a wide range of people representing the full bandwith of society"

engineering degree in his 30s, a Master's in education and management in his 40s, a doctoral degree in education in his 50s, and he was conferred as professor in his 60s.

He admits he wasn't 'terribly good at school', but says an electrical apprenticeship helped him close his education gap. In awe of his teachers, Kelly ended up emulating them and teaching on the course. He and other tutors were given the opportunity to complete an honours degree in building services engineering at the Technological University Dublin (TU Dublin) – formerly the Dublin Institute of Technology. After graduating , Kelly led the team that created the electrical services degree programme for school leavers and apprentices.

'From a diversity point of view, it was good to provide an opportunity for people who may not have had their Leaving Certificate [the Irish equivalent of A Levels],' he says.

'When I see apprentices coming through at CIBSE, I think it's fantastic. It's a brilliant way for young people, who may not be able to go to university, to earn and learn and enter the industry.

'I'm absolutely opposed to any glass ceilings and to those who say, "oh, well, they're only apprentices. They can't go all the way through." I will fight tooth and nail to provide those ladders of opportunity and let them burst through.'

Strength through diversity

To meet the changes in the industry, Kelly believes companies and organisations have to be more agile – which, he says, means being more inclusive and employing a diverse workforce, to ensure there is a wide awareness of changes to the environment.

'If you've got a changing external environment, you need a wide a range of people in your company, representing the full bandwidth of who is in society,' he says.

He defines an inclusive organisation as being made up of people of different ages, genders, backgrounds, religions, sexual orientation, race, and physical abilities. 'It seeks to represent the society it is set in,' says Kelly.

Kelly encourages companies to hire more women and minorities and to try over time to get balance at boardroom level too.

CIBSE Groups and Societies have an opportunity to be more representative of their members, and Kelly believes steering groups should be as diverse as their membership – and that chairs should be making sure successors are representative of different groups.

'The more diverse you are, the more likely you are to attract Members. I want this to be a big part of my presidential year. I will be »

» asking the BAME community what we can do to make CIBSE more inclusive.'

Kelly has a sense of how women experience the industry through his daughter, a finance director at a construction company. He tells how she took a male project manager (PM) along for a meeting with a male agent, and despite her being the decision-maker, the agent only spoke to the PM, even when his daughter was asking the questions.

'I asked her, "did it affect your decision?" She said, "not really, but if it was touch and go, and there was another company with the same offer, he wouldn't have got the business".

'It's really stupid for people to be like this, but they don't realise they're doing it,' says Kelly. 'It's subconscious bias.'

At TU Dublin, Kelly says there was training to overcome this bias, which he underwent. 'It makes you question yourself and increases self-awareness,' he says.

'Training should be compulsory for every organisation, because subconscious bias is so prevalent, and people are unaware they are doing it. It's up to all of us to question the way we treat people from different backgrounds.'

> "People do want to meet in real life, but we need to retain virtual meetings - particularly for families. They're an extra layer of inclusivity"

Kelly believes that the Covid-19 pandemic will leave a legacy of virtual working that will help with diversity, because it is more inclusive and will particularly enable parents with young children to remain active in the profession. 'Although people do want to meet in real life, and one to ones are easier, we need to retain virtual meetings – particularly for families. They're an extra layer of inclusivity.'

On diversity, Kelly is leading by example. As CIBSE President, he has co-opted three women onto the CIBSE Board to increase the ratio of women to men from 3:9 to 6:9.

'I made it clear that I want to hear more female voices on the board,' he says. 'If everybody at the top level is male, there's something seriously wrong – that doesn't represent the society they are serving.'

Kelly is also keen for the CIBSE Board to be more representative of minorities. 'We still have a very white board. We have one representative from Hong Kong, but we really, really need more representation from BAME people.

It's clear from his inauguration speech and our interview that Kelly intends to spend his year in office realising the goals laid out in his curriculum vitae: that there will be increased opportunity for talented people – regardless of their background – with no discrimination or snobbishness in any form.

The co-opting of three women to the CIBSE Board is just Kelly's first step towards creating a more balanced and representative Insitution. CJ

CIBSE President Kelly wants to foster more collaboration between academia and industry

THE IMPORTANCE OF EDUCATION

Responding to climate change while ensuring buildings are safe and healthy are significant challenges that need to be addressed when developing new building services courses and CIBSE CPD content, says Kevin Kelly.

'Current courses need to evolve quite quickly, so engineers can develop new ways of providing energy-efficient buildings and systems that reduce energy demand and carbon emissions, and inspire confidence that buildings are safe, sustainable and healthy to work in. Digitalisation is key to delivering some of this.

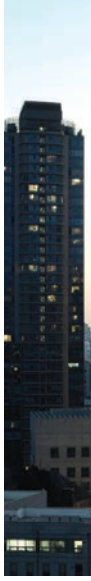
We may also need new courses that focus more explicitly on these challenges – perhaps at postgraduate level. Meeting the challenges of zero carbon and building safety will be a constant theme for training and education providers throughout the supply chain.

I would also like to see increased collaboration between industry and universities, and increased numbers of working engineers undertaking research degrees.

This would help close the gap between research and industry, and enable industry to respond better to challenges and then evaluate innovative design solutions.

There is an opportunity for CIBSE to strengthen its CPD lecture scheme. Virtual meetings have opened new opportunities to share content and it is likely that, even when we begin to move back to regional meetings, we will have a blended approach.

It is important to recognise that the building-safety agenda will mean raising standards of competence. CIBSE will need to continue to develop its CPD courses and career training further, so that mid-career engineers update their knowledge in response to industry change.'



A WINDOW ON TO SEOUL

To reduce energy demand and enhance occupant comfort and wellbeing, passive systems for daylighting, shading and natural ventilation were maximised at the HQ of Seoul's largest cosmetics company, Amorepacific, as **Andy Pearson** reports

The brief was to create a landmark building with a distinct identity that was also an exemplar for low energy and sustainability, says Arup's submission to the 2021 CIBSE Building Performance Awards, Project of the Year – Commercial/Industrical category.

The consultant's entry is for the building services design of the Seoul headquarters of South Korea's largest cosmetics company, Amorepacific. Arup worked on the scheme with David Chipperfield Architects Berlin. The design team has embraced the brief by making sustainability inherent to key design decisions, the most significant of which relate to the building's form. In Seoul, the convention is for corporate headquarters to shout about their presence by building tall. However, Amorepacific's HQ has been designed as a mid-rise, 29-storey, 110m-tall cube, to maximise the use of passive systems for daylighting, shading and natural ventilation, to reduce energy demand and enhance occupant comfort.

To avoid the creation of deep-plan office floor plates, the building's core has been exposed by punching an opening through the roof and down through the cube's centre, to allow natural light and air to enter the heart of the building.

'The proportions of the building have been carefully designed around a central atrium to maximise the effectiveness of natural ventilation and daylight on all floors,' says Ant Marsh, building performance and systems engineer at Arup.

Additional horizontal openings have been punched through the elevations to the core, on the fifth, 11th and 17th floors. These openings house landscaped gardens and terraces to provide recreational spaces for staff and visitors. Arup optimised the location of the openings to take into account the impact of the prevailing wind direction and minimise wind deflections from the façades down onto the entrances below.

A courtyard has been created at the base of the building's open core, on what is actually the roof of the building's double-height atrium. This courtyard incorporates a glazed floor to admit daylight into the atrium below. The floor is partially covered by a 70mm-deep reflecting pool, which enhances the courtyard's calming ambiance.

The effectiveness of the courtyard façade shading reduces the office peak load by 50% at upper levels and 25% at lower levels, which reduces the required size of terminal units and chillers for climate control in offices.

The courtyard is intended to be the communal centre of the company workplace. Above it, the quadrangular office floor plates provide 80,000m² of office space; below it, the ground-level atrium is open to visitors and the public on all sides. In addition to being the main arrival point, the atrium is an event space for art installations, concerts, lectures and other cultural activities, including a museum, restaurants, retail spaces, and 450-seat auditorium.

Controlling solar gains

While the atrium is open to the streets, above it the building's glazed façades are partially concealed behind a diaphanous covering of vertical brise soleil. The fins are needed because the building's orientation at an angle of 45° from north means that two elevations face in a northerly direction, while glare and solar gains have to be carefully controlled on the south-west and south-east elevations.

The courtyard incorporates a glazed floor to admit daylight into the atrium below


The glazed façades are partially concealed behind vertical brise soleil


The courtyard floor is partially covered by a 70mm-deep reflecting pool

The distinctive metal curtain formed by the bespoke brise soleil solution has become a signature feature of the building. It comprises 1,150 aluminium fins in four sizes – 450mm, 350mm, 250mm and 200mm deep. Although these fins appear to be uniform, they are grouped in patterns that vary around the building in response to solar exposure. On the north-east and north-west elevations, where direct solar exposure is minimal during normal work hours, shallow fins are used to maximise the amount of natural light permeating the façade. Controlling solar gain and glare is more critical on the south-east and south-west façades, so deeper fins are used to give enhanced solar shading and reduce cooling loads.

South Korea is subject to typhoons, so the brise soleil are designed to resist high wind loads. To optimise the fin design, Arup conducted a series of tests to enable the behaviour of wind at the edges of the large façade openings, and the down-wash impact at entrances, to be predicted, while ensuring the structural robustness of the fins. As a result of the tests, the engineer introduced 3mm linear vertical protrusions to the fins to encourage vortex shedding. These linear strips help induce micro turbulence, which reduces deflection and vibration effects, while improving robustness.

> "The façade is formed from triple-glazed panels, with solar-reflective glass, to maximise daylight and views while retaining thermal resistance to heat gains"

Behind the brise soleil, the façade is formed from triple-glazed panels, with solar-reflective glass, to maximise daylight and views while retaining good thermal resistance to both heat gains and losses.

The brise soleil are separated from the glazed façades by perforated metal walkways at each floor level. As well as supporting the fins, these provide horizontal shading and allow the outside of the windows to be cleaned. The walkways also provide access to the motorised ventilation louvres at the top and bottom of the windows that enable the office floor plates to be naturally ventilated.

Ventilation

The external design conditions for Seoul are: 31.2°C »

GROUND SOURCE HEAT PUMPS

The Amorepacific headquarters incorporates 160 backfilled boreholes, each containing a pipework loop to a depth of 150m. Warm water is circulated through the pipes, dissipating heat to the cool (approximately 15°C) ground surrounding the boreholes. A set of heat pumps located in the basement plant room converts this cooling into chilled water at a useful temperature to provide 950kW of supplementary cooling.

In order to operate effectively, the heat pump has to provide an equivalent level of heating in the winter months. If the heat pump was used solely for cooling year round, the ground temperature would slowly rise until it became ineffective as a heat sink.

Using the ground as a heat source through the winter months prevents this heat build up from occurring. The lower temperature hot water from the heat pumps is used to provide underfloor heating to the day care nursery, as well as heating to frost coils on air handling units.

TWIN ELEVATORS ARE A DOUBLE WIN

The central courtyard arrangement means the lift and stair cores have had to be positioned in the four corners of the building. The cores comprise five passenger lift shafts, and one service and firefighting lift.

Unusually, the scheme features two independent lift cars in each shaft, one on top of the other. Both cabins use the same guide rails and landing doors. According to Arup, this twin-lift arrangement, with hall control, gives 'an increase in conveyance capacity and a reduction in waiting time, as well as a reduction in energy consumption' when compared with a conventional double-deck lift. At the time, it was the largest application of its kind in the region.

The courtyard is intended to be the communal centre of the workplace

» drybulb/25.5ºC wetbulb summer, and -11.3ºC in winter. The opportunity for natural ventilation on the office floors during the swing seasons has been maximised by locating workstations next to the façade, with meeting rooms and auxiliary areas concentrated in the interior zones of floor plates. Motorised ventilation louvres at high and low level ventilate the perimeter spaces in spring and autumn, to reduce power demand from the air conditioning.

Underfloor mechanical displacement ventilation serves the central floor zone and provides mixed-mode ventilation to the perimeter. Displacement ventilation was chosen to provide flexibility in the layout for the floor plans and to facilitate a simple zoning control strategy between the perimeter zone (which can be isolated when the windows are open) and the central floor plate zone, which remains operational regardless of window position. 'During spring and autumn, conditions at the perimeter of the building can be maintained by natural ventilation, as can those in the areas of building facing the courtyard,' explains Marsh.

In line with LEED, office ventilation rates are 30% higher than ASHRAE 62.1 minimum requirements. The systems are designed to operate at full fresh air when external conditions allow. An interlock prevents operation of the mechanical ventilation system when the louvres are open.

"Placing workstations next to windows maximises the use of daylight and exploits views out"

Office temperatures are maintained by a combination of perimeter fan-coil units for the perimeter zones, and floor-standing air handling units for the central areas. Fresh air is delivered from central air handling units, located at roof level. Placing workstations next to windows also maximises the use of daylight and exploits views out; 98% of workspaces have a direct line of sight to the outside.

A central chilled water system will provide cooling to meet the building requirements. Chilled water plant is installed in the basement, with water cooled chillers, primary and secondary pumps, and ancillary equipment located in a dedicated plant room. Cooling towers provide heat rejection for the chillers.

The maximum cooling load for the site is about 10MW. Local codes limit the cooling that can be directly generated using dedicated chillers to 40% of the total building load. The chiller room will house four water-cooled centrifugal chillers. Two chillers provide chilled water

directly to the primary chilled water system, while two chillers are linked to a bank of individual ice storage tanks located in the basement.

During the night, the ice storage chillers will operate to generate ice in the storage tanks. During the day, the peak cooling load will then be met by a combination of the direct chillers (40%) with the ice storage chillers providing cooling directly to the building (30%) and the release of cooling energy that has been stored in the ice banks overnight (30%). Each of the three chilled water generation elements will be fed into a single primary header from which connections will be made to each core for distribution throughout the building.

The primary source of heat for the building will be steam. Steam will be generated by four steam boilers. Steam will be used directly for heating coils and humidification within air handling units, and for domestic water heating. Steam will be used to generate low temperature hot water, which will be distributed within each core to provide heating as required at each level of the building.

The building was awarded LEED Gold certification. This included a 'LEED innovation in design' credit for the use of an ice-storage system. The system was introduced to increase the efficiency of the cooling system by producing and storing extra coolth at night. This is used to offset the cooling requirement the following day, to help to minimise the building's peak electrical loads – which also helps to reduce capacity requirement on the local electricity grid.

In addition, to reduce demand for potable water and minimise wastewater generation, the building incorporates rainwater harvesting, greywater treatment and low-flow water fixtures.

On the electrical systems, sub-metering is included on all electrical distribution points in the building. Dali lighting control, including daylight linking and occupancy sensing, were also used to reduce energy consumption, and the scheme has roof-mounted PV panels.

Performance data

In 2018, Amorepacific moved into its new headquarters. It undertook an occupant survey, focusing on the impact of the new facility on staff satisfaction and wellbeing. Impressively, the survey found that, after relocating to the new headquarters, 70% of employees felt the workplace environment had improved.

Amorepacific also uses an online platform to solicit ongoing feedback from staff on the building's internal environment. These comments are used to make adjustments and give feedback on user preference. After an initial period of operation, the company provided 12 months of detailed energy performance data, which formed the basis of an energy-performance review after the building's first full year in operation.

Based on the review, Arup made a number of suggestions to optimise the building's performance, including:

- Examine the operation of the natural ventilation system and whether greater energy savings could be realised
- Examine the operation of the floors with the lowest energy consumption to determine whether there are lessons that can be applied to floors with a higher consumption
- Check the lighting loads on the floors to see whether more savings can be made by adjusting the automated lighting-control system
- Consider whether additional sub-metering of the main supply would allow a better understanding of the contribution of individual sub-systems to overall energy consumption
- Examine the sub-metering of the renewable and low carbon systems (for example, PV and ice storage) to ascertain whether they are delivering peak operational benefit
- Examine the sub-metering of water to determine more detail on consumption patterns, and compare with Korean benchmark data to see where improvements can be made.

UTILITY CONSUMPTION

The overall utility use for the building was calculated and converted into industry-standard energy use intensity (EUI) figures, so that the building could be compared against other office buildings.

APHQ	Total (kWh)	EUI (kWh·m^{-2}·y^{-1})
Electricity	23,607, 692	109
APHQ	**Total (kWh)**	**EUI (kWh·m^{-2}·y^{-1})**
Gas	13,974,733	65
	Total m^3	Water-use intensity (L·m^{-2}·y^{-1})
Water	157, 320	728
Hot water	51,549	238

The building performance data compared well with benchmarks for South Korean commercial buildings taken from a peer-reviewed academic study published in 2017. This study takes data from South Korean government statistics and derives a set of internationally comparable benchmark values for a range of building types.

One of the key findings from the Arup study was that the building's operational energy performance is, overall, 50% below South Korean benchmarks for commercial buildings. The study also showed that the headquarters performs significantly better than the South Korean benchmarks across all categories of end-use energy consumption, with reductions of 62% for mains power, 38% for lighting, 42% for small power and 52% for gas (for heating).

When the Amorepacific HQ building won Project of the Year – Commercial/Industrial category in this year's CIBSE Building Performance Awards, the judges commended the scheme for 'its contribution to the quality of life for the building's occupants and visitors'. A worthy winner. CJ

CLIENTS CRUCIAL TO DRIVE CHANGE

Many clients are driving change towards net-zero buildings, but finance and resource constraints are holding back others, according to a survey of 49 firms signed up to Building Services Engineers Declare. Hoare Lea's **Ashley Bateson** and **Andy Cane** report the main findings

Clients are the biggest factor in determining whether building services engineers can design net-zero buildings to tackle the climate and biodiversity emergency, a new survey has revealed.

While client priorities are the biggest driver for net-zero buildings, the survey of signatories to the UK Building Services Engineers Declare also found that clients hindered change, with financial, time and resourcing constraints identified as the main challenges.

Of all the commitments laid out in the declaration, respondents said that the one concerning life-cycle costing, whole-life carbon modelling and post-occupancy evaluation was the hardest to achieve, with 32% saying it is currently impossible or hard to deliver. Encouragingly all respondents said their companies were able to raise awareness of the climate and biodiversity emergencies among clients, collaborators and supply chains.

The Building Services Engineers Declare Climate and Biodiversity Emergency was established in 2019 as a platform through which firms and organisations could affirm their intent to advocate and act on net-zero carbon pathways, and tackle the climate and biodiversity emergency.[1] There are now more than 95 signatories, including small and large consultancies and institutions such as universities. See 'Engineers respond to the emergency' in January 2021 *CIBSE Journal*.

Signatories of the UK declaration were invited to participate in the survey to gather information on how organisations are approaching the declaration, and how their business are dealing with the climate and biodiversity emergency. The survey ran for four weeks between February and March 2021, and was sent to the individuals responsible for signing the declaration on behalf of their organisations. In total, 49 responded.

On the whole, the responses were provided by directors, partners or owners of the organisations. Some key findings from the survey are outlined below:

Meeting the commitments

- All respondents felt they were able to raise awareness of the climate and biodiversity emergencies among clients, collaborators and supply chains, with 63% feeling that they were completely able to do this and 37% mostly able to do this. This commitment received the highest number of positive responses.
- 32% of respondents found it hard to include life-cycle costing, whole-life carbon modelling and post-occupancy evaluation as part of the basic scope of work, making this the toughest commitment to meet overall. Nevertheless, 63% of respondents felt they were mostly able or completely able to deliver this service.
- Respondents were most uncertain about establishing climate and biodiversity mitigation principles as a key measure of

success, with 10% of respondents unsure of whether they were currently able to do this.

Organisational change

- All respondents felt they were able to meet at least some of the declaration commitments before they became signatories, with 54% saying they were already able to meet most or all of them.
- Around half of respondents thought that their organisation and approach to projects had been affected since becoming a signatory; however, the remaining half felt theirs had not.
- Of those respondents making changes, client priorities were considered to be the biggest driver, followed by staff demanding change. Specific comments received also highlighted the moral obligation felt by organisations to do the right thing.
- Conversely, client priorities were also considered to be the most significant challenge to implementing change. Financial, time and resourcing constraints were identified as key barriers.
- 56% of respondents had assigned responsibility within their organisations for evaluating performance against the Declaration commitments, and 24% were planning to do this. However, 20% had not assigned responsibility, and were not planning to do so.

Insights from signatories

Andy Cane, senior sustainability consultant, Hoare Lea

It's encouraging that, even though a third of firms find it hard to include life-cycle costing, whole-life carbon modelling and post-occupancy evaluation in their basic scope of work, two-thirds of firms are able to do this.

For me, this shows a clear opportunity for the industry to pull together and share knowledge, so that we can learn from the strengths of others. Perhaps a key challenge will be to what extent we're able to usefully share knowledge with competitors and I believe that the 'declares' movement provides a key way to enable this, by placing advocacy and knowledge sharing at the core of its purpose.

It's also clear that knowledge sharing needs to extend beyond the building services engineering industry to reach clients and developers, whose priorities can be both the biggest driver and biggest barrier to delivering sustainable developments. »

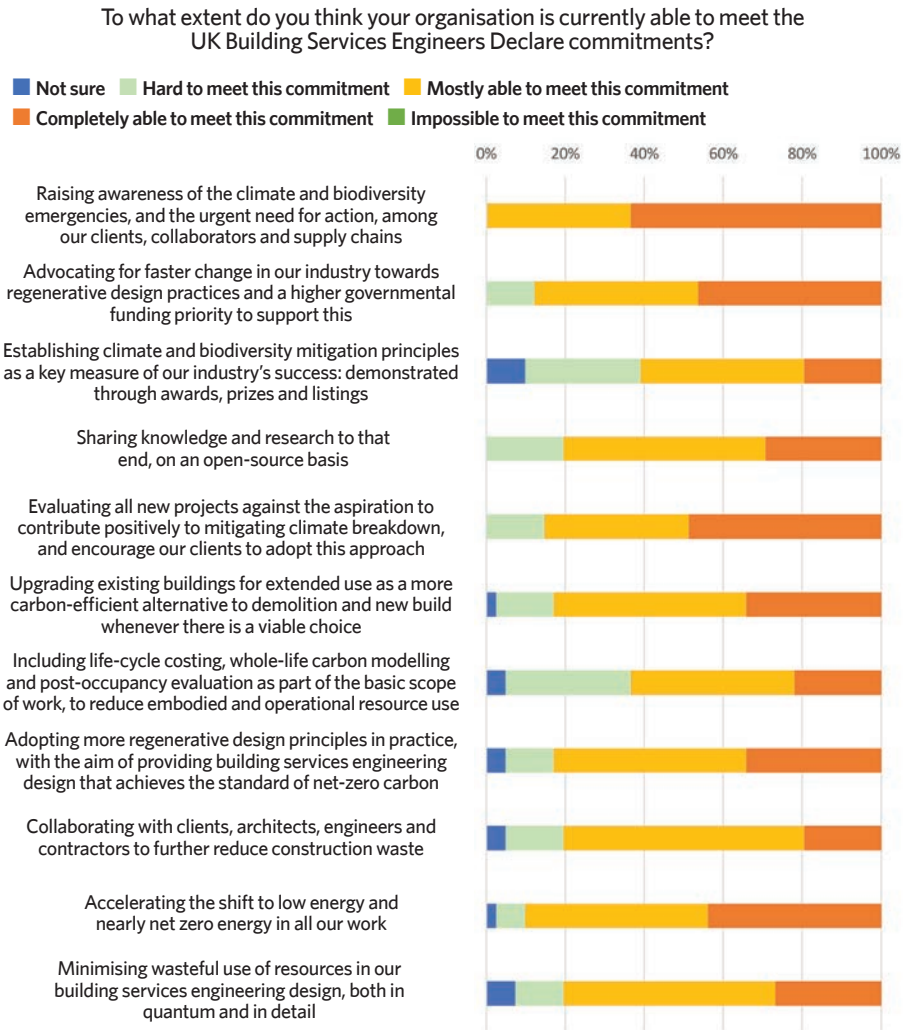
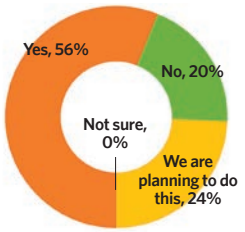
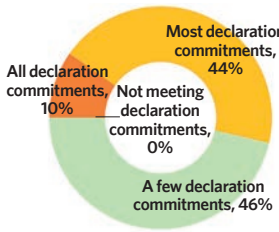


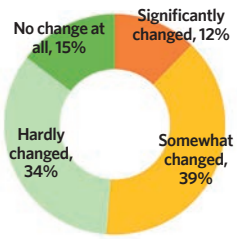
Figure 1: Survey responses – signatories were asked how well they felt they could achieve the commitments of the climate change and biodiversity declaration



Has responsibility been assigned to an individual or a working group in your organisation for evaluating and monitoring performance against achieving the declaration commitments?



How much do you feel your organisation was already meeting the declaration commitments before you became a signatory?



To what extent has becoming a Building Services Engineers Declare signatory affected your organisation and your approach to projects?

Figure 2: Survey responses – signatories were asked how signing the climate and biodiversity declaration had changed their operational practices

"Knowledge sharing needs to extend to reach clients and developers, whose priorities can be both the biggest driver and the biggest barrier to delivering sustainable developments"

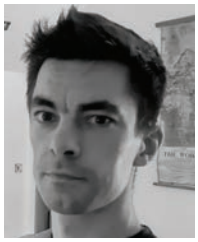
Eleanor Hoey, senior engineer, Method Consulting

Hitting climate change head-on has always been something we need to do and, as a young engineer, I feel it's apart of my duty to do so for my generation and to protect future generations.

There has always been resistance to change, and many of us can feel more comfortable sticking with how things have always been done. However, with correct knowledge and education we can collectively approach clients and colleagues with the tools to break down these barriers and make sustainable practices simple and natural.

The initial response from the survey indicates that client constraints are a huge challenge when implementing change. Making the declaration brings back into focus the climate emergency and reminds clients that they too play a role when it comes to sustainability.

By creating a network where expertise and knowledge can be shared among all levels within a practice, we, as engineers, can work with the client to break down constraints and resistance.



Jonathan McMillan, associate, Hulley & Kirkwood

It was very encouraging to see the consensus in responses that change is being driven by engineers based on principle, and that there is a passion – potentially from younger engineers – to break away from the 'business as usual approach' and to apply new techniques to deliver innovative designs that will mitigate climate change.

The individual responses suggest that evolving planning and regulatory policy have helped to promote climate-neutral design, but the responses also highlight that the parallel rollback of incentive schemes – such as the RHI, FIT and ECA (to name a but a few) – have presented financial constraints that have hindered change.

Marian Ferguson, founding director of Energylab Consulting

It is encouraging to see from the survey that there is an appetite in our industry to collaborate and knowledge share through the forum of Building Services Engineers Declare. While there is obviously commercial confidentiality to consider, building services engineers can see the benefit of working together and sharing experiences to help with the challenges that the climate emergency poses. Good to see that there is senior buy-in, too. CJ

ASHLEY BATESON is a partner and **ANDY CANE** a senior sustainability consultant at Hoare Lea

References:

1 **www.buildingservicesengineersdeclare.com**

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Quality time

According to a new study, a paradigm shift in how buildings are ventilated is needed, on the scale of the reforms that followed the health crisis caused by contaminated water in 1800s Britain.

The study's authors want governments to recognise that infections can be prevented by improving ventilation systems. They are calling on the World Health Organization to cover airborne pathogens in its indoor air quality guidelines, and for building ventilation standards to include higher airflow, filtration and disinfection rates, as well as monitors. More research is also needed on airborne transmission and, on page 42, members of CIBSE's Natural Ventilation Group look at the factors that determine how long a virus is viable indoors.

To help make a business case for investing in workplace design, Cundall has created a productivity-mapping toolkit, which shows how offices can increase employees' wellbeing and productivity, and save on operating costs (page 34). Of course, any design interventions need properly specified monitors to ensure measurements remain accurate over time (page 38).

Liza Young, deputy editor of *CIBSE Journal*

CONTENTS

Thinking positively

There is no denying the Covid-19 pandemic has prompted reflection and changes in the behaviour of office-based workers. While employees' working habits have changed, the latest research shows that many are still feeling optimistic about returning to work.

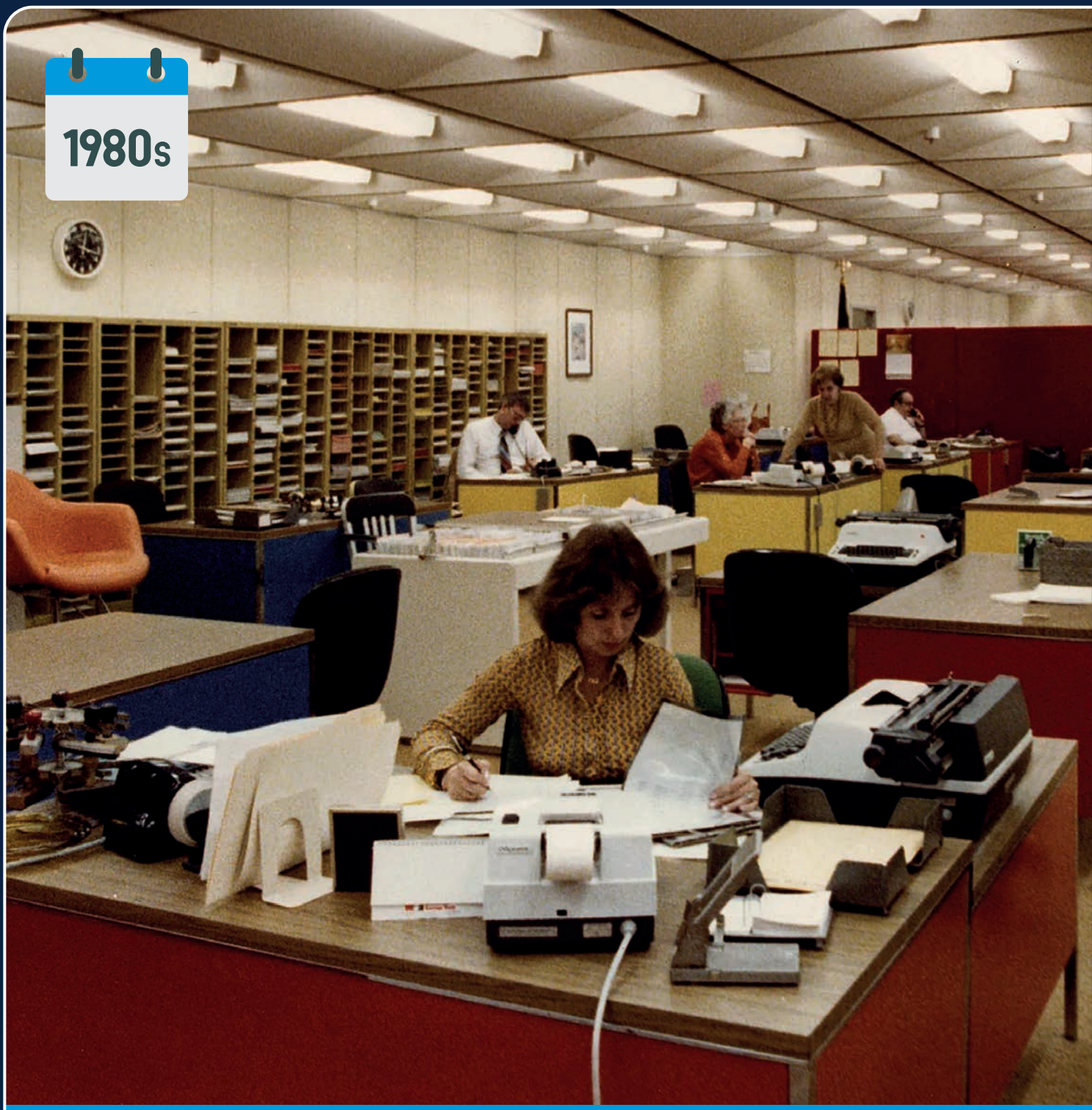
Some businesses will reduce their physical presence; many of Britain's biggest employers have publicly confirmed their intention to embrace hybrid working models. What is certain, however, is that companies retaining their offices will be keen to create spaces that are safe, as they seek to encourage people back into the workplace.

More than ever, employers and staff are realising the value of workplaces that focus on creating a positive environment. So, it's arguable that there has never been a better time to review core building systems.

Lighting is critical to providing a safe and productive working environment, and it is intrinsically supportive of employee wellbeing. Those who invest in the latest technology can be buoyed by the realisation that they are creating a healthier environment that can boost alertness, productivity and comfort.

Now is the time to think carefully about how offices can be used best when life begins to return to normal. Incorporating technologies that will support more varied and unpredictable occupancy patterns is the only way to go – and, in this regard, integrated LED lighting and control systems represent a straightforward win-win for employers and employees alike.

tamlite.co.uk/wellbeing



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The business case for wellbeing

Winner of the 2021 CIBSE Building Performance Awards Product or Innovation of the Year – Wellbeing is a timely productivity mapping toolkit from Cundall that helps make the business case for interventions in workplaces to improve wellbeing. Phil Lattimore reports

How do you make a business case for investing in workplace design to increase wellbeing to boost productivity? The winner of this year's CIBSE Building Performance Awards Product or Innovation of the Year – Wellbeing was developed to address exactly this.

Multidisciplinary engineering consultancy Cundall has created a productivity mapping toolkit, which demonstrates how investing in workplace design can increase wellbeing and productivity and, ultimately, save on operating costs. It is estimated that 90% of business costs are associated with staff, so every small percentage improvement in productivity can equate to significant savings for businesses – a sum that could add up to hundreds of thousands, or even millions, of pounds, depending on the size of the organisation.

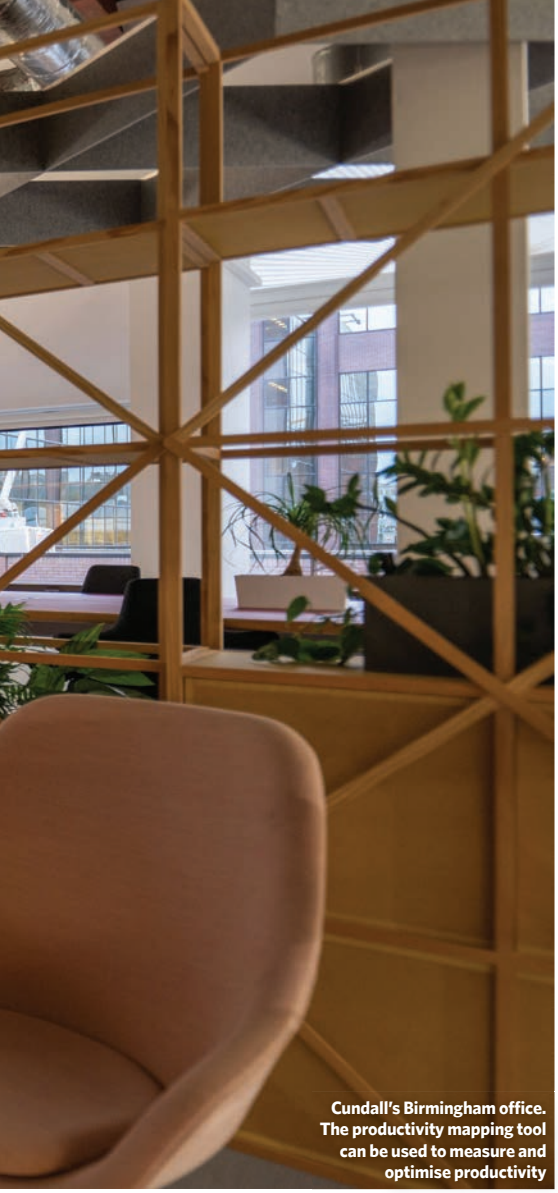
In developing its toolkit, Cundall explored a growing body of research (see panel, 'Sources for Cundall's wellbeing and productivity research') that suggests workplace environments significantly affect productivity and office wellbeing. Studies from Harvard and Oxford Brookes universities, for example, estimate a 20% impact on productivity based on a range of environmental factors. Quantifying and calculating the impact of such environmental changes is at the toolkit's core.

Productivity boost

The toolkit was praised by the awards judges for the 'effective way it demonstrates to clients the impact of wellbeing'. Cundall's productivity mapping tool, which quantifies elements of the indoor environmental quality (IEQ) – such as temperature, CO_2 levels and daylight – can be used to measure and optimise employee productivity in existing workplaces, as well as in the design stage of new buildings.

The company used the latest academic and industry research to produce a bespoke parametric modelling tool that shows where occupant performance metrics are linked with the environmental parameters of thermal comfort, CO_2 and daylighting at each desk position across a floor plate on an hourly basis. The tool can identify areas in a building where the IEQ is likely to reduce levels of occupant productivity. It can then be used to optimise architectural test fits of options to improve productivity.

Cundall says the toolkit can predict the loss of productivity at any workstation and assess the benefit of remedial measures. It can also aggregate the loss of productivity, which, when combined with an organisation's revenue or the salary of the occupier, can give an assessment of the financial impact for a range of measures. When linked with the capital costs, it can be used to demonstrate the financial return on investment and payback of each proposed intervention.



Cundall's Birmingham office. The productivity mapping tool can be used to measure and optimise productivity

Demonstration

The drive for healthier workplaces predates the Covid-19 pandemic. Increased understanding of the link between healthy environments and productivity was developing alongside advances in environmental simulation and monitoring tools that enable engineers to assess IEQ at design stage and once buildings are occupied. While improved monitoring and research may have spotlighted the link, however, Cundall recognised the difficulty in demonstrating this in financial terms to occupiers and investors.

Simon Wyatt is the sustainability partner at Cundall, responsible for the delivery of the firm's health and wellbeing offering. He explains: 'We started on a journey into health and wellbeing around six years ago, when we applied the Well Building Standard to our office fit-out in London – we were the first people in Europe to achieve certification using that standard. Off the back of that, we started to do quite a lot of work in health and wellbeing. As engineers, we got interested in the details, the measurement and verification side – the fact that it was based on actual performance rather than design performance; actually achieving measured results.'

After several presentations by Cundall on this subject at conferences and in CPDs, one question kept coming up: how much does it cost, and what is the business case associated with designing for wellbeing? This prompted the team to look at a review process that would enable them to demonstrate return on investment to a client, in a similar way they would for energy-saving assessments.

'At the time, organisations such as the British Council for Offices were putting out reports and studies into the effects of occupant wellbeing on productivity,' says Wyatt. 'So, we carried out a review of the academic literature around it.'

Cundall explored a plethora of studies linking wellbeing and IEQ. 'We were confident we could accurately assess IEQ, whether monitoring it in existing buildings or using environmental simulation tools to predict it for new buildings,' Wyatt says. 'We use IEQ parameters – such as temperature, relative humidity and light levels – which can be monitored and measured on a minute-by-minute basis.

'For new buildings, we use standard industry simulation tools, such as Radiance for daylighting, and IES, TAS and EnergyPlus for thermal comfort and thermal parameters, and we use sensors to sample CO_2 concentrations and air quality. We then process the IEQ data using the bespoke parametric tool we developed, and convert that into statistical average productivity gain.'

Live feedback loops can also give occupants the information to improve their environments, and help with fine-tuning a building post-occupancy. The toolkit could also be used for organisations selecting potential buildings to lease, as part of a due diligence process, to estimate the likely impact the floor plate of a particular building will have on employee performance and productivity.

The toolkit can predict productivity loss at a workstation and assess remedial measures benefits

> "Improving productivity by even 1% or 2% can indicate significant savings – which can be measured in hundreds of thousands of pounds, with a payback of months or weeks"

Marginal gains

Cundall's literature review took in more than 100 academic papers and other research, with the team honing them down to around 16 (see texts in panel), and drawing on particular ones to combine and consolidate the relationship between IEQ and productivity for its model. While studies from Harvard and Oxford Brookes universities have indicated an impact of up to 20% on productivity from environmental factors, Wyatt says Cundall was more cautious in attributing such large potential impacts when refining its toolkit.

'Some academics and industry figures are sceptical about claims linking IEQ, wellbeing and productivity, especially when it comes to CO_2 levels, and we were circumspect about some of the more headline-grabbing claims about »

» improvements to cognitive performance,' Wyatt says. 'The toolkit was developed by me and Ed Wealand – head of the CIBSE Air Quality Group – and we had data scientists and data engineers building the tool, going through the studies and making the links.'

The tool takes a conservative approach to estimating potential wellbeing productivity gains from improving environmental factors, says Wyatt. 'We're only estimating very marginal gains for all these things, but these are significant because we're talking about the productivity of people – and, for most organisations, that's 90% of their costs. Improving productivity by even 1% or 2% can indicate significant savings, which can be measured in hundreds of thousands of pounds, with a payback of months, or even weeks. So, you don't need a 20% forecast saving to make a compelling business case.'

Cundall is looking to enhance the toolkit, when possible, by incorporating the impacts of acoustic treatment, HVAC system types, and the effectiveness of air distribution and internal pollutants.

Model workers

Measuring and modelling environmental factors in a building is within the technical capability of engineers, but productivity is more challenging. 'If you go into an organisation and try to measure an individual's productivity based on the space, you'll never get it, because productivity is affected by many variables. It's impossible to isolate the critical factor,' Wyatt says.

'We did some CO_2 cognitive performance testing in our offices, for example, by changing ventilation rates, but we couldn't get consistent results because, obviously, there were intangibles such as how people were feeling that day, their emotional state, whether they were feeling stressed.

'But the academic studies we looked at are done on such a large group that they are able to establish statistical averages. So, all of the tools and the assessments we're doing aren't looking at specific individuals – statistically, that space is realigned or interventions are made to deliver a better result. The person sitting at that workspace is statistically more likely to be slightly more productive by removing some of the frictional negative experiences they feel.'

The most effective deployment of the tool so far has been in live environments, Wyatt adds, where quantitative monitoring over time, using sensors, has been combined with qualitative studies, such as building use studies and occupancy surveys. Getting feedback from occupants on how the building environment affects their perception of wellbeing and productivity can inform interventions, and help build a business case for modifications in areas such as ventilation and lighting.

Although objective improvements in IEQ have correlated to greater feelings of wellbeing in survey participants, Wyatt accepts that part of the perception of occupants that their productivity has improved may be down to other factors – including a 'placebo effect'. Simply being seen to take action can boost feelings of wellbeing. 'Studies indicate that, if people feel they are being listened to, their feeling of wellbeing increases and, generally, their productivity is expected to rise. We have seen such responses from just installing sensors before interventions.'

Pandemic impact

The Covid-19 pandemic may have brought into focus issues surrounding IEQ of buildings and ventilation, but the lockdown and widespread closure of offices in the UK means there has been limited interest in the productivity mapping element of the toolkit.

However, Wyatt says there has been a big increase in interest in improving IEQ, particularly with the reopening of many workplaces imminent. 'We're seeing a lot of sensors being installed at the moment, and an increasing demand [from businesses] for certification and badges to verify their commitment to IEQ and employee wellbeing in buildings,' he says. 'A number of landlords are using our services as a way of encouraging people back into the office.' CJ

Simulation of occupant access to daylight linked to productivity loss

SOURCES FOR CUNDALL'S WELLBEING AND PRODUCTIVITY RESEARCH

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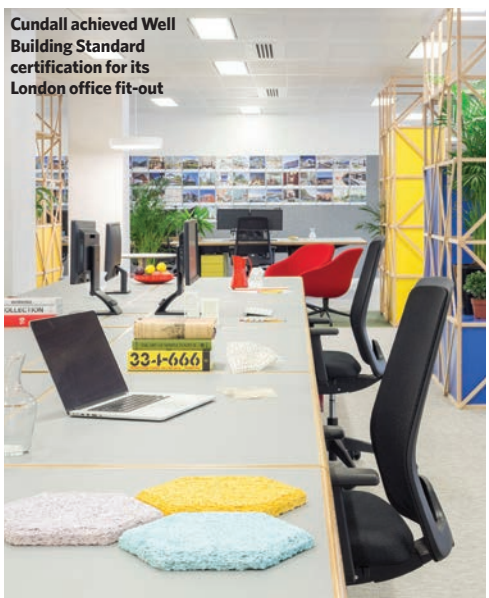

Cundall achieved Well Building Standard certification for its London office fit-out


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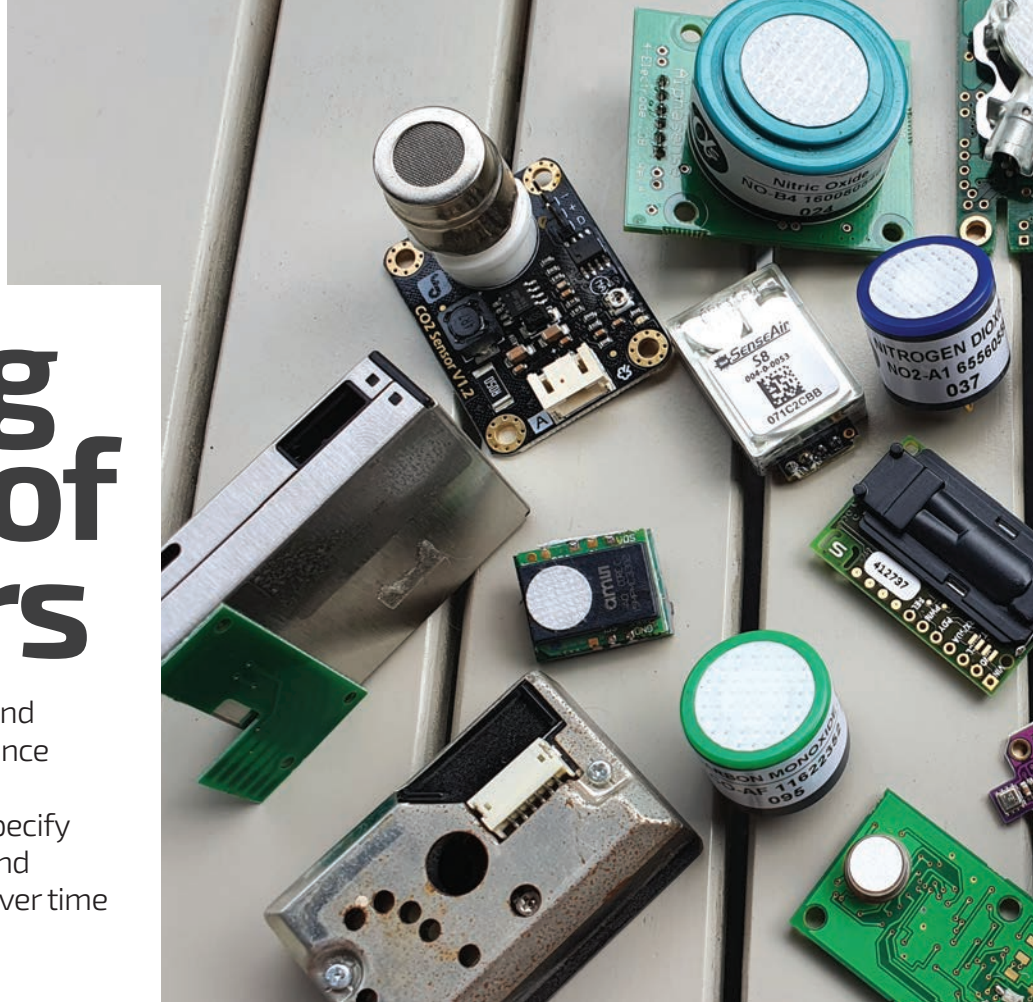

Making sense of sensors

Air quality sensors are not fit and forget – they require maintenance and will drift over time. Arup's James Hare explains how to specify accurate monitoring devices and ensure they remain accurate over time

The advent of cheap sensing technology and the rise of wellbeing standards – such as Reset and Well – for offices and buildings have created a large market for air quality monitoring. Not all air quality monitors are created equal, however.

Specifying and maintaining monitors requires research and astute questioning. Observed variation in output between sensing elements used by manufacturers is frequently seen, and can be significant. This may require standards such as Reset and Well to consider how this can be addressed.

In this article, we refer to an air quality 'monitor' as a packaged product sold by a manufacturer and 'sensors' as the discrete sensing devices within monitors.

Air quality monitors offer a fantastic and relatively cheap way of continuously monitoring, in one unit, a large range of parameters, such as: carbon dioxide; carbon monoxide; volatile organic compounds (VOCs); particulate pollution size ranges, such as PM1, PM2.5 and PM10; and parameters that require more complex sensors and systems, such as ozone and nitrogen dioxide.

A few years ago, this range of parameters would have, typically, required a large number of discrete handheld devices, with someone taking readings throughout a building over the course of a day. It was hit and miss as to whether your building had a good or a bad air quality day.

A search on the internet for 'air quality monitor' brings up a plethora of results, many with their own scales categorising what conditions are 'good' and 'bad', which makes it impossible to compare data from manufacturer A with that from manufacturer B.

Standards

Enter the Reset standard, which takes a more scientific approach, defining guidance on accuracy, calibration and deployment methodology. At the time of writing, Reset maintains a list of 17 air quality monitors on its website that have been tested to meet its Grade B standard for commercial-grade monitors.

The Reset Air Test Procedure for Accredited Monitors v2.0 test procedure, to certify monitors as being compliant with Grade B, is an involved process requiring laboratory conditions.

The Well standard does not have an accredited list of monitors. However, Well and Reset aligned in 2018, so monitors that meet the more stringent Reset requirements are suitable for use on Well-standard projects. Note that

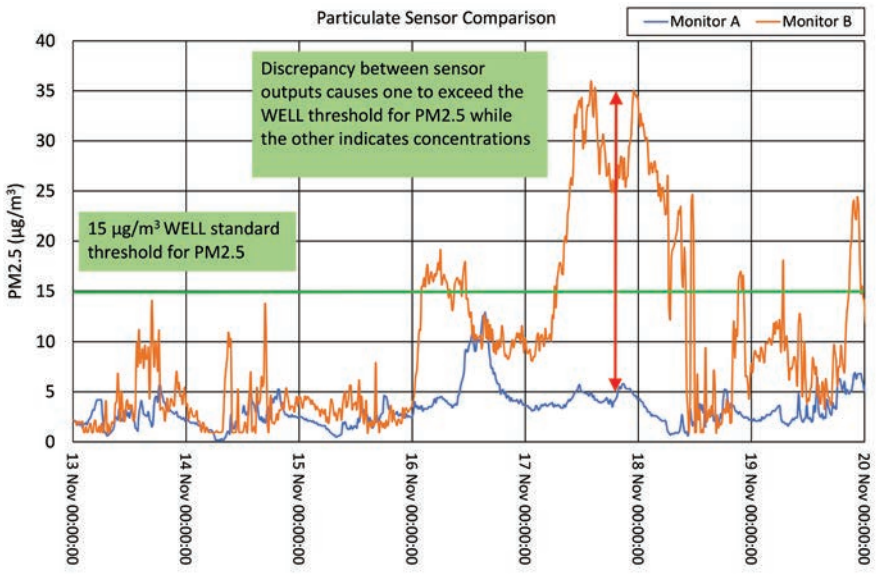

Figure 1: Particulate sensor comparison

Manufacturers often say they can baseline sensors remotely, but this is nonsensical when the monitor is in an uncontrolled environment

"Inaccurate or poorly calibrated air quality monitors can have serious consequences for indoor air quality and energy efficiency"

continuous monitoring does not remove the need for onsite performance tests for Well certification.

Set up and maintenance

Monitors are certainly not fit and forget, and require maintenance, and sensors will drift over time. Well and Reset both state that monitors or discrete sensors should be calibrated or replaced annually, with calibration certification supplied. A sensible approach is to select monitors that allow calibrated sensor-module replacement. Unfortunately, many manufacturers construct their products with no user-replaceable parts, such as sensor heads or modules that have a finite life. This means the only option is to dispose of the whole device at the end of its useful life and buy new, or send it back to the manufacturer for refurbishment or replacement. Facilities managers and specifiers need to consider this during procurement.

When asked, manufacturers of monitors will often state that they can baseline sensors and adjust for drift remotely, but this is generally nonsensical when the monitor in question is in an uncontrolled customer environment of unknown pollution concentration.

Observed sensor variability

Our tests of new Reset Grade B-certified monitors from different manufacturers, alongside each other in an office environment, showed differences in the measured values for VOCs and particulates, most probably because of different sensors or correction algorithms. In the PM2.5 example (Figure 1), one sensor shows the space meeting Well requirements and the other shows non-compliance.

Similarly, the TVOC example (Figure 2) shows troughs for both monitors when air handling units are on. However, there is an obvious issue with variation in sensitivity or minimum detection capability, as a 300 parts per billion (ppb) difference is seen at times. Weekend trends show VOCs increasing for monitor A, but decreasing for monitor B, suggesting sensitivity to different compounds.

Carbon dioxide sensors generally employ non-dispersive infrared (NDIR) technology, commonly with accuracy ±50 ppm (parts per million) ±3% of reading or better. Most employ automatic baseline correction, where the sensor stores the lowest concentration seen as its 400ppm baseline. For example, this process repeats every eight days for Senseair sensors.

This approach can be appropriate for many applications, but does not work in environments that are occupied 24/7, where sensors can calibrate to a false high and read low.

Volatile organic compounds are difficult to measure accurately, because VOC sensors are sensitive to a wide range of compounds, such as formaldehyde »

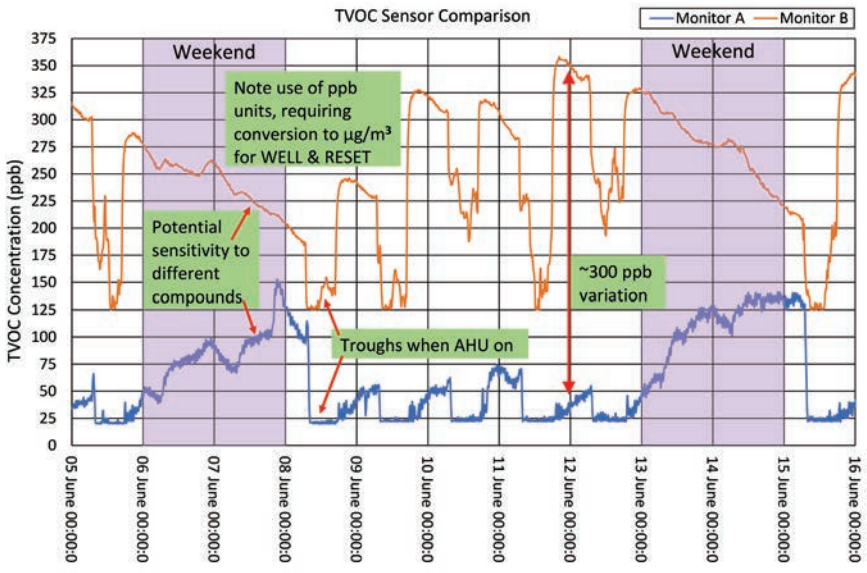

Figure 2: TVOC sensor comparison

"Be wary of the accuracy of products offering parameters other than carbon dioxide, TVOCs and particulates in a small package"

» in flat-pack furniture and limonene in oranges or some cleaning products. For this reason, they are often called Total VOC (TVOC) sensors.

Sensors are typically calibrated to give a response factor of one to isobutylene or ethanol because the molecular weight of these compounds is a middle ground between toxic VOCs.

Units given are $\mu g/m^3$ or parts per billion, but the two are not easily converted. Two identical sensors that have been baselined together can show if one space has higher concentrations, but you should think of readings as a reference, not an accurate measurement. VOC speciation and accurate measurement requires air sampling and lab measurement. TVOC sensors, such as the Sensirion SGP-30 or Bosch BME680, often employ metal oxide semiconductor technology in miniaturised format. Sensors often require baselining in a clean environment before use.

Particulate sensors typically employ optical technology to measure the amount of light obstructed by airborne particulate, usually providing PM2.5 and PM10 data, with some providing PM1 and PM4 categorisation. Consideration should be given to sensors that are fan aspirated, such as those by Alphasense, HoneyWell, Plantower and Sensirion. However, different models have been shown to have variation in output.

Take care when manufacturers advertise measurement of nitrogen dioxide, ozone and carbon monoxide. They will often put in low-cost, metal oxide semiconductor-based sensors that don't perform well. Done properly, detection at low concentrations of these gases requires bulky electrochemical sensors, which drives up the cost. **CJ**

JAMES HARE, senior engineer, Arup Building Performance and Systems

When selecting air monitors, compare the outputs of two identical devices

HOW TO SPECIFY ACCURATE AIR QUALITY MONITORS

1. If going for Well certification, review the need to measure all the parameters suggested, or just carbon dioxide, TVOCs and particulates (PM2.5 and PM10). Carbon dioxide is a good indicator that there is sufficient ventilation; VOCs will tell you if you have off-gassing problems from indoor furniture or sources from cleaning products; particulates will tell you how effective your air handling units are at filtering outdoor air. Carbon monoxide is no longer a problematic traffic pollutant, only a problem with indoor combustion, and ozone is only commonly produced by toilet ionisers and older photocopiers.

2. Be wary of the accuracy of products offering parameters other than carbon dioxide, TVOCs and particulates in a small package, as a total solution. Ask for model numbers of the discrete sensors employed to research their type and the sensor manufacturer's accuracy claims.

3. Do not mix and match monitor manufacturers in a building, as sensor outputs will probably not allow direct comparison. Select models with user-replaceable, calibrated sensor modules, allowing easy maintenance and future upgrades.

4. Ask the manufacturer how they calibrate their sensors in the factory, for how long this is valid, and if they can supply a certificate.

5. Ask how they deal with sensor drift, and if TVOC and carbon dioxide sensors can be recalibrated/baselined in the field – say, by putting the unit outside (protected from the weather).

6. If required, ask if you can turn off carbon dioxide auto recalibration, but be mindful of the need to repeat baselining periodically.

7. During your selection process, ask for two of the same devices to be sent to you so you can run them alongside each other and compare the outputs.

8. Ask if there is any particular requirement on site to commission sensors. Run sensors next to each other for two weeks to see if they all read the same before installing them.

9. Ask what communications protocols the sensors employ. The vast majority use Wi-Fi/Ethernet and, if on a corporate network, they may need communication ports opening to the manufacturer's cloud service, with data then available over an API. Shop around if you want local MQTT and BACnet/Modbus output for smart building or BMS integration.

10. Take care when siting air quality monitors in a deployment, to ensure sufficient numbers for coverage and collection of data from potential problem areas, such as meeting rooms. Reset provides good guidance on mounting heights and positions.

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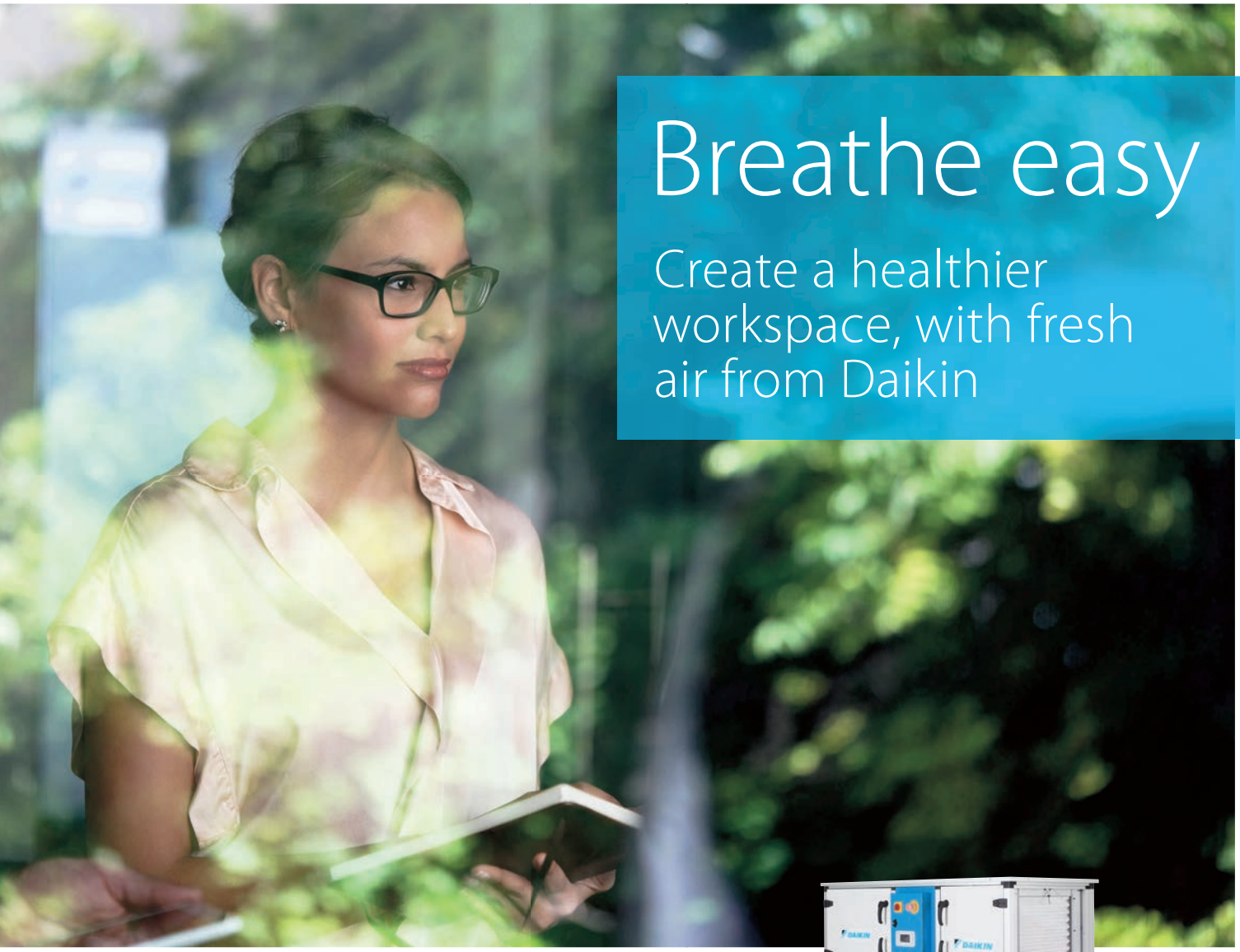

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Why space volume matters in Covid-19 transmission

It's not just ventilation that removes viable virus from indoor air. To understand the risk of transmission of Covid-19, the University of Nottingham's Benjamin Jones and Chris Iddon say other mechanisms that are dependent on the volume of a space have to be considered

There is a lot of focus on the role of ventilation in reducing the risk of far-field (>2m separation) transmission of the SARS-CoV-2 virus in indoor environments. However, ventilation is not the only mechanism for removing viable virus from indoor air. Others include the biological decay of the virus and the deposition of aerosols onto surfaces.

These removal mechanisms are space-volume dependent. This means that, in spaces with a larger volume, the *equivalent* ventilation rate is higher, assuming the number of occupants – and the airflow rate per person ($L \cdot s^{-1}$ per person) – is the same. Consequently, the steady-state concentration of viable viral laden aerosols is also lower.

One of the reasons it is not straightforward to set ventilation rates to mitigate secondary transmission risks is that space volume matters. Here, we try to explain why this is the case:

Steady state concentration

We tend to use two metrics to quantify airflows, either a volume flowrate ($L \cdot s^{-1}$ or $m^3 \cdot s^{-1}$) or an air change rate (h^{-1}). When a pollutant is continuously released into a space, its concentration eventually plateaus and reaches a steady state, and the two airflow metrics reveal different characteristics about it.

Consider a tracer gas whose sole removal mechanism is ventilation, which is released at a constant rate into two offices, where one has twice the volume of the other, and both are ventilated with outside air containing no tracer gas. If each office receives the same **constant volume flowrate**, the concentration of the tracer gas will reach the same steady state value in both rooms, irrespective of their volume. However, the number of molecules of the tracer gas (or the volume of the tracer gas) is greater in the larger space (see Figure 1).

Alternatively, if each office is ventilated at a **constant air-change rate**, the steady-state concentration of the tracer gas is lower in the larger space, but the number of molecules in each office is the same (see Figure 2).

By considering these principles, we can begin to explore the risk of far-field (>2m) SARS-CoV-2 transmission via virus-laden aerosols in indoor spaces:

Consider two hypothetical offices, both containing 20 occupants doing the same activity and with a floor-to-ceiling height of 3m. Office A has an occupancy density of $10m^2$ per person, giving a volume of $600m^3$. Office B has an occupancy density of $15m^2$ per person, giving a volume of $900m^3$.

Suppose there is a single infected person in each office, shedding the virus at exactly the same rate. Office A is ventilated at $10L \cdot s^{-1}$ per person, giving a total airflow rate of $200L \cdot s^{-1}$. Office B is ventilated at $7L \cdot s^{-1}$ per person, giving a total airflow rate of $140L \cdot s^{-1}$.

Assuming the air is well mixed, in which office do susceptible occupants inhale less viable virus on average?

Viable virus steady-state concentration

By considering the ventilation rate alone, one might assume that Office A is safer than Office B because it receives 1.43 times more outside air per unit of time and because the CO_2 concentration is lower.

However, the virus is encapsulated in aerosols and is a biological organism, so there are additional removal mechanisms

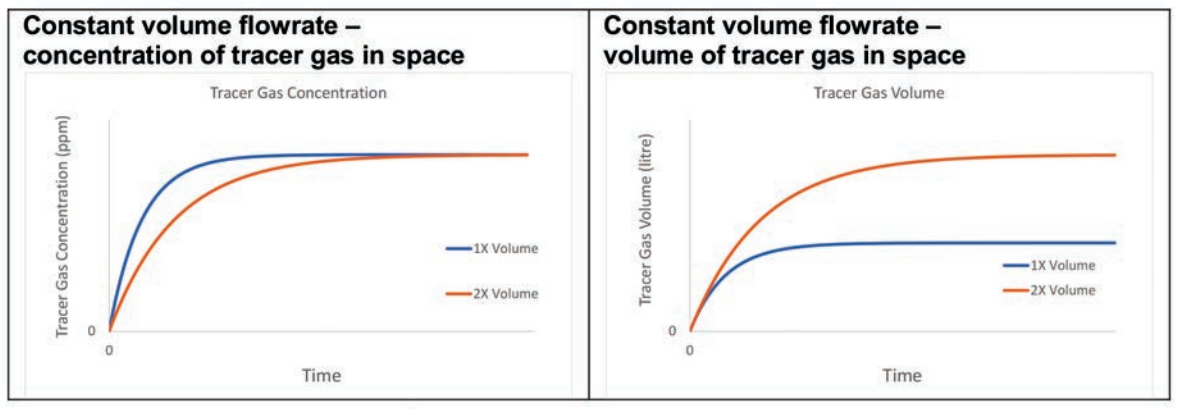


Figure 1: Two offices with different volumes ventilated with the same constant volume flowrate

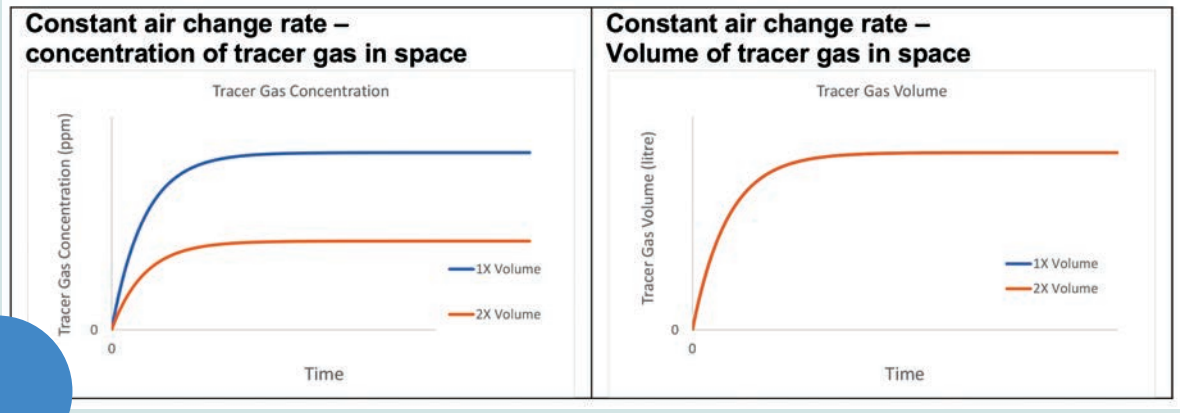


Figure 2: Two offices with different volumes ventilated with the same constant air change rate

ADDITIONAL REMOVAL MECHANISMS

- **Ventilation rate ψ – the air change rate is a function of the ventilation rate and the space volume *V***
- **Biological decay rate λ – a function of the half-life of the virus, the time for half of all viruses present in a space to become unviable when outside a host cell, and the rate of biological inactivation by *devices* such as UV**
- **Respiratory tract absorption ζ – a small number of viruses may be inhaled by occupants of the space, some of which is exhaled; some may deposit in the respiratory tract and proportional to the concentration of viable virus in the air and the breathing rate of occupants**
- **Surface deposition rate γ – the rate that aerosols containing virus deposit on surfaces via ballistic deposition and momentum deposition, and is a function of surface area**
- **Filtration rate ω – the rate that aerosol-borne virus are filtered from the air by a mechanical device. Hereon, we assume no filtration is present.**

that work differently to ventilation, but whose effects can be expressed as an *equivalent* air change rate (see panel, 'Additional removal mechanisms').

The risk of a susceptible occupant of becoming infected is related to the number of viable viruses they absorb into their respiratory tract, and the dose required before infection occurs. The higher the concentration of viable viruses there are in a space, the more viable virus is inhaled, increasing the risk of an infective dose.

The steady-state quantity of any pollutant (number of molecules of a gas or number of viable virus) in a space, n_{ss}, is proportional to the quotient of the emission rate, G, and the total removal rate, ϕ, also known as the *equivalent* air change rate, expressed as an equivalent air change rate (h^{-1}).

$$n_{ss} \propto \frac{G}{\phi} \qquad (1)$$

The total removal rate is the sum of all individual removal mechanisms $\phi = \psi + \lambda + \zeta + \gamma + \omega$ (2)

»

	ψ (h^{-1})	γ (h^{-1})	λ (h^{-1})	ζ (h^{-1})	ϕ (h^{-1})	ϕ ($L{\cdot}s^{-1}$)
Office A	1.200 (49%)	0.619 (25%)	0.630 (26%)	0.010 (0.4%)	2.459	410
Office B	0.560 (31%)	0.600 (33%)	0.630 (35%)	0.007 (0.4%)	1.797	449

Table 1: Typical values of biological decay λ, deposition γ, and respiratory tract absorption ζ (see Jones *et al*[1]) where ψ is the air change rate, and ϕ is the equivalent air change rate

» The pollutant concentration, $\frac{n_{ss}}{V}$, is dependent on the space volume and is given by $\frac{n_{ss}}{V} \propto \frac{G}{\phi V}$ (3)

For a tracer gas whose only removal mechanism is ventilation, then $\phi = \psi$, so, for the two example offices:

Office A ψ = 200L·s^{-1} or 1.2h^{-1}

Office B ψ = 140L·s^{-1} or 0.56h^{-1}

If the emission rate of the tracer gas, G, is the same in both spaces, the concentration of the tracer gas at steady state is lower in Office A because the volume flowrate is higher. The air change rate is also higher in Office A, so the total number of tracer gas molecules is lower.

However, for the SARS-CoV-2 virus, the contribution of the other removal mechanisms can be significant. We now consider the effects of biological decay, deposition, and respiratory tract absorption and typical values are given in Table 1.

The effect of all the removal mechanisms can be summed into a single *equivalent* air change rate, ϕ, using equation 2. Its value is greatest for Office A (2.459h^{-1} compared with 1.797h^{-1}), which means that the total number of viable viruses is lower in Office A if the virus emission rate is the same in both offices.

However, the concentration of viable virus is proportional to the risk of inhaling an infective dose and 'not' the total number. To compare the concentration of viable virus in each space, the equivalent air change rate needs to be converted to an *equivalent* volume flowrate, which is space dependent.

Office B has the greatest equivalent volume flowrate (449L·s^{-1} compared with 410L·s^{-1}), so the concentration of viable virus is lower in Office B, despite having a lower ventilation rate (140L·s^{-1} compared with 200L·s^{-1}). Therefore, the risk of viable virus depositing in the respiratory tract of a susceptible person is 8% less, reducing the likelihood of an infective dose on average, even though the steady-state CO_2 concentration in Office B is around 20% higher than that in Office A. If offices are now ventilated at 10L·s^{-1}per person then the equivalent ventilation rates are 410L·s^{-1} and 509L·s^{-1} for Office A and Office B, respectively.

The reservoir effect affects exposure

An indoor space can act as a fresh-air *reservoir*, which is useful for absorbing the impact of pollution emissions. The greater the volume of the space, the greater the effect (see Figure 1a). This reservoir effect means that the time taken to reach the steady state is longer in the larger Office B (volume of 900m^3 compared with 600m^3), thus susceptible occupants are also exposed to the steady-state concentration of viable virus for less time than in Office A, reducing their time averaged exposure.

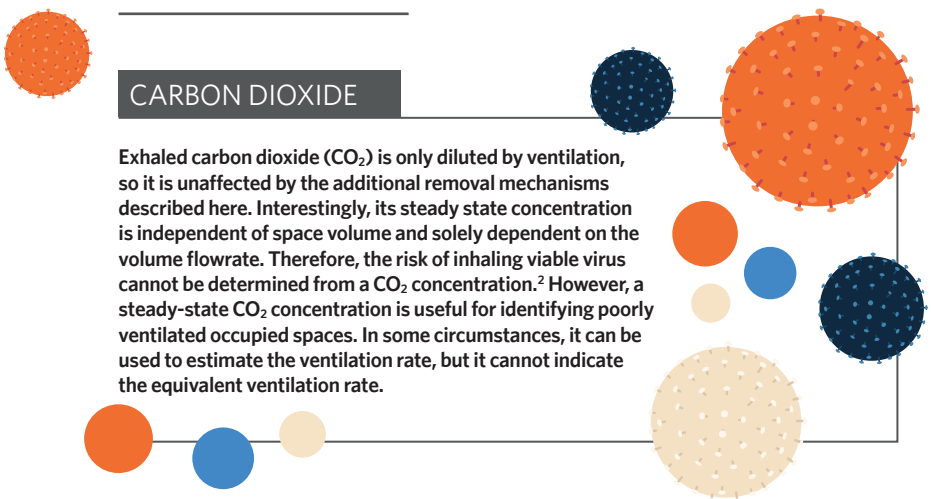
This example demonstrates that the total *equivalent* volume flowrate that is the determining factor in assessing the concentration of SARS-CoV-2 virus-laden aerosols in an indoor space, that the outside ventilation flowrate cannot be used in isolation, and that the total equivalent volume flowrate is space-volume dependent. Space volume matters! CJ

NOTE: In this example, the number of occupants is the same in both spaces and, therefore, the probability of an infector being present is the same. If the number of occupants is different, the probability of an infector being present changes – but that is another story!

"The concentration of viable virus is proportional to the risk of inhaling an infective dose"

CARBON DIOXIDE

Exhaled carbon dioxide (CO_2) is only diluted by ventilation, so it is unaffected by the additional removal mechanisms described here. Interestingly, its steady state concentration is independent of space volume and solely dependent on the volume flowrate. Therefore, the risk of inhaling viable virus cannot be determined from a CO_2 concentration.[2] However, a steady-state CO_2 concentration is useful for identifying poorly ventilated occupied spaces. In some circumstances, it can be used to estimate the ventilation rate, but it cannot indicate the equivalent ventilation rate.



References:

1 Jones, B. et al. (2020) Modelling uncertainty in the relative risk of exposure to the SARS-CoV-2 virus by airborne aerosol transmission in buildings, *Building and Environment*. 191:107617 doi:10.1016/j.buildenv.2021.107617

2 AIVC. Can a measured CO_2 concentration show a building is SARS-CoV-2 safe? AIVC newsletter. November 2020. tinyurl.com/2daasfct

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Applying specific fan power for efficient ventilation and air conditioning systems

This module looks at the relevance of the specific fan power and how it is influenced by fan selection and location

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Establishing the specific fan power (SFP) for ventilation (and air conditioning) systems is not simply a mundane calculation to evidence compliance with regulations and standards. It provides an important measure of the performance of fan-powered systems that impacts a building's energy costs and carbon impact for the whole life of the installation. This CPD will explore the relevance of the SFP, and consider some aspects of how the fan selection and location will influence its value.

Fan power is a significant consumer of energy in buildings. For example, in the building energy efficiency survey of non-domestic stock for England and Wales in 2014-15,[1] the energy consumed by fans was estimated at more than 6GWh per year. To put this into context, this compares with the 5.4GWh used for space cooling and humidification, and amounts to more than 7% of electrical energy use in the non-domestic stock. The survey report noted that the energy consumption for fans was most significant in sectors with long hours of use – including healthcare and emergency services – or where there was a need for extract ventilation to deal with catering odours and heat gain, such as those serving community centres, and arts, leisure and hospitality facilities.

The efficiency of a fan that is employed to move air in ventilation and air conditioning systems is commonly expressed in one of two ways – impeller efficiency and total fan efficiency.

Impeller efficiency relates to the mechanical power transferred to the impeller shaft and might, for example, be used when choosing a suitable motor; this provides the data that is typically represented in fan-efficiency curves. This efficiency is useful to provide a general indication of performance, but will reduce when the fan is installed, because of its relationship with the immediate elements of the ventilation system, as discussed later.

The total fan efficiency is often used to describe efficiency in terms of the electrical power for the whole fan system that is drawn from the mains electrical supply. This includes the power consumed by the motor control (such as the frequency converter), motor, and any intermediate drive chain elements, such as belt drive and shaft bearings, to provide the motive force to the impeller. The total efficiency may be determined at any operating condition from the air power (as described in the panel, 'Air power') divided by the power drawn from the electrical supply.

Total (installed) fan efficiency = air power (W)/total electrical input power (W)

The SFP is a standardised measure of how much total power is required by the fan to move air through the connected system, and is expressed variously as $W \cdot L^{-1} \cdot s^{-1}$, $kW \cdot m^{-3} \cdot s^{-1}$ or (increased by 1,000) as $W \cdot m^{-3} \cdot s^{-1}$.

$$SFP = \frac{\text{Total electrical power, kW}}{\text{Air volume flowrate, } m^3 \cdot s^{-1}}$$

The standard BS EN 16798-3:2017 *Energy performance of buildings – ventilation for buildings – Part 3: for non-residential buildings* provides extensive and accessible »

» information on the determination of SFP.

By setting, and implementing, a target maximum SFP (as, for example, in the UK and European regulations), it is possible to impose a standardised limit to the power requirements of ventilation systems. Reducing the SFP requires consideration not only of the fan, with its drive mechanics and control, but also its connection to the system and components of the ductwork installation. This considers the total pressure and will include frictional resistance (in terms of static pressure losses), velocity pressure 'losses' at entry and exit to the system and, importantly, the losses resulting from the 'system effect' or fan installation.

As illustrated in the example of a centrifugal fan in Figure 1, the velocity profile of air leaving the fan will take some distance to evolve into a spin-free, symmetrical, fully developed velocity profile. The uninterrupted straight duct length should be at least two and a half times the hydraulic diameter (hydraulic diameter = 4 x cross-sectional area of the outlet divided by the outlet perimeter), and preferably more than six diameters, depending on speed.[3] This allows the asymmetric velocity profile at the outlet to develop as the initial high-velocity pressure converts to static pressure (known as 'static regain'). If a component, such as a cooling coil (in a 'blow-through' AHU), or a sharp bend is placed in the still-settling airflow, the high-velocity air will be reflected from its surfaces, consuming power and creating subsequent collisions in the air streams. This creates turbulence and further loss of motive power, generating noise and so requiring an increase in the fan power to deliver the design flowrate of air – thereby increasing SFP. Any changes in direction should be sympathetic to the air streams, and they should be gradual, employing smooth-surfaced transitions. If a bend is necessary, it should follow the direction of airflow from the fan and preferably include turning vanes.

There are similar considerations for fan inlets. The approach path for the incoming air should be smooth and unobstructed (for example, no dampers or tees). The entering air should have a symmetrical, fully developed, streamlined velocity profile. The inlet duct should be of similar dimensions to the fan inlet and, if needed, employ a 15° transition.

The inlet duct should ideally be straight and at least three times the length of its hydraulic diameter. If this is not possible, then rectangular duct bends should have turning vanes to prevent spin and ensure even, streamlined flow, as discussed in CIBSE

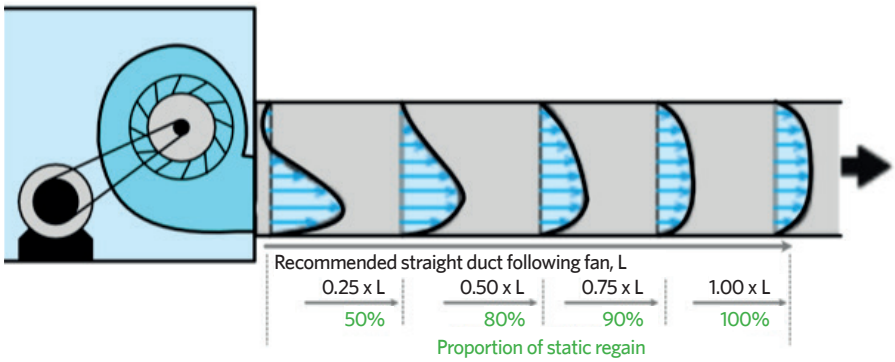


Figure 1: Typical velocity profiles and proportion of potential static regain in air leaving a housed centrifugal fan. The length of blue arrows indicates air velocity and illustrates that a uniform and steady profile does not develop until some distance away from the outlet (Based on data from AIVC Technical Note 65[2])

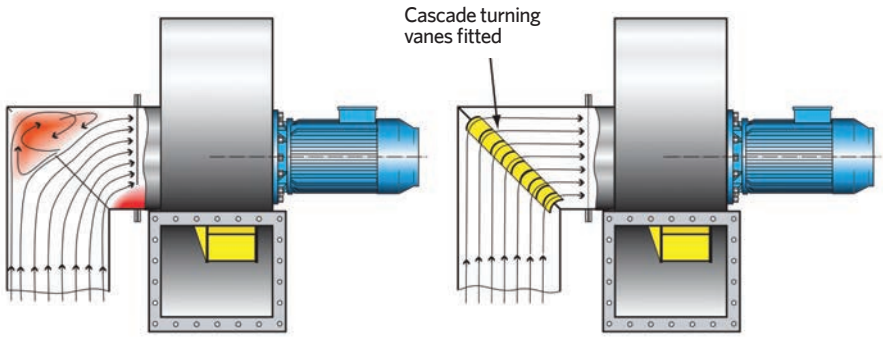


Figure 2: Adding turning vanes to minimise the impact of the bend that would otherwise adversely impact the fan performance (Source: CIBSE TM42)

TM42 *Fan Application Guide* and illustrated in Figure 2. Circular duct bends should have an inner radius at least as large as the duct diameter. Flow straighteners, such as filters, coils or heat exchangers, will act to reduce the inlet system effect.

For fans housed in a plenum, such as plug fans, the minimum distance from the fan inlet to the nearest plenum wall should[2] be greater than 0.75 times the fan inlet diameter.

Ideally, SFP should be minimised; however, systems with very low SFP will be more susceptible to being influenced by external pressure changes – such as the effects of local wind. Although the SFP is most commonly determined as part of the desktop design exercise, it is important to ensure that the installed system represents the design intent, and so should be measured when operational.

The design (and installation) of the AHU components, ducting, dampers, diffusers, grilles and flexible connections can offer the most immediate opportunity to reduce the resistance to airflow (as discussed in the October 2011 *CIBSE Journal* CPD). However, without applying effective fan technology, efforts to reduce air power used in the system will be somewhat wasted. As reported by Eurovent,[3] the EU Ecodesign legislation has led to myriad innovations in the manufacturing of ventilation components. Motor and fan efficiencies have increased significantly, highly efficient energy-recovery components in mechanical ventilation systems have been enforced by law, and characteristic dimensions of AHUs grew by around 30% to meet the restrictions on the energy consumption of fans. Probably the most common type of fans used in building HVAC are centrifugal fans with

AIR POWER

Noting that 1Pa ≡ 1N·m^{-2}, and 1J = 1Nm, and 1W = 1J s^{-1}, so 1W ≡ 1NM s^{-1} ≡ 1Pa x 1m^3·s^{-1}, air power delivered by the fan impeller (watts) = total system pressure (Pa) x air volume flowrate (m^3·s^{-1}).

SETTING THE STANDARD FOR SFP

Table 1 provides an example of the requirements for centralised fan systems, taken from the guidance document[5] for the regulations for non-domestic applications for England (the full document additionally includes values for other types of fan-powered ventilation systems).

The required values as shown in the table are significantly lower than those historically found in buildings.[6] The recent 2021 consultation on potential revisions to Approved Document L *Conservation of fuel and power* provided a new set of target SFP values (as abstracted in the final column of Table 1). The apparent increase in SFP is misleading, as it now includes the previously separate allowance for a heat-recovery device and associated filter, as heat recovery is now the standard requirement for ventilation systems.

	Specific fan power ($W \cdot L^{-1} \cdot s^{-1}$)		
System type	**New buildings**	**Existing buildings**	***2021 Consultation Part L (new buildings)***
Central balanced mechanical ventilation system with heating and cooling	1.6	2.2	*2.0*
Central balanced mechanical ventilation system with heating only	1.5	1.8	*1.9*
All other central balanced mechanical ventilation systems	1.1	1.6	*1.5*
Additional allowances are added for heat recovery and other specialist components – most notably, the use of a HEPA filter allows an additional $1W \cdot L^{-1} \cdot s^{-1}$			

Table 1: Examples of maximum specific fan power in air distribution systems for buildings to comply with England Building Regulations 2010

double inlets, backward curved centrifugal fans either with a scroll housing or as plenum, or plug fans, as shown in Figure 3. The plug fan effectively flings air in all tangential directions from the rotor, and the kinetic energy is quickly converted to static pressure, making the outlet stream less susceptible to system effects, and air enters the outlets as a fully developed, streamlined flow (as shown in Figure 4). The outlets should be smooth to reduce pressure losses.

Although the smaller, forward-curved bladed centrifugal fan can deliver high airflows, it has lower impeller efficiencies, as well as high outlet velocities, and there is greater opportunity to suffer velocity pressure losses from system effects. Such fans are not typically applied in AHUs, as they would contribute to a high SFP.

When a fan is housed in an AHU or duct, there will be pressure losses and increased noise not accounted for in the standalone performance data supplied by the fan manufacturer. Some AHU manufacturers/integrators reportedly base their published fan performance data directly on information supplied by the fan manufacturer, although this would provide a misleading indication of performance.

As discussed by Berg,[4] centrifugal fans with double intakes have been typically chosen for ventilation and air conditioning applications when relatively high outlet velocities are required – for example, more than $8m \cdot s^{-1}$ – and the ducting is practically straight without any restrictions (caused, for example, by changes in cross-sectional area, sudden changes in direction, or by dampers or attenuators immediately on the output side of a fan). This would commonly be found in larger ventilation plants.

Plug fans, employing directly connected inverter or electro-commutated (EC) drives, are typically used in smaller AHUs with lower airflows, and are commonly used for ductwork systems designed for lower velocities (for example, less than $6m \cdot s^{-1}$), with consequently smaller pressure drops. They provide great flexibility in outlet connections (from the plenum), and do not require an uninterrupted length of straight duct at the outlet. The efficiency will be dependent on the fan's location within the plenum and the relationship of the fan to its outlet – the plenum being used to convert the kinetic energy in the air to deliver the static pressure. Because of their simplicity and high installed efficiency, plug fans are increasingly being developed and applied in larger systems.

In terms of whole-life cost (and total-life carbon emissions), there is a limit to how low the SFP can go before the capital cost of the equipment outweighs the operational savings in lower pressure drops – this is discussed at length in CIBSE TM30 *Improve life-cycle performance of mechanical ventilation systems*. (The spreadsheet included in TM30, although a little dated in its example data, provides an excellent basis for examining the whole-life costs of a system, and can be readily extended to provide an indication of relative operational carbon impact.)

The Building Regulations[5] in the UK limit the installed power that may be consumed by fans in ventilation systems in terms of SFP. In these regulations, the value of the SFP for an air distribution system accounts for the combined sum of the design watts of the system supply and extract fans, including losses through switchgear and controls (such as inverters), divided by the design airflow rate through that system. (See panel, 'Setting the standard for SFP').

Any such standardised SFPs should not be seen as the ultimate target. Better standards are achievable through careful, but typically simple, design practices – such as including turning vanes in bends – that can generate significant benefits in lifetime operational energy consumption, costs and carbon emissions.

Turn to page 50 for further reading and references. »

Figure 3: A plenum, or 'plug', backward-curved centrifugal fan

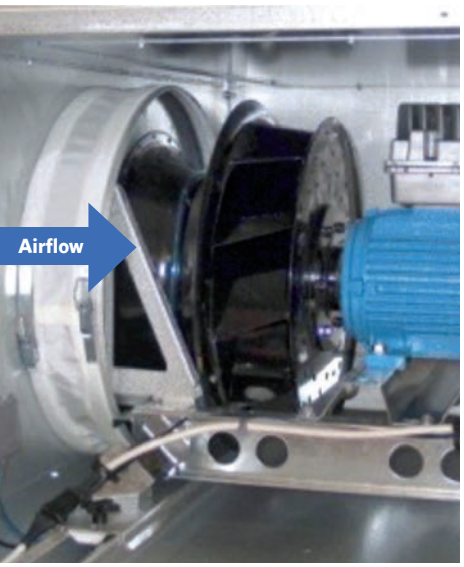
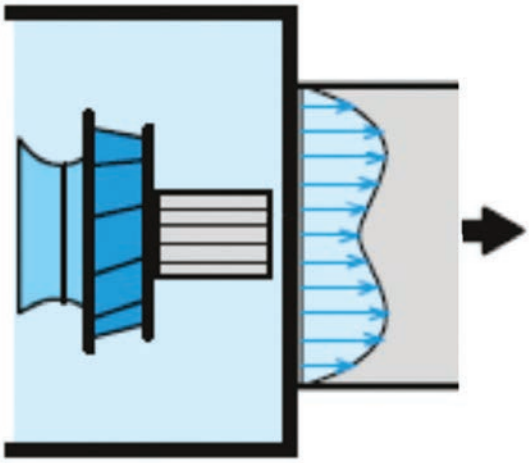


Figure 4: Velocity outlet profile from the plenum of a plug fan. The profile is fully developed and allows transitions close to the outlet of the fan (Source: Swegon)



Module 181

June 2021

» **1. In the quoted building energy efficiency survey, what percentage of electrical energy was estimated as being consumed by fans in 2014-15 in non-domestic stock?**

- ☐ A More than 5%
- ☐ B More than 6%
- ☐ C More than 7%
- ☐ D More than 8%
- ☐ E More than 9%

2. At the outlet of a scroll-housed centrifugal fan, what is the proportion of the maximum regain of velocity pressure to static pressure after 0.50 of the recommended straight length?

- ☐ A 25%
- ☐ B 50%
- ☐ C 80%
- ☐ D 90%
- ☐ E 100%

3. What would the SFP be for a system where the total electrical power supplied is 1.5kW for an air volume flowrate of 0.75$m^3 \cdot s^{-1}$ and a total system pressure drop of 0.6 kPa?

- ☐ A 0.6$W \cdot L^{-1} \cdot s^{-1}$
- ☐ B 0.75$W \cdot L^{-1} \cdot s^{-1}$
- ☐ C 1.5$W \cdot L^{-1} \cdot s^{-1}$
- ☐ D 2$W \cdot L^{-1} \cdot s^{-1}$
- ☐ E 2.5$W \cdot L^{-1} \cdot s^{-1}$

4. What growth in the physical size of AHUs was reported by Eurovent to meet the restrictions on energy consumption?

- ☐ A 25%
- ☐ B 30%
- ☐ C 35%
- ☐ D 40%
- ☐ E 45%

5. If a system employs a HEPA filter, what additional allowance is made to that in the table of limiting SFPs for England?

- ☐ A 0.2$W \cdot L^{-1} \cdot s^{-1}$
- ☐ B 0.4$W \cdot L^{-1} \cdot s^{-1}$
- ☐ C 0.6$W \cdot L^{-1} \cdot s^{-1}$
- ☐ D 0.8$W \cdot L^{-1} \cdot s^{-1}$
- ☐ E 1$W \cdot L^{-1} \cdot s^{-1}$

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Further reading:

CIBSE TM42: *Fan Application Guide* (2006) provides detailed information on the assessment and installation of HVAC fans.

AIVC Technical Note 65, *Recommendations on specific fan power and fan system efficiency* gives detailed commentary and analysis of this application of fans for HVAC.

Swegon Air Academy *AIR* Chapter 25 *Fans and SFP* by Gunnar Berg inspired and provided content for this CPD article.

References:

1 **www.gov.uk/government/publications/building-energy-efficiency-survey-bees** – accessed 13 May 2021.
2 Schild, PG et al, *AIVC Technical Note 65, Recommendations on specific fan power and fan system efficiency*, AIVC 2009.
3 *Eurovent Guidebook – air handling units*, Eurovent 2018.
4 Berg, G, AIR Chapter 25 *Fans and SFP*, Swegon Air Academy, 2014.
5 *Non-domestic Building Services Compliance Guide*: 2013 Edition, NBS 2014.
6 *Specific fan power – a tool for better performance of air handling systems*, Jorma Railio and Pekka Mäkinen, Clima 2007.

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New Eurovent AHU summer label launched

Label uses ASHRAE database to obtain climate conditions

A new energy label for air handling units (AHUs), accommodating warm weather conditions, will be made mandatory from September. The Energy Efficiency Classes for Summer Application (EECS) label will also acknowledge humidity recovery.

While the Eurovent Certification energy label for AHUs has become a reference point for the market, helping customers compare brands, it is based on conditions in colder northern European countries. This is because many initiatives were largely driven by companies in this region, which were the first to highlight the need to look at energy-saving opportunities.

Jörn Doerk, technical product manager, AHU design and certification, Menerga, Systemair Group, said: 'It was dismissive of the situation in areas with warmer climates, and that is what we want to change and correct with the introduction of the summer label.'

Systemair has said it will adopt the 'summer label' for its range of Eurovent-certified AHUs by June. Andy Bijmans, the company's development manager in the Netherlands, said: 'The summer label wants to strengthen the idea of energy saving in the context of hot-weather situations. As such, it has the added benefit of acknowledging humidity recovery in view of its important contribution to overall energy-efficiency performance, which makes the label more advanced than the calculations for the winter label.'

The certification body claims the label gives a realistic representation of the usefulness and necessity of a certain heat-recovery efficiency in summer conditions, with the air resistance that this may cost at a certain fan efficiency.

It uses the ASHRAE climate database to obtain climate conditions. Customers can select their location, or the closest fixed city available, to get the suitable options in the AHU configurators of Systemair and Menerga. The calculations have considered the temperature and humidity at the highest level, in view of its impact on the cooling rate.

New ventilation at Elta Fans' HQ

Elta Fans has installed a new air handling unit (AHU) at its head office in Kinsgwinford, Dudley.

The manufacturer said it upgraded its ventilation system in October to ensure good indoor air quality.

Ana Cross, AHU product manager at Elta Fans, said: 'We used the reduced occupancy in the building as an opportunity to make changes to the space. We opted for a Prema 540 with an electric heater to ensure we could maintain ambient temperature for staff, while improving indoor air quality.'

The system is fitted with a fine filter (ePM1 55%) on supply to remove respirable particles from incoming air, which Elco says has improved indoor air quality. 'We have seen a 33% decrease in peak CO_2 levels throughout the working day. The fact that the system is demand-controlled has also allowed us to adapt to the various lockdowns, meaning it only works as hard as it needs to depending on occupancy levels.'

Combining a low-energy consumption EC motor with the ability to heat incoming air through a dedicated heat exchanger ensures utility costs are minimised, said the manufacturer. CO_2 and other types of pollutants, including $PM_{2.5}$, TVOCs, NO_2 and O_3, are continuously monitored.

Cross said: 'If events of the past year have taught us anything with regards to indoor spaces, it's that we need to ensure ventilation remains a top priority.'

Faster air exchange poses risk, study finds

A recent study published in the *Building and Environment* journal, by researchers at the US Department of Energy's Pacific Northwest National Laboratory, has suggested that – in a multiroom building – rapid air exchanges can spread the SARS-CoV-2 virus rapidly from the source room into other rooms at high concentrations. Particle levels spike in adjacent rooms within 30 minutes and can remain elevated for up to approximately 90 minutes.

Dr Chris Iddon, CIBSE Natural Ventilation Group chair, believes the authors have conflated ventilation flowrates and recirculation. 'Where we might understand high air exchange rates as bringing in more outside air, in this study, the high air exchange rates are inclusive of mixing air, therefore increasing movement of air from a source room to another room,' he said.

Professor Catherine Noakes, who supported CIBSE in producing ventilation guidance for Covid-19, said: 'This isn't about air change rates, it's about mixing between spaces. A higher level of mixing reduces the risk in the source zone but increases the risk in the other zones. If the viral emissions are higher enough, this could potentially increase the overall risk, as there are more people available to be infected.

'Where this has real implications is not so much recirculation ventilation, but in buildings where there are pressure differences between spaces – probably most risky where you have flow from a source room, which could have reasonable ventilation, to a neighbouring room that doesn't have good ventilation, and the virus builds up. The important thing therefore is to ensure good ventilation in all occupied rooms to minimise this risk.'

Read the study at **bit.ly/CJJun21PNNLstudy**

AHU leakage advice

Guidelines for improving indoor air quality and correcting the performance of air handling units (AHUs) as a result of internal leakages has been published by Eurovent.

Produced by the association's air handling units product group (PG-AHU), Eurovent Recommendation 6/15: *Air leakages in air handling units* gives an in-depth overview of the issue. It includes: explanations of leakage types; reference to related standards and regulations; clarification of leakage indicators; typical leakage rates for various design options; guidance on design, commissioning and maintenance for eliminating or minimising leakages; and correction of AHU performance as a result of internal leakages. It is available at **bit.ly/CJJun21Eurovent**

Five steps to AHU efficiency

Demand Logic's **Mike Darby** shares five ways to improve air handling unit efficiency, based on common issues identified using his company's building analytics platform

MIKE DARBY is CEO and co-founder of Demand Logic

1. Understand the optimum start stop: When not fighting a pandemic, ventilation AHUs should not necessarily be subject to heating and cooling optimum start stop strategies to extend ventilation hours. When there is no need for purge ventilation, AHUs being brought on before occupancy must be questioned; if needed, this can be fixed by a BMS contractor.

2. Humidification and supply control: We see cases where supply air-controlled AHUs dehumidify air because relative humidity (RH) appears to be high, only to find that, when the air reaches the warmer space, the RH drops considerably. Fix this by either modifying the BMS to calculate supply air moisture content, control to space or return air RH.

3. Temperature control for condensing boilers: It is not unusual for AHUs with preheat and reheat coils to operate with preheat for frost protection and reheat to deliver required supply temperature. This can lead to redundant capacity in either coil and potentially shift condensing boilers (with demand-led LTHW flow temperature) outside optimal operation temperatures. Subject to specific preheat requirements, an alternative feeds the output of the reheat control loop into the preheat control, so the preheat operates from the maximum of either the frost protection loop or reheat loop. At lower outside air conditions, both coils will operate in tandem, so LTHW temperature is elevated only when both coils are at maximum.

4. Optimise the variable air volume (VAV) fan speed: Static pressure setpoint, which controls fan speed, is often manually increased in an attempt to overcome cooling problems and then inadvertently left at this level. In many digital systems, the AHU controller can interrogate VAV box controllers. This can inform a demand-led automatic adjustment of the set point for duct static pressure to maintain the lowest possible fan speed while keeping the maximum number of VAV box control dampers fully open (and all boxes supplying required flowrates).

5. Beat the cold start performance: A sudden flow of sub-zero temperature air over an AHU coil can cause a frost stat to trip, or a coil to freeze and split, if controls don't respond quickly. Ensure the controls delay the fan start sufficiently according to outside air temperature.

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D-AHU
Modular R

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up to 6.95 m3/s

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THE RISE OF HEAT RECOVERY CHILLERS

Using chillers with heat recovery technology means utilising otherwise wasted heat to provide a building's heat or hot water. **Andy Pearson** looks at the options

Heat recovery chillers are ideal for mixed-use schemes where there is a range of occupancy patterns and a diversity in peak heating and cooling demand times. The technology is also applicable to smaller-scale projects, such as large offices where workstations close to one façade may be in direct sun and require cooling, while those close to the opposite, shaded façade may require heat.

The benefit of using heat recovery chillers is that they capture heat that would otherwise be wasted and use that for heating, which helps minimise carbon emissions and saves money.

An additional benefit of using heat recovery chillers is that the installation will have little or no impact on the amount of plant space needed for a project.

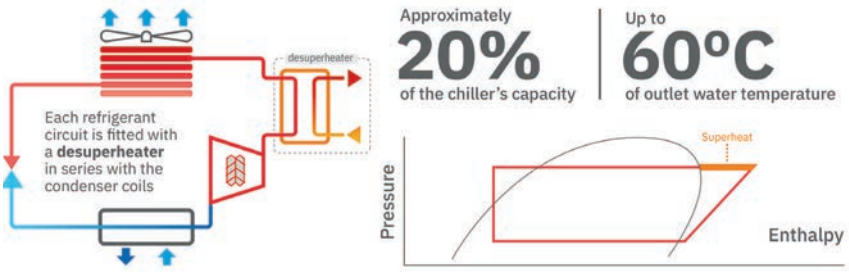
There are a number of heat recovery chiller solutions available:

Total heat recovery is a solution best suited to applications with a very large cooling requirement, such as a data centre or a manufacturing plant.

In a total heat recovery system, a heat exchanger is installed in parallel with the heat rejection condenser coil circuit. This allows 100% of the heat rejection circuit to pass through the heat recovery heat exchanger, to ensure a useful amount of heat is available to generate hot water. Under this arrangement, the chiller will produce as much hot water as possible while controlling the leaving chilled-water temperature.

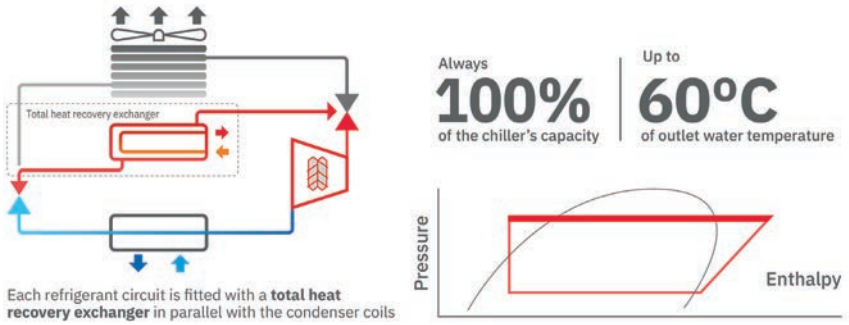
The benefit of using full heat reclaim is that a high percentage of waste heat can be recovered. If the heat demand is sufficient, then full heat recovery could, potentially, eliminate the need for the chiller to be piped to a cooling tower. This arrangement results in a dramatically more attractive financial incentive for heat recovery, but is limited to applications that can use the temperature of hot water able to be produced.

Partial heat recovery (desuperheater)



This method is appropriate for smaller applications, and for providing domestic hot water in a building

Total heat recovery



This method is appropriate where there is a large cooling requirement, such as in manufacturing processes

For smaller applications, partial heat recovery using a desuperheater can be used to harness waste heat and provide domestic hot water at a temperature of approximately 60°C. For this method of heat recovery, the desuperheater is fitted in series with the condenser circuit. The desuperheater recovers heat from the higher-temperature super-heated refrigerant gas at the compressor outlet; only the heat of compression is captured.

An alternative approach to using a conventional chiller and boiler system is to use a reversible electric-powered heat pump to provide both cooling and heating. The benefit of this solution is that there is no need for a gas boiler and, consequently, no need for a gas connection, which can simplify the hydronic system design and reduce the amount of plant space required, and save on costs. In addition, maintenance and controls are rationalised, which can also save on capital costs. According to Mitsubishi Electric, the long-term operating costs of this type of system can be 'significantly lower' than a chiller-boiler combination, and energy savings are claimed to be up to 40%.

Integrated heat recovery electric heat pumps are available that contain the usual heat pump elements of compressor, evaporator and condenser, as well as additional auxiliary exchangers to enable the chiller to capture heat from the cooling system for use elsewhere in the building.

In May's *CIBSE Journal*, we featured Joel Gustafsson Consulting's proposed scheme for the Mill Lane redevelopment in Cambridge. The scheme is one of the first in a new wave of large-scale projects where site-wide heating and cooling is supplied by electric-powered air source heat pumps. The heat pumps incorporate a heat recovery feature, which enables heat removed by the heat pump in cooling »

"Heat recovery chillers capture heat that would otherwise be wasted, and use it for heating – minimising carbon emissions"

» mode to be used in the scheme's heating and hot-water systems. The Mill Lane scheme uses a reversible heat pump chiller to provide simultaneous heating and cooling. For this scheme, the heat pumps have three modes of operation:

- Heating mode, where the units extract heat from ambient air
- Cooling mode, where heat is rejected to the ambient air
- Heat recovery or balanced mode, where the heat removed by the cooling system is added to the heating and hot-water systems, saving heat energy that would otherwise be wasted by jettisoning it into the atmosphere.

Maximum system efficiency occurs when the system is in balanced mode, when heating and cooling demands are matched. To maximise the time the system will operate in this mode, the Mill Lane scheme incorporates buffer vessels.

Another heat recovery option is to use a dedicated heat recovery heat pump. This approach is best suited to large, water-cooled chiller applications. It uses the condenser water, or return chiller water, as its heat source. Removing heat from the return chiller water helps increase the system's overall efficiency, which reduces its overall energy use and, hence, its carbon emissions.

Case study: 350 Euston Road, London,

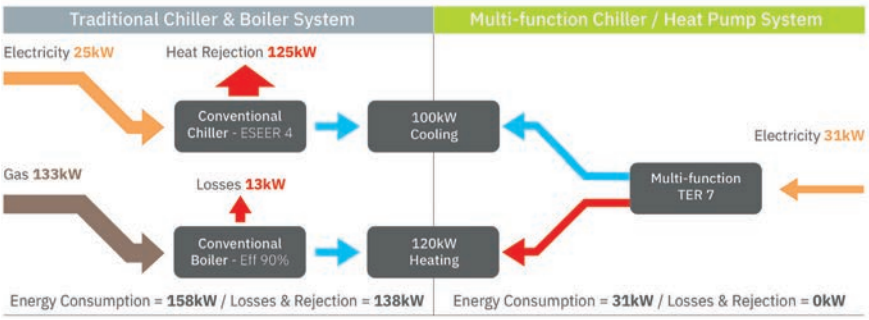
This seven-storey office building forms part of property developer British Land's Regent's Place retail and leisure development. When the traditional boiler and chiller system was due for replacement, British Land's property management partner, Broadgate Estates, worked with Cavendish Engineers to find a low carbon alternative.

The old central heating, ventilation and air conditioning system comprised three boilers, two air-cooled chillers and two air handling units (without heat recovery).

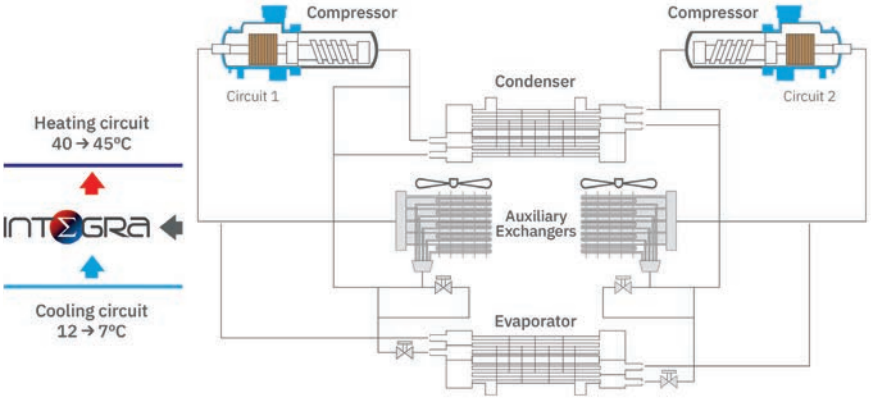
The team developed a comprehensive energy model to simulate the building's operation. It used the model to analyse two alternative solutions:

- Replacing the old chillers and boilers with the latest energy-efficient ones
- Installing a system based on air source heat pumps.

Simultaneous heating and cooling chillers



Long-term operating costs are lower than the chiller-boiler combination, with up to 40% energy savings



The four-pipe Integra chiller contains additional auxiliary exchangers

The air source heat pump option offered the best efficiency and greatest lifetime savings for occupiers, based on payback. In addition, because the heat pump (Climaveneta Integra) can produce a combination of hot and chilled water, it replaces the need for separate boilers and chillers, which has saved space on the roof that is now available to occupiers for additional plant requirements.

The first year of operating the new system resulted in a saving of 218 tonnes of CO_2 emissions and a reduction in primary energy consumption of around 47%. The scheme's energy-efficient operation means that occupiers will continue to benefit from ongoing savings. CJ

- The project was nominated in the Commercial/Industrial Project of the Year category at the 2018 CIBSE Building Performance Awards.
- See case study in *B&SERT* 2017 at **bit.ly/CJJun21chiller**

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GREAT POTENTIAL

As the HFC phasedown bites, the switch to R32 is gathering momentum. Carrier UK's **Andy Legg** explains the background to the adoption of this lower-GWP refrigerant, and highlights some benefits for building owners

Careful component selection ensures safe and efficient R32 chillers

Adoption of R32 refrigerant for use in air conditioning chillers and heat pumps is gathering pace as the F-gas Regulation continues to impact the marketplace. The change is being driven by the need to move away from using high global warming potential (GWP) refrigerants to cool and heat buildings and adopt lower-GWP alternatives. R32, for example, has a GWP of 675 (as per IPCC Fourth Assessment Report), compared with 2,088 for R410A, the refrigerant it often replaces – a cut of two-thirds in potential environmental impact.

The F-Gas Regulation requires a phasedown in the use of R410A – and all hydrofluorocarbon refrigerants – and a reduction of 79% by 2030 (relative to 2015). As production is scaled down, the cost of the refrigerant is likely to rise, giving an additional incentive to move to lower-GWP alternatives. The lower GWP of R32 is due to its chemical composition. R410A is a mix of R32 and high-GWP component R125, whereas R32 is a single-component refrigerant. As a working fluid in chillers, R32 has a 2.5% higher operating pressure than R410A, at around 12-26bar (174-377Psi), but it has better heat transfer and higher refrigerating capacity.

R32 is classified as an A2L refrigerant, a category established to denote fluids that may be of lower flammability in certain circumstances. After detailed testing, it is widely accepted that, if good practice is followed, any risks are extremely small and can be managed, and are acceptable in light of significant environmental benefits.

The Federation of Environmental Trades Associations (FETA) says that 'in practical terms, it is very difficult to ignite A2L gases, but some precautions must be taken to prevent accidental buildup of refrigerant, particularly during charging of systems'.[1]

Contractors working with R32 are required to take additional training as a top-up to mandatory F-gas handling qualifications, to ensure correct procedures are followed while installing and servicing systems.

For manufacturers, the introduction of R32 has required a number of changes in the design and construction of equipment. For example, R32 units must be designed to eliminate sources of ignition, with the use of brushless motors, enclosed relays, and protected contactors or control boxes.

Performance in practice

Carrier went back to the drawing board to ensure R32 systems are fully optimised at every stage in the thermodynamic cycle. This required careful component selection and testing to ensure the best possible match for the unique properties of the refrigerant.

As well as designing scroll compressors specifically for use with R32, further efficiency gains are made possible by using the latest micro-channel heat exchangers. These all-aluminium components help reduce refrigerant charge by 40% versus standard copper/aluminium coils.

The exchangers are paired with high-performance sixth-generation fans, which have a new multi-blade design for improved aerodynamic performance. Accurate load matching is assisted by variable-speed condenser fans and pumps. Brazed plate heat exchangers with asymmetric channels are used to reduce pressure drop and minimise the risk of fouling on the water side. Their dual-circuit design also assists performance in both full and part-load conditions.

The use of multiple-stage compressors operating in independent refrigeration circuits means that, in the unlikely event of a compressor failing, chillers can continue to operate. It also limits the risk of refrigerant leakage in the case of accidental damage.

As a result of design improvements and careful component selection, the refrigerant carbon footprint of our latest commercial scroll chillers and heat pumps operating on R32 has been reduced by up to 80%. This reflects the refrigerant's lower GWP and reduction in charge compared with the previous generation using R410A. **CJ**

ANDY LEGG is Carrier UK's product manager for chillers and heat pumps

References:

1. *An introduction to A2L refrigerants*, FETA.

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Ensuring healthy building environments with mechanical ventilation systems

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This module explores the demands on mechanical ventilation systems to maintain healthy indoor environments, as well as considering the emerging application of UV-C in air handling units

For building services engineers, the prerogative to deliver healthy and productive environments is not new, but the focus on this has increased because of the recent overriding imperative to minimise the exposure of building occupants to SARS-Cov-2. In many cases, particularly in commercial and institutional applications, the provision of appropriately healthy indoor air will depend on mechanical ventilation. This CPD article will consider the demands on the ventilation systems to maintain healthy internal environments, and briefly explore the application of ultraviolet germicidal irradiation (UVGI) in air handling units (AHUs) as a means of providing energy efficient microbial cleaning.

Air in buildings is likely to contain contaminants, including particulate matter (some biological in origin), gases, and vapours,[1] and there is a plethora of guidance on the acceptable limits of common – and not so common – air pollutants that could impact the internal environment. Sources for many of these contaminants may be located indoors – from building components, occupants and occupant activities – outdoors, or both indoors and outdoors. The range of possible substances is daunting (as comprehensively illustrated in the World Health Organization (WHO) *Air Quality Guidelines for Europe*[2]) but, in terms of typical European applications, there are key chemical contaminants[3] of carbon monoxide (CO) and nitrogen dioxide (NO_2), and the volatile organic compounds (VOCs) formaldehyde, benzene and naphthalene. There are several of lesser significance, and their impact will be dependent on exposure levels – this, notably, includes carbon dioxide (CO_2). Additionally, there are bacteria and viruses, particulate matter (PM2.5, PM1.0 and ultrafine particles) and, in some locations, gases such as radon. Moderating gaseous contaminants and ultrafine particles requires air-cleaning devices in addition to general particle filters.

As explained in CIBSE Technical Memorandum TM40 *Health and wellbeing in building services*, exposure to air pollutants can have both acute and chronic health effects, from mild to severe – and the pollutants may not even be perceived by occupants. The effects can include temporary discomfort and annoyance (or pleasure) from odours, while some pollutants can have negative impacts on cognitive performance. Poor indoor air quality (IAQ) can lead to headaches, fatigue, lack of concentration, and irritation of the eyes, nose, throat and lungs; conversely, optimised ventilation providing improved IAQ has been shown to significantly improve cognitive functioning of office workers, including in areas such as crisis response, information usage and strategy.[4]

TM40 relates to several studies that have found benefits in improving IAQ by avoiding pollutant sources, providing adequate ventilation rates, and filtering the air supply. TM40 refers to 'a number of studies that found benefits in increasing fresh air rates beyond current best practice recommendations; for example, reducing non-specific symptoms, such as headaches, irritation, or self-reported lethargy, and sick leave'. However, it is noted that most of these studies are inconclusive about the possible »

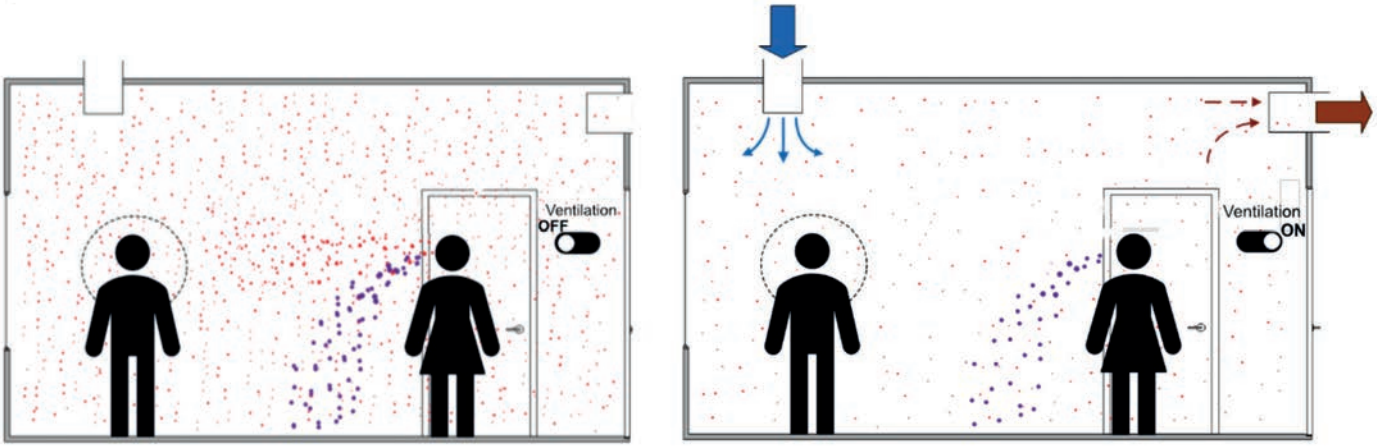


Figure 1: Illustration of how a mechanical ventilation system is likely to impact exposure from an infected person (speaking woman on the right), with aerosol exposure (red dots) in the breathing zone of another person (man on the left). Large droplet exhalation is marked with purple dots (Based on REVHA Covid-19 Guidance[6])

» causes for the improvements; they do not link ventilation rates with monitored IAQ parameters, and it is therefore not known whether the effects may be related to CO_2 levels or to other pollutants.

Part of the cocktail that makes up the IAQ are the variables of air temperature and moisture content, and the consequent relative humidity. These are the comfort parameters that are most readily directly controlled by a mechanical ventilation system, but, in themselves, can trigger events that will impact other aspects of IAQ. For example, high relative humidity will promote microbial growth such as mould, dust mites, fungi, and bacteria, which can have adverse health effects. Higher temperatures and higher humidity levels are linked to increased VOC off-gassing from materials. Maintaining relative humidity between 40% and 60% minimises the risk of microbial growth, as well as maintaining hydrated and intact mucosal barriers of human occupants.

The key principles for identifying and controlling potential risks – as proposed in CIBSE TM40[5] – are 'source control' and the 'precautionary principle'. Ideally, controlling or potentially treating pollutants at source – before they enter the occupied environment – provides the most effective way to reduce risk and avoid reliance on costly, complex, or maintenance-intensive solutions. In terms of precaution, the health effect of design solutions will sometimes only become apparent in the long term, or possibly after they unexpectedly impact a subset of the population. TM40 emphasises that this does not mean a limit to innovation, but that new methods should be carefully tested prior to application, and a plan should be in place for their monitoring. New solutions should be demonstrated to be safe, rather than waiting for potential evidence that they are not. Any proposed design solutions should be simple to understand and should take account of the expected resources required for operation and maintenance, such as skills, staff and budget.

The predominant advice during the Covid-19 pandemic has been to employ ventilation to dilute and remove contaminants in the indoor air. In many cases, and particularly for domestic and smaller buildings, this may be achievable through increasing the number of open windows and other natural ventilation pathways. However, in larger commercial and institutional buildings, and for buildings located in areas of poor outdoor air quality, mechanical ventilation may present the most practical solution.

Figure 1, based on an illustration in the recently published *REHVA Covid-19 Guidance*,[6] indicates that employing simple mechanical ventilation (with good air mixing) will probably reduce the potential for cross-contamination within a space. When applied with an appropriate ventilation rate, this example illustrates that the risk of cross-infection from SARS-Cov-2 is lowered by virtue of the dilution provided by the incoming (uncontaminated) air – subject to not creating contaminant-laden airstreams connecting the source and receiver. Therefore, where there is an internal source of pollution – such as SARS-Cov-2 – 100% outdoor-air systems are widely advocated as a means of sustaining low contaminant levels. In most cases, there will be a need for some form of air cleaning to at least protect the air-handling equipment and decorative state of the building, and, increasingly, to reduce outdoor air pollutants that would otherwise adversely affect the health and productivity of occupants.

Full outdoor-air systems would normally include some form of heat recovery to reduce the heating, cooling and humidification energy consumption. Many systems are designed to employ some proportion of air recirculation (rather than maintain 100% outdoor air), in a compromise between air quality and operational costs. Both full outdoor-air and recirculation systems are designed to supply sufficient air to maintain good air movement in the occupied space, since this will also impact the occupants' comfort. However, particularly as a result of the pandemic, there is increased concern about the potential risks of cross-contamination between rooms where they are ventilated by shared recirculated air systems.

Research[7] published this month (undertaken by the US government's Pacific Northwest National Laboratory (PNNL) provides an interesting assessment on the impact of ventilation rates, recirculation and filtration on the potential for Covid-19 cross-infection through transmission of aerosols (which can reasonably be extrapolated to other similar airborne contaminants). It confirms that the potential for infection in a single ventilated space reduces significantly as (uncontaminated) air-change rates rise. When considering multi-space recirculated air systems, the picture is not quite so simple, as higher flowrates from a contaminated room will increase the proportion of contaminants passed into the recirculated air and onto other spaces; the paper provides a detailed, and accessible, explanation of the modelled scenarios. This can lead to a comparatively large increase in the accumulated contaminant levels in the rooms that are supplied with some proportion of this recirculated air. However, the research determined that, for typical recirculation rates, the introduction of a very basic MERV 8 (≈ ISO Coarse >95%) filter in the recirculated air path significantly reduced the risk of cross-infection, and the modelling indicates that there was little benefit of employing higher-rated filters.

Many control systems in contemporary heating, ventilation and air conditioning (HVAC) systems are able to provide sophisticated building and zone modulation of

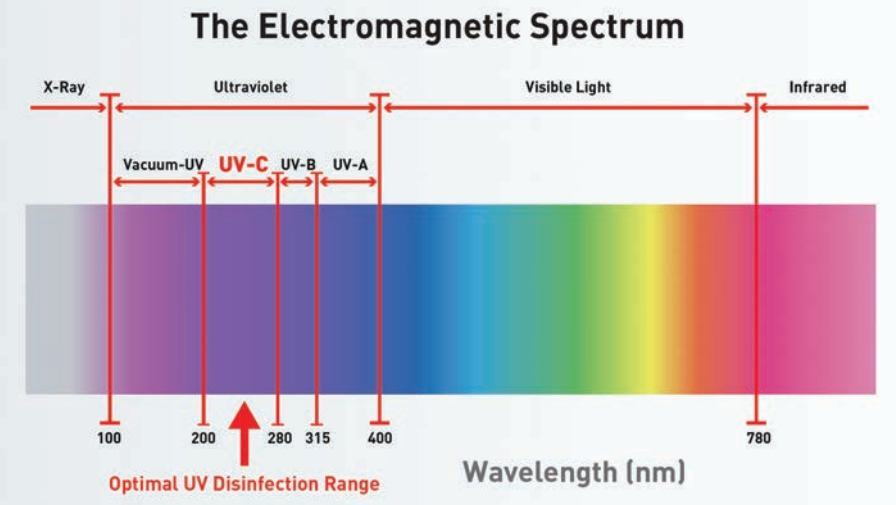


Figure 2: The electromagnetic spectrum highlighting the low-pressure mercury vapour lamp with a main emission at 254nm. Unwanted emission at 185nm generates ozone

ventilation rates. These can typically be programmed to deliver purge ventilation before occupation, so, for example, reducing VOCs that have off-gassed from furnishings and finishes, removing lingering airborne aerosols emitted by occupants during a lunch break, or simply introducing large amounts of outdoor air to stabilise the internal environmental temperatures and humidities to ensure comfortable and healthy conditions immediately before occupation. This can be linked into the control of night-time free-cooling systems that can supplement or replace a purge cycle by precooling the space with outdoor air. In the period after the Covid-19 pandemic, the pattern of working – particularly in offices – may well change, and lead to buildings regularly operating with partial occupancy. Ideally, the HVAC control will allow operation that provides occupancy-based ventilation rates, making more outside air available to occupied zones, thereby ensuring optimal IAQ in occupied areas and reducing energy consumption.

Traditional air-cleaning techniques include different forms of general air filters (classified by BS EN ISO 16890[8]) and EPA, HEPA and ULPA filters (classified by BS EN 1822[9]).

As discussed in the August 2020 *CIBSE Journal* article,[10] the air-pressure drop across a HEPA filter is likely to be two or three times that of a general purpose panel filter. So, existing, and refreshed, technologies have seen accelerated application as building operators seek air 'cleaning' devices to moderate the microbial load in the air that do not add significantly to airflow system resistance, system physical dimensions or energy consumption. An example is the integration of ultraviolet germicidal irradiation (UVGI) into AHUs, which inactivates viruses by UV-C photons photochemically interacting with the RNA/DNA molecules in a virus or bacterium, to render these microbes non-infectious.[11]

Commentaries on ultraviolet light and its safe application to UVGI are provided in the August 2020[12] and November 2020[13] *CIBSE Journal*.

Modern applications, such as that shown in the indicative panel 'Application of UVGI in an AHU' (below), typically employ low-pressure mercury vapour lamps with a main emission at 254nm, which falls close to the peak germicidal wavelengths of 265nm to 270nm. (LEDs are still comparably expensive for such applications.) Some lamps can also emit UV at 185nm (variously categorised as UV-C or 'vacuum UV', as shown in Figure 2), which will produce ozone as it splits the oxygen molecules in the air. Ozone is not a desired, or safe, addition to indoor air in occupied spaces, so it is important that such lamps are not used. UV-C will have little impact on moving airstreams where there is a limited ultraviolet dose, as the contaminants swiftly pass by.

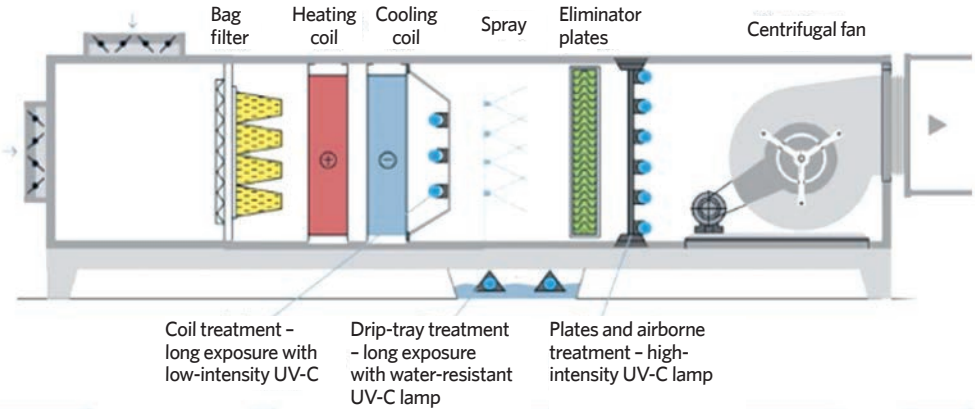
UVGI systems do not provide filtration, so inactivated particles, such as dead fungal spores, may remain in the airstream. Therefore, these systems should only be used with a downstream particle filter. Far UV-C light in the range of 200nm to 222nm has been shown[14] to disrupt microbes efficiently, but without the potential skin-damaging effects associated with 254nm UV-C. (It can still reach inside viruses and bacteria to cause damage to the RNA/DNA because the microbes are very small.) Far-UVC is likely to evolve into new applications of UVGI.

Whatever the technology, TM40 notes that a monitoring capability should be included in the design, enabling opportunities to gather data on operational indoor environmental quality and on user safety, comfort and satisfaction.

Turn to page 66 for further reading and references. »

APPLICATION OF UVGI IN AHU

UV-C lamps can be installed at strategic points within the AHU enclosure. In the manufacturer's example illustrated in Figure 3, the UV-C lamps are employed to decontaminate the coil surface condensate in the drip tray and, within the limitations of the exposure time and UV-C intensity, the air passing through the AHU housing. The lamps are fully enclosed within the AHU's metal housing, and the units include safety interlocks to avoid accidental exposure to technicians during maintenance.



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Module 180

June 2021

» **1. Which of these is not included as one of the key contaminants in European applications?**

- ☐ A Benzene
- ☐ B Carbon monoxide
- ☐ C Formaldehyde
- ☐ D Naphthalene
- ☐ E Sulphur dioxide

2. Which CIBSE technical memorandum specifically provides guidance on health and wellbeing?

- ☐ A TM11
- ☐ B TM26
- ☐ C TM40
- ☐ D TM42
- ☐ E TM65

3. What range of relative humidity is suggested as being most appropriate to minimise risk of microbial growth?

- ☐ A Under 25%
- ☐ B Between 25% and 40%
- ☐ C Between 40% and 60%
- ☐ D Between 60% and 75%
- ☐ E Above 75%

4. Which research centre undertook the research investigating the impact of ventilation on the potential for Covid-19 cross-infection through transmission of aerosol?

- ☐ A BRE
- ☐ B BSRIA
- ☐ C CDC
- ☐ D PNNL
- ☐ E US DOE

5. Using which of these wavelengths of UV light would risk generating ozone in the airstream?

- ☐ A 185nm
- ☐ B 205nm
- ☐ C 225nm
- ☐ D 245nm
- ☐ E 265nm

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Further reading:

CIBSE Journal CPD Module 27: Indoor air quality and Module 116: CIBSE guidance for delivering good IAQ in the built environment.
CIBSE Knowledge Series: KS17 – Indoor air quality and ventilation.
CIBSE TM26: *Hygienic maintenance of office ventilation ductwork*.
CIBSE Covid-19 Guidance: Ventilation (v4).

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Products of the month

Rinnai future-proofs its commercial hot-water heating units

Manufacturer's N Series range ready for hydrogen-blend fuel as decarbonisation continues

After extensive testing and verification, Rinnai's N Series commercial hot-water heating units and systems are 'hydrogen ready'. In addition, the company says any N Series units installed since December 2019 are retro-compatible with the proposed natural gas and hydrogen blend fuels that could be fed through existing gas pipeline infrastructure in the future.

'This is a major announcement for our customers' installations, whether current or planned,' says Rinnai's Chris Goggin. 'It means you are future-proofed.'

There are four models in the N Series range: the N1600i giving 954 litres per hour ($L{\cdot}hr^{-1}$); the N1600e (external; $954L{\cdot}hr^{-1}$ at 50°C); the N1300i ($775L{\cdot}hr^{-1}$) and the N1300e ($775L{\cdot}hr^{-1}$ of temperature-controlled water at 50°C). The two 1600s have load profiles of XXL and are class A rated for water efficiency, as are the 1300s, which have load profiles of XL.

'Decarbonisation is the goal for all of us, but it won't be achieved by a single product type or energy vector,' adds Goggin. 'There will be a requirement for different energy sources, whether that be hydrogen, electric or district heat. We need to be pragmatic and logical when considering services design within our very diverse building stock.'

Hydrogen has been successfully supplied to Keele University's campus in the Midlands under the HyDeploy project. It delivered a 20% hydrogen blend to 30 university buildings and 100 homes, without the need for customers to make any changes to their existing appliances.

The next phase of trials is at Winlaton, near Gateshead, where 670 houses – plus a church, primary school and several businesses – will receive a 20% hydrogen blend for around 10 months. For those interested in the impact of industrial clusters, there is the HyNet programme in the North West, where more than two million buildings – from Liverpool to Manchester – are expected to receive blended hydrogen in the near future.

Hydrogen is forecast to at least price-match industrial-scale alternatives within a decade.

Rinnai is planning to create an online information hub dedicated to hydrogen as a low-carbon energy for the future. Aimed at consultants, engineers, specifiers and end users, the hub will include webinars and all requested digital or onsite meetings.

Call 01928 531 870, email engineer@rinnaiuk.com or sales@rinnaiuk.com, or visit www.rinnaiuk.com

Manufacturer calls for unity in push for net zero

Rinnai believes a council will concentrate sectors' efforts to meet carbon emissions goals

Rinnai has called for a single body to represent all sectors of the buildings, products and services industries, to promote and help achieve the goal of net-zero carbon emissions.

The manufacturer of continuous flow hot-water systems says the council should be composed of all interested parties – residential and industrial consumers, contractors, installers, distributors, designers and consultants, and manufacturers – to plan for a realistic and practical route to net zero.

Its managing director, Tony Gittings, believes this can only be achieved through unity and responsible information exchange, to avoid partisan or 'silver bullet' approaches to technology. He also says industries must look at this challenge from the consumers' point of view and put accurate information in the public arena.

'We cannot be agnostic towards energy vectors of the future,' adds Gittings. 'The combination of hydrogen, BioLPG and electricity will provide a robust decarbonisation pathway.

Rinnai's MD Tony Gittings

'In our sector, we have manufacturers of similar or like-for-like products that are looking to what will replace natural gas as the fuel of mass consumption, and how that will affect them. We also have the pragmatic logic of trying to find affordable fuels for the mass market.

'Alternatives, on their own, are simply not an answer. We also need to look at the range of innovations and developments that will come on stream.'

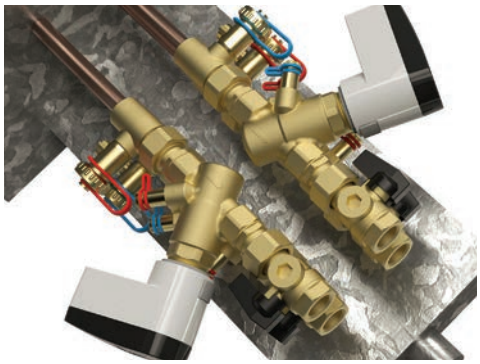
Gittings believes no single product or system can solve the issue of carbon emissions. What, for example, would be the net-zero answer to a commercial or industrial building envelope that needs legionella-prevention regimes and constant high-temperature hot water in large volumes? Likewise, he asks, how will electrification and heat pumps be attractive in terms of capital, installation, and ongoing operational costs and performance?

'When we look towards notional building models within the new Future Buildings Standard, or the Scottish energy in buildings draft, these documents are clearly looking for a silver-bullet solution that doesn't exist,' Gittings says.

'Everything has a role to play, and everything non-carbon can have a future. A collective, equitable effort will give us the result we all want – the result we must have if we are to have a sustained quality of life.'

Call 01928 531 870, email engineer@rinnaiuk.com or sales@rinnaiuk.com, or visit www.rinnaiuk.com

Save time and labour with Essco's new FCVA



Essco's new fan coil valve assembly (FCVA) is designed to save time and reduce labour costs, allowing users to easily set up the system and perform maintenance.

The FCVA connects fan coils, ceiling conditioning systems and cold beams on to primary heat networks within multi-dwelling buildings, and provides control of the secondary circuit, with automatic shut-off, balancing and filtering.

With pre-assembled heating and cooling handed assemblies, with only four connections to make on site, installation time is reduced – and at 225mm x 84mm x 159mm, Essco's FCVA is light and easy to handle.

Assemblies also come with an ID tag to record the flow coefficient (KV) and commissioning information, which gives a permanent record for future system servicing. Installers can also access the installation, operation and maintenance (IOM) manual via their mobile, tablet or laptop using the QR code on the ID tag.

Maintenance is minimal, with a simple annual strainer check to carry out, and there is a two-year warranty from point of delivery.

Call 01489 779068 or visit www.esscogroup.co.uk

Scott bids farewell to Condair

Condair's sales and marketing director Tim Scott is retiring after 32 years with the company.

Scott joined the sales department in 1988, when the firm was JS Humidifiers, becoming service director 13 years later, and sales and marketing director in 2007.

'I feel privileged to have worked with such amazing people,' he said. 'The past 32 years have been an absolute pleasure.'

Tony Fleming, head of Condair's Northern Europe sales operations, added: 'We wish Tim every happiness, and thank him for the contribution he has made to Condair.'

Visit www.condair.co.uk

Hospital M&E health matters

NHS hospitals and staff have faced considerable pressure in recent times, as a result of the pivotal role they have been playing in fighting the effects of the Covid-19 pandemic.

At Grundfos Pumps, we have been proud to play our role in supporting UK hospitals and – as we have done for decades – delivering a broad spectrum of pump demands. Like the NHS staff, these 'hidden heroes' have been asked to go over and above their normal operation and remain in peak condition 24/7.

These pumps and pump systems perform important tasks that include: maintaining complex HVAC demands; ensuring the delivery of sufficient clean water; the removal of wastewater; fire-suppression demands; and many other ancillary functions.

For more information on how our team of specialists can help you get the best from your pump solutions, go to our website, where you will also discover how Grundfos can support hospitals and a wide range of other applications.

Visit www.grundfos.co.uk

Residential ventilation is focus of Domus CPD

Domus Ventilation has revised its CIBSE-accredited CPD course Residential Ventilation Principles and Building Regulations. Focusing on new build, the course explains the changes to Part F – Ventilation, and topics include: why ventilation is necessary, with greater emphasis on pollutants and indoor air quality; the types of ventilation available, plus ductwork and installation practices; and relevant regulations/directives. The course also looks at Part B – Fire Safety, addressing the requirements for using combustible material in cavities, while MVHR guidelines and best practice also feature.

Email megan.bennett@domusventilation.co.uk

nVent's UFH thermostat gets smart update

The premium nVent RAYCHEM SENZ WIFI electric underfloor heating (UFH) thermostat has been updated to allow users to control their heating using voice commands via a smartphone app or home-hub device. Enabled by the development of an open application programming interface, the new feature allows the thermostat to be integrated with leading smart-speaker devices and building management systems, bringing connected underfloor heating to any application.

Call +44 (0) 7836 236 534 or email david.perry@nVent.com

Viega launches smart Pressgun range

Viega has upgraded its Pressgun suite of products to include the new Pressgun 6 Plus and Pressgun Picco 6 Plus.

These compact tools link wirelessly to a smartphone and offer enhanced functionality via the Viega Tool Services app. Users can choose between the default pressing mode, Viega AutoCycle, or the Viega SmartCycle, which presses the connection in two stages to allow inspection before completing.

The 6 Plus press jaw holder can be rotated 360°, while the Picco 6 Plus has a rotating head of up to 180°.

With a pressing force of 32kN, the 6 Plus is suitable for metal press-connection systems with a dimension of 12mm to 108mm, Megapress steel pipe connections of 3/8in to 4in with the Pressgun Press Booster, and multilayer pipe systems of 12mm to 63mm.

The Picco 6 Plus can deliver a 24kN pressing force and handle metallic press connectors (12mm to 35mm), Megapress steel pipe connectors (3/8in to 3/4in), and plastic pipeline systems (12mm to 40 mm).

Visit: www.viega.co.uk

Jung Pumpen launches FAQ videos

A series of 'frequently asked questions' videos are now available on the UK's Jung Pumpen website at: **www.jung-pumps.co.uk/what-the-faq-series-by-jung-pumpen/**

Other Jung Pumpen resources include a 3D library for wastewater and sewage floor-mounted pumping systems and access to personal online presentations.

Berkshire-based Pump Technology is one of only two firms authorised to supply Jung Pumpen products in the UK.

Call 0118 9821 555 or email support@pumptechnology.co.uk

Elco delivers premium upgrade to office refurb

Elco Heating Solutions has supplied 15 Trigon XL 570kW boilers as part of a major upgrade of 10 Upper Bank Street in London's Canary Wharf.

The building has 30 occupied and four basement floors, function suites, a gym, a swimming pool, and auditorium. Heventa Building Services Engineering installed the floor-standing boilers over three floors: the fifth, sixth and 31st.

The Trigon XL has seven models, with outputs of 150-570kW, ultra-low NO_x emissions, an 8bar working pressure, 30K flow/return temperature differential, and an ultra-compact footprint.

Visit www.elco.co.uk or www.heventa.co.uk

TF Solutions becomes Mitsubishi Electric wholesaler

TF Solutions has become a wholesaler for Mitsubishi Electric's advanced range of HVAC solutions, and now offers the manufacturer's range of products 'off the shelf'.

'We are currently moving through a period of rapid growth and expansion,' says managing director Andy Cherrill. 'We know the market for sustainable and energy-efficient products is expanding rapidly, and our customers need product choice and design support as they look to capitalise on new opportunities.

'With Mitsubishi Electric now held in stock across all of our branches, this complements our current stock offering of Fujitsu and Samsung.'

Gary Lamsdale, distributor, wholesaler and VAR manager for Mitsubishi Electric, says: 'We're delighted to support TF Solutions as it grows its business.'

TF Solutions has branches in Leeds, Stockport, Burton, Northampton, Bristol, Dunstable, Crayford, Guildford and Smethwick, with more to come. The firm is also planning three training centres to serve the UK.

Call 0330 041 5283 or visit www.tfsolutions.co.uk

Exyte Hargreaves appoints new operations director

With more than 30 years' experience of working with companies in and outside of the UK, David Fitzpatrick has become operations director of Exyte Hargreaves' Smoke and Fire business unit.

Fitzpatrick has spent a large part of his career working within smoke-related manufacturing companies, such as NuAire and Actionair, and has previously worked for Airvent and Colt International, as well as creating Adexsi UK.

In his new role, he will be responsible for managing Exyte Hargreaves' smoke and fire business unit, where his extensive industry experience will complement the customer-focused culture.

Fitzpatrick joined the CIBSE board in May 2019, and was chairman of CIBSE Patrons from 2012 to October 2019. Commenting on his new appointment, he said: 'This was an opportunity I could not turn down. Exyte Hargreaves has done some of the most complex smoke projects – from Crossrail to Manchester Airport.

'This new business unit allows us to build upon the tremendous experience and knowledge the business has to package a stand-alone service to a broader customer base.'

Visit www.exyte-hargreaves.net

Smoke safety specialist joins Exyte Hargreaves to support new solution launch

Exyte Hargreaves has appointed David Ayling as technical manager within its Smoke and Fire Safety (SFS) business unit.

Ayling has a 30-year career in the smoke industry, working across key disciplines, including the design and manufacture of smoke and environmental control systems and ventilation projects.

He has been instrumental in delivering major engineering projects, including the 2012 Olympic Village development, for which he commissioned and installed smoke and environmental ventilation systems for the athletes' residential blocks.

SFS offers clients an end-to-end package in the specification and delivery of natural and mechanical smoke-control systems, from design and manufacturing through to installation and commission.

'As an electrical engineer, my focus has always been on the detail of smoke and ventilation systems, ensuring they offer the highest quality solutions possible. Exyte Hargreaves' approach is unique and long overdue within the industry, and it's exciting to be involved from the start,' said Ayling.

Andy Sneyd, at Exyte Hargreaves, added: 'David will be instrumental in us being able to saturate the market with our smoke safety and ventilation products and solutions, and we look forward to having him on board.'

Visit www.exyte-hargreaves.net

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Waterloo's CIBSE-approved CPDs are now available to everyone as live webinars.

The next dates scheduled are:

- **An Introduction to VAV systems – Thursday 24 June 2021 at 3pm**
- **General Air Distribution – Thursday 8 July 2021 at 3pm**

For more information or to register for either of these events, visit **www.waterloo.co.uk/cpd-and-training**, where you will also find recordings of previous sessions of both CPDs.

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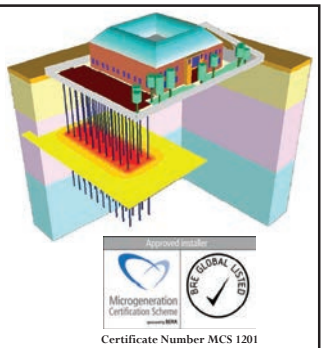

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How you can help us

The CIBSE Benevolent Fund is made possible by voluntary donations from Members. It is a service provided by Members, for members.

There are several ways you can help the work of the CIBSE Benevolent Fund.

Simply:

- Pay the voluntary contribution along with your annual CIBSE membership subscription
- Write a cheque payable to the CIBSE Benevolent Fund, return to CIBSE, 222 Balham High Road, London, SW12 9BS
- Set up a regular standing order or direct debit (please email benfund@cibse.org)
- Remember the Fund in your will
- Run a local fundraising event – talk to your local Almoner: www.cibse.org/CIBSE-Benevolent-Fund/Almoners

Thank you

"I would like to take this opportunity to thank CIBSE members for their continued support, without which the work of the Benevolent Fund could not be sustained."
– David Wood, Chair of the CIBSE Benevolent Fund Trust.

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Hurley Palmer Flatt's merger with American company HDR means Adrian Gray has global responsibilities

Since Hurley Palmer Flatt joined forces with American-based HDR 18 months ago, HDR | Hurley Palmer Flatt has been restructuring to form a global engineering division with more than 1,000 staff. It has offices in all the major cities across the US, as well as many in Europe, the Middle East and Africa, and Asia-Pacific, with former Hurley Palmer Flatt directors taking many of the leadership roles.

As sector leader for corporate and commercial offices, Adrian Gray is preparing the growth and development strategy for all geographic regions. He says meeting and collaborating with colleagues around the globe is not only exciting, but has also helped offset the challenges brought about by lockdown restrictions in the UK.

How is the US market emerging from the Covid-19 pandemic?

The US is a vast market for our services, and the new political environment has brought renewed enthusiasm for sustainability and energy goals. We are able to share with the US the skills and experience we have developed in London designing sustainable, low energy offices.

There is huge disparity between states in the US and how each has responded to the pandemic. Many have not imposed the harsh lockdowns that we have seen across Europe, so some city centres are buoyant in comparison, with a vibrant market for office development. It has been interesting to be an integral part of this research and finding the best opportunities for us to invest and grow.

How does building services engineering differ in the US?

There is a considerable divergence in approach across the US. For example, it is the culture in many cities and states to procure all engineering services through the architect, so it is important to understand the market before developing a local strategy. HDR has a large US architectural division and has delivered complete multidisciplinary services for offices in many locations.

How are you ensuring clients' buildings are safe?

We aspire to keep buildings as safe as possible by providing a comprehensive approach to Covid-related advice that goes beyond implementations recommended by CIBSE and the British Council for Offices (BCO). Many strategies can be implemented to mitigate the risk of infectious disease transmission in the built environment. Related to the SARS-CoV-2 virus, these strategies can be applied to existing office HVAC systems. It has been interesting to observe the differing approaches by clients in the UK and the US. There is more interest in the investigation of new technologies in the US, compared with the typical approach we have seen in the UK of clients being satisfied to follow guidelines, such as from CIBSE and BCO.

The pandemic has made us all reassess how we approach planning, analysis, design and emergency preparedness, to ensure buildings and their occupants are healthy. HDR and the University of Nebraska Medical Center's Global Center for Health Security have teamed up to address healthcare resilience across the globe as we all transition and recover from the impacts of Covid-19.

It is fascinating and a privilege to have access to some of the most comprehensive research that is available on Covid-19 in the built environment, and to be able to share this with our clients around the globe.

What will be the impact of Covid-19 on building design in the long term?

We will see an occupier-driven desire for more fresh air and buildings with opening windows. There needs to be more research on the risks associated with different methods of cooling and ventilation in offices, so systems with less risk of spreading contaminants are recognised. The UK standard office solution, using overhead fan coils with an extract plenum, causes me some concern, as any microbiological particles drawn into the plenum could be redistributed throughout office space by fan coils drawing recirculated air directly from the extract plenum. By comparison, other systems appear to present less risk of such widespread contamination.

Are you recommending air-purification solutions?

I have seen for myself the effect these systems have on reducing microbes and pathogens. More work needs to be done to study the long-term use of disinfection systems in workplace environments. Studies are under way in the US, but I am not aware of anything comparable in the UK, which I find disappointing in a pandemic. If you consider the enhanced cleaning required to make a workplace safe in the post-Covid era, there is a role to be played by ionisers and ozone-based systems that could operate 'out of hours'. This would provide a daily clean without the need for vast quantities of cleaning materials, and all the associated manufacturing and transportation pollution and costs this entails.

EVENTS

TECHNICAL SYMPOSIUM

13-14 July

This year's event, being held virtually, is titled: Engineering the built environment for a new 'normal' – delivering safe, healthy and versatile buildings. The symposium encourages the participation of young and experienced industry practitioners, researchers and building users to share experiences and develop networks. Register at **www.cibse.org/symposium**

CIBSE REGIONS AND GROUP EVENTS

Check the website for up-to-date information on regions and groups meetings, webinars and podcasts. Visit **www.cibse.org/events**

Society of Public Health Engineers AGM
8 June
Followed by a technical presentation.

North West: Lowering energy bills with new technology
10 June
How new biocommunicational technology can assist in saving energy and reducing residents' costs.

Online membership application workshop
15 and 22 June
These bite-sized sessions will help you prepare to apply for MCIBSE. Over the two live sessions, CIBSE interviewers will guide you through starting your application.

ILEVE AGM
16 June
The Institute of Local Exhaust Ventilation Engineers' AGM will be followed by a technical presentation by committee member Colin Russell, RCS managing director.

Western Australia: Electric vehicle charging infrastructure
22 June
This presentation will discuss the infrastructure needs for electric vehicles in Australia.

SoPHE: Seeing is believing – active and passive drainage ventilation
23 June
Seminar by Aliaxis, to help further understanding of key elements of sanitary pipework design.

North West: BS EN 15232 and the impact of building automation on energy efficiency
30 June
This CIBSE-approved CPD looks at the BS EN 15232 standard and how it shows the potential benefits a BMS can bring to the energy efficiency of a building.

CIBSE Membership

CIBSE Membership 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 two-part webinar series includes: session 1, covering routes to membership; and session 2, focusing on how to write the Engineering Practice Report.

Upcoming webinars:
- **22 and 29 June**
- **13 and 20 July**

For further details and to register, visit www.cibse.org/webinars

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

CIBSE JOURNAL WEBINARS

CIBSE Journal hosts regular, sponsored webinars covering a wide range of building services-related topics. The next *CIBSE Journal* webinar is taking place on 9 June at noon, and is titled: Understanding DPCVs and PICVs for effective flow control in variable volume systems.

Register for this, or any of the on-demand webinars, at **www.cibsejournal.com/cpd/webinars**

NEW LIVE ONLINE TRAINING COURSES

CIBSE 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 **www.cibse.org/training**

Electrical services explained
1-3 June

Overview of current fire legislation and guidance
3 June

Low carbon design
7-9 June

Introduction to Heat Networks Code of Practice (CP1)
8 June

Fundamentals of drainage
11 June

Heat Networks Code of Practice (CP1)
14-15 June

High voltage (11kV) distribution and protection
15 June

Building services explained
16-18 June

Earthing and bonding
18 June

Heat Networks (CP1) half-day update
22 June

Mechanical services explained
22-24 June

Low carbon consultant building operations
6-9 July

Energy Savings Opportunity Scheme
7 July

Introduction to Heat Networks Code of Practice
8 July

Energy surveys
8 July

Fire safety building regs Part B
13 July

Electrical services overview
13-15 July

Air conditioning and cooling systems
14 July

Building services explained
20-22 July

Low carbon design
20-22 July

Low carbon consultant
21-22 July

Above-ground drainage
21 July

Low carbon buildings and infrastructure for local authorities
22 July

Heat Networks Code of Practice
26-27 July

ONLINE LEARNING

CIBSE has a portfolio of online learning courses, which contains interactive content, with quizzes and additional resources to support your learning.
www.cibse.org/training

WEBINARS #Growyourknowledge

CIBSE's free webinar series continues. Taking place every two weeks on Thursday at 11am, the webinars are designed to support the CIBSE community in maintaining their CPD remotely. All previous webinars are available on demand. **www.cibse.org/growyourknowledge**


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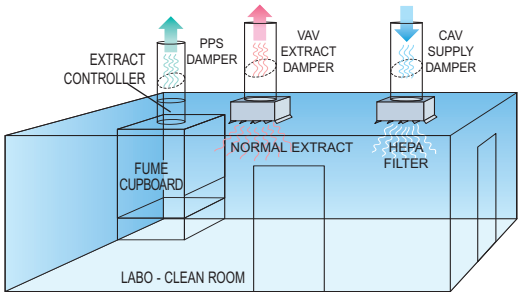

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