CIBSE JOURNAL

#Build2Perform

November 2019 www.cibsejournal.com

THE GREENHOUSE EFFECT

How developers of Britain's biggest glasshouses plan to grow 12% of the country's tomatoes using heat from waste water

YOUNG ENGINEERS TAKE CENTRE STAGE

CREATING A DIGITAL TWIN

HEATING OPTIONS IN ZERO CARBON HOMES

CPD Special

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CIBSE Journal is written and produced by CPL (Cambridge Publishers Ltd) Tel: +44 (0)1223 378000. **www.cpl.co.uk**
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Editorial copy deadline: First day of the month preceding the publication month

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Sowing the seeds

Build2Perform Live, taking place on 26-27 November, is particularly well timed this year. The event will give delegates the chance to discuss the hugely important proposals put forward by the government in its consultations on Part L and F of the Building Regulations for dwellings, as well as on the Future Homes Standard.

The changes will influence the method of building for a generation, and are intended to ensure that the construction industry delivers low carbon buildings that will allow Britain to achieve its goal of net zero carbon buildings by 2050.

Julie Godefroy rounds up the relevant proposals, and the closing dates for contributions to CIBSE's response, on page 24. They include changes to SAP and proposals for the minimum energy efficiency standard for privately rented homes. CIBSE is also consulting on a draft revision of *CIBSE TM23 – Testing Buildings for Air Leakage*. The government's Part L consultation includes a proposal for testing every home for airtightness.

One area of contention is the government's proposal that local authorities should not adopt standards higher than Building Regulations. This would mean, for instance, the proposed energy reduction in new homes of up to 31% over existing Part L would be less than the reductions required in the London Plan.

The new regulations will help determine what heating and cooling strategies will be adopted over the next decade. Chris Twinn, on page 56, has compared the cost of 11 systems based on the carbon factors proposed in SAP that will be used in new Part L (and already adopted in the London Plan). He concludes that the internal heat gains in an insulated home should act as the main heat source, and can help deliver heating and hot water using a two-stage MVHR– exhaust air source heat pump.

One project that will use reclaimed heat as its main heat source is the huge greenhouse scheme planned for East Anglia, which could grow up to 12% of Britain's tomatoes. The developer is working with Anglian Water to use heat from nearby waste water treatment works to provide the perfect growing conditions for peppers, tomatoes and other produce.

It's encouraging to see engineers focusing their energy strategies on nearby, readily available sources of heat. The project could have achieved net-zero status, but, ironically, a gas-fired CHP is required to produce the CO_2 levels required for growing perfect tomatoes.

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CONTRIBUTORS

Hywel Davies
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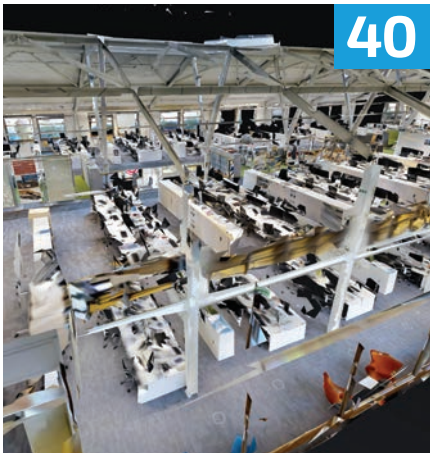

CIBSE JOURNAL

www.cibsejournal.com

The official magazine of the Chartered Institution of Building Services Engineers

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 ISSN 1759-846X

SUBSCRIPTION ENQUIRIES

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

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

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

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

CREDITS

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ABC audited circulation:
17,765 January to December 2018
Printed by: Warners Midlands PLC

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Part L proposals do not go far enough

Fabric performance could be worse, says Leti


Clara Bagenal George

The government's proposed changes to Part L of the Building Regulations will not lead to the cut in carbon emissions required for the UK to meet net-zero energy targets, according to a leading group of design professionals.

The London Energy Transformation Initiative (Leti) said that it was unable to support a number of proposed changes in the regulation governing energy use.

The government has published the consultation for Part L (housing) and the Future Homes Standard, which is due to ban gas boilers in new homes from 2025.

Leti said that the proposal to remove the fabric energy efficiency standard (Fees) would mean that housebuilders could meet improved performance targets through system upgrades alone.

'If designers changed to a heat pump, you could get the higher level of savings with an inferior fabric,' said Clara Bagenal George, founder of Leti. George said new proposed minimum standards for fabric performance did not go far enough to compensate for the removal of Fees.

BuroHappold stainability and physics associate Jon Gregg said: 'Ultimately, you could circumnavigate the fabric approach by using renewables. [Part L] needs fabric improvement, low carbon heating and renewables.'

Leti has criticised the proposal to use primary energy as the principal performance metric, as it masks the energy performance of the building by including energy source carbon factors. It advocates using the Passivhaus metric kWh·m^{-2} per year. George said: 'We want an absolute figure, so you can compare buildings year to year.'

George said that the metric could be used as an optional route to compliance, so people had time to develop the tools ahead of 2025, when the government's Future Homes Standard comes into force.

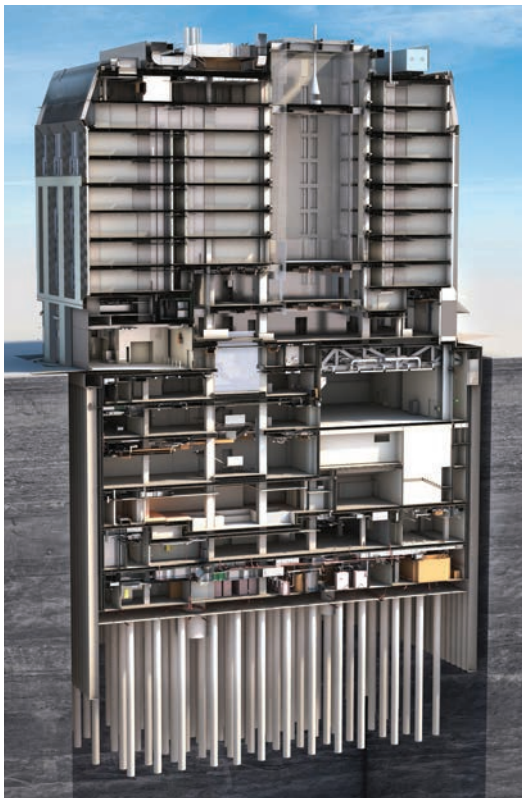
Leti believes that the government needs to mandate for zero carbon buildings by 2030 to meet its 2050 net-zero carbon targets. George said: 'If we are aiming for net-zero buildings by 2030, we have five years to learn how to do it. Otherwise, it will be too late.'

The removal of the power of local authorities to set carbon reduction targets beyond Building Regulations has also been questioned by CIBSE and Leti. George said: 'This is completely unnecessary and will send London and many cities backwards.'

See pages 9 and 24 for more on Part L.

GOING UNDERGROUND

Arup is supplying multidisciplinary design services for a £300m new hotel in Leicester Square, which features a ballroom and 15-metre swimming pool within its six basement levels. The Londoner is being developed by Edwardian Hotels London and is due to open in summer 2020. Arup is providing mechanical, electrical and public health services on the project, which is aiming for Breeam Excellent and a reduction in carbon emissions of more than 30% compared with Part L 2016.



Labour reveals plans for net-zero carbon in 2030s

A 2020 zero carbon building standard is among 30 recommendations that the Labour Party has made to decarbonise the UK. It said the UK should be put on a 'climate emergency' footing for the next decade.

The 30 recommendations span four goals: reducing energy waste; decarbonising heating; boosting renewable and low carbon electricity generation; and keeping the system balanced to ensure security of supply.

Labour said that, if its recommendations are implemented, the UK would cut UK energy emissions by 77%, compared to 2010. It said the proposed investment in the energy sector would lead to a net benefit of £800bn to the UK economy.

Its four key goals by 2030 are to reduce heat demand by 20%, cut electricity demand by 11%, increase supply of renewable and low carbon heat to 50%, and increase supply of renewable and low carbon electricity to 90%.

The plan recommends establishing a pledge to heat all new buildings by 'renewable or low carbon energy only (or as close as possible), with no fossil-fuel heating from 2020'.

Labour's Shadow Business Secretary Rebecca Long-Bailey said: 'The recommendations in this report could put the UK on track for a zero carbon energy system during the 2030s – but only if rapid progress is made early on. The next five years are, therefore, crucial.'

£500m renewables and heating pipeline up for grabs

Procurement organisation Fusion 21 has published a new national heating and renewables framework, covering a four-year programme of work on behalf of the Department for Education in schools, academies and colleges, worth up to £500m.

It aims to select firms offering both domestic and commercial heating services – including consultancy, design, service and maintenance, and installation – for the programme, which starts early next year. It aims to give SMEs, in particular, chances to bid for specialist work.

Work will also require renewable technology applications, ranging from air and ground source heat pumps to solar thermal, electric heating and hot-water systems. District heating and the installation and servicing of heat interface units will play a key role in the commercial projects, according to the procurer.

IN BRIEF

£20bn a year needed to deliver net zero

It will cost up to £20bn a year to deliver the government's net-zero carbon target by 2050, according to a new report by Vivid Economics.

Decarbonisation measures would cost between £1bn and £2bn a year up to 2030, rising to between £6bn and £20bn depending on which technologies are adopted, the research claims. The most expensive measures, such as carbon capture, could cost between £160 to £470 a tonne of savings, while the cheapest options, such as habitat restoration, would cost between £8 and £78 per tonne, the economists calculate.

Local authorities sign clean-energy deal

Technology firm Siemens has signed an agreement with a group of 94 local authorities to unlock investment in clean-energy projects. All parties will now work with the Department for Business, Energy and Industrial Strategy to create a pipeline of clean-energy projects by combining finance from local authorities, private capital partners and government sources.

According to Siemens, a survey of local authorities suggested that more than £100bn could be rolled out to develop and commercialise clean-energy projects.

Scotland's 2045 zero carbon target

Scottish MSPs have unanimously backed a new Climate Bill committing the nation to achieve net-zero carbon emissions by 2045.

The vote was 113 to 0 in favour of moving on from Scotland's previous climate target of a 90% reduction in emissions by 2050. Ministers also agreed to a Labour Party amendment raising its interim target to cut net emissions by 75% by 2030 – measured against a 1990 baseline.

A pledge to hold a 'citizens' assembly' on how to tackle climate change was added to the bill.

Environment Secretary Roseanna Cunningham said the government was 'putting in place the most stringent framework of statutory targets of any country in the world'. But Green MSP Mark Ruskell said the bill did not represent 'meaningful action' and urged other political parties to stop 'hiding behind targets'.

Circular economy crucial to tackling carbon emissions

Fewer than 10% of the 92.8 billion tonnes of materials used annually are reused, claims yachtswoman's foundation

Decarbonising the energy sector will not deliver a net-zero carbon economy, according to the Ellen MacArthur Foundation (EMF).

The environmental charity has produced a report calling for the wider adoption of 'circular economy' principles, such as closed-loop value chains and carbon capture and storage, which, it says, could lead to cuts in emissions of more than 9.3 billion tonnes.

The report, *Completing the Picture: How the Circular Economy tackles Climate Change*, states that a wholesale switch to renewables would only address 55% of greenhouse gas emissions. It examines how the circular economy could shake up production of steel, plastic, aluminium, cement and food. Keeping materials in use can reduce emissions by up to 40%, claims the foundation.

'To achieve targets on climate, it is critical that we transform how we design, make, and use products and food,' said EMF founder Dame Ellen MacArthur. 'This paper shows that transitioning to a circular economy is not only an opportunity to tackle emissions across sectors, but also to design an economy that is restorative and regenerative, creating benefits for society, businesses and the environment.'

Currently, just 9% of the global economy could be considered circular, which means fewer than 10% of the 92.8 billion tonnes of materials used annually are reused, according to the report. It predicts that material use will double by 2050 to keep up with global economic growth – having already tripled since the 1970s.

Dame Ellen MacArthur

BCIA chief calls for 'one small change'

The Building Controls Industry Association (BCIA) has launched an initiative to encourage people to make 'one small change' to their everyday lives to improve energy efficiency in buildings.

The organisation is urging individuals to share their successes on social media using the hashtag #OneSmallChange, and it held a joint event with the CIBSE FM Group to promote measures for improving the performance of buildings in operation.

'It is easy to think that issues surrounding climate change are too big to be fixed and that the actions of individuals will not make a difference,' said BCIA president Jon Belfield. 'However, if each one of us takes one small step on a daily basis to save energy usage, collectively it makes a huge difference.'

Belfield praised the seven finalists in the CIBSE ASHRAE Graduate of the Year Award, held in October, for outlining how 'collaborative determination, innovation and commitment' can help the UK achieve its net-zero carbon target by 2050.

'We all have to change our relationship with energy and #OneSmallChange serves to cover simple actions, as well as more complicated initiatives such as a demand-driven strategy for ventilation,' added Belfield.

The Queen outlined the government's legislative programme

Building safety proposals outlined in Queen's Speech

Plans to improve energy efficiency of commercial buildings in private rented sector also announced

The Queen's Speech included the possibility of criminal sanctions for breaches of revised Building Regulations, as the government seeks to tighten building safety in the wake of the Grenfell Tower fire.

Parliament was told that Boris Johnson's government will bring forward 'laws to implement new building safety standards', including an independent Building Safety Regulator to oversee compliance by contractors, designers and building owners. Responsibility for a building's safety would be shared between at least five parties, including the principal contractor.

The legislation would aim to capture recommendations made by Dame Judith Hackitt's review of Building Regulations. It will be centred on a safety framework for high-rise residential buildings, including a 'clearer scope of accountability and duties' during design, construction and occupation.

The government also announced plans to 'dramatically improve' the energy efficiency of commercial buildings in the private rented sector, with the aim of cutting £1bn annually from tenants' energy bills by 2030. It is consulting on a proposal to set the minimum energy efficiency standards for the sector at EPC band B by 2030, which, it says, could reduce UK emissions by the amount currently produced by half a million homes.

It also plans to consult on mandatory in-use energy performance ratings for buildings used by UK businesses and on proposals to make it simpler for large-scale energy-storage facilities to get planning permission.

Future Homes targets 31% carbon cut

The Ministry of Housing, Communities and Local Government is inviting views on proposed options to increase the energy efficiency requirements for new homes. *The Future Homes Standard: changes to Part L and Part F of the Building Regulations for new dwellings* is the first stage of a two-part consultation. It covers the wider impacts of the regulations and the guidance contained in their Approved Documents, including standards of airtightness and efforts to improve 'as-built performance' of existing homes.

Two potential targets are offered in the consultation, which closes on 10 January. The first is a 20% reduction in carbon emissions compared with the current standard for an average home. According to the government, this could be delivered through higher fabric standards – using triple glazing and minimising heat loss from walls, ceilings and roofs. The second target is a 31% reduction through greater use of carbon-saving technology, such as heat pumps and photovoltaic panels. It would also impose higher fabric standards, but not as high as in the first option.

The government says the second target 'would deliver more carbon savings and result in lower bills for the householder'. It would also help to drive the uptake of heat pump technology and grow the number of skilled installers. However, it acknowledges it would involve higher upfront build costs.

Housing design guide launched

A new National Design Guide has been published alongside the new Future Homes consultation by the government.

It considers the role of passive design principles and is intended to help local authorities deliver targets on sustainability, energy efficiency, and health and welfare of building occupants. It describes 'well-designed homes' as being efficient and cost-effective, adding that they should 'help to reduce greenhouse gas emissions by incorporating features that encourage sustainable lifestyles'.

They should also make maximum use of 'natural ventilation, avoid overheating, minimise sound pollution and have good air quality'.

The guidance also recommends using detailed information about the layout and aspect of internal spaces, management of solar gain, and natural ventilation opportunities to deliver better living conditions.

It was published in response to warnings issued by the parliament's Environmental Audit Committee, which predicted a tripling of heat-related deaths in the UK over the next 30 years.

Have your say

CIBSE would like to hear your views on the government's consultations on changes to the Building Regulations and the proposed Future Homes Standard, to be introduced by 2025.

CIBSE will submit a response to the consultation and would like to hear your views at **bit.ly/CJNov19Reg**

This first phase of the consultation covers new homes and includes two options to raise the energy-efficiency standards in Part L in 2020. The proposal also restructures the guidance into two Approved Documents (ADs), to give guidance on Part L for dwellings and for buildings other than dwellings. This replaces the current four ADs.

A further consultation is promised, which will propose changes to the energy-efficiency standards for non-domestic buildings and for building work to existing homes and non-domestic buildings, as well as on preventing overheating in buildings.

The government is also consulting on a new release of BRE's Standard Assessment Procedure (SAP) software.

Sector urged to listen over mental health

Six out of 10 construction workers have suffered mental ill health because of their work, according to a report released on Mental Health Awareness Day by Mates in Mind.

The charity added that two workers in construction-related professions took their own lives every working day and it called for industry leaders and government to be 'more considerate and consistent' on the issue.

Last year, the number of deaths by suicide in the UK rose to 6,507 – the highest since 2002 – according to the Office for National Statistics. 'We are deeply concerned to see a rise in this figure, despite the attention that has been given to suicide prevention and increased awareness of mental health in recent years,' said Mates in Mind managing director James Rudoni.

Interest in the subject has intensified in the past three years and understanding is improving, he said, but organisations need to 'listen, encourage and support employees, rather than simply running short-term awareness campaigns or one-off training'.

Schools and hospitals missing millions in energy savings

More than 147,671 tonnes of CO_2 could be saved annually, says EDF

Energy-efficient lighting and better heat-management strategies could cut more than £45m from the energy bills of schools, hospitals, hotels, offices and police stations, according to new research by EDF Energy. The firm claimed the average UK organisation could achieve annual energy savings of more than £46,000. Measures include LEDs and heat-management systems that ensure heating is turned off when a building is unoccupied.

EDF Energy analysed consumption at more than 4,000 sites and found that 62% could generate cost savings through lighting improvements, while 61% could improve the heating schedule using occupancy sensors. 'Our data covers a relatively small proportion of the UK's businesses and public sector organisations – imagine what the impact would be if all such organisations made even the simplest of changes,' said EDF Energy's director of energy solutions Vincent de Rul.

EDF also calculated that emissions reduction of more than 147,671 tonnes of CO_2 could be achieved annually from the same 'simple measures'. On average, it said organisations could make annual savings of £10,800 per site by installing efficient lighting. This would also reduce their carbon emissions by 24 tonnes per site, per year.

Cash for firms to develop low carbon heating

The Scottish Government has created a £30m fund for businesses and technology companies able to provide low carbon domestic heating solutions.

The Scottish Low Carbon Heat Funding Invitation encourages companies to devise a solution to inefficient household heating by offering successful companies financial assistance for up to 50% of the total eligible costs of a capital project, up to a maximum of £10m.

It is part of the country's Low Carbon Infrastructure Transition Programme, which encourages companies to develop technology and methods to reduce carbon emissions.

'Scotland's homes are responsible for the emission of 6m tonnes of harmful carbon dioxide into our atmosphere every year – 15% of all emissions,' said Scotland's Energy Minister, Paul Wheelhouse.

'To meet Scotland's ambitious proposed climate-change targets, we estimate that nearly every Scottish home – unless already on a renewable heat supply – will have to change its heating system by 2045, if not before.'

Climate action 'blind spot' is coalition's aim

By 2050, space cooling alone could be using as much electricity as China and India today, claim experts

Greenhouse gas emissions from cooling technologies could grow by 90% by 2050, unless there is a concerted effort to ensure the 'best available technologies' are adopted worldwide, according to the United Nations Environment Programme (UNEP).

Its recent Climate Action Summit in New York heard that a move to these technologies would reduce emissions by 38-60 gigatons of CO_2 equivalent ($GtCO_2e$) by 2030, and by up to 130-260 $GtCO_2e$ by 2050. It would also save up to $2.9tn in energy costs worldwide.

After the meeting, the Cool Coalition – a global network of around 80 organisations from the private sector, government, cities, finance and academia – announced commitments to deliver more sustainable cooling.

'The cooling challenge has been referred to as a "blind spot" in climate action, which must increase at least fivefold to keep the global temperature rise this century to 1.5°C,' said a Cool Coalition statement.

More than one billion people face 'immediate risks from a lack of cooling', according to the UNEP. By 2050, it added, space cooling alone could be using as much electricity as China and India today, and much of the world's projected renewables capacity. 'Getting cooling right offers a three-in-one opportunity to cut global warming, improve the lives of millions, and realise huge financial savings,' said UNEP executive director Inger Andersen.

Cooling industry seeking to bridge gap and reach people

The air conditioning and refrigeration sectors could achieve more sustainable outcomes if their potential was better understood and communicated, according to industry body the European Partnership for Energy and the Environment (EPEE).

It says there is a 'huge gap between science, policy and people that needs to be closed as a matter of urgency' and it has launched the **#CountOnCooling** campaign. This includes a white paper that will be unveiled later this month, at the 31st Meeting of the Parties to the Montreal Protocol in Rome.

'Cooling does not suffer from a lack of innovation or sustainable technologies,' said EPEE director general Andrea Voigt. 'There are many efficient solutions readily available… waiting to be scaled up and deployed. [This is] not a question of innovation, but a question of reaching the people.'

Loan rate hike 'trashes' social housing plans

The government has announced a surprise one percentage point increase on cheap Public Works Loan Board (PWLB) finance, raising fears that plans for more social housing across the UK may have to be shelved.

The PWLB is the main source of long-term finance for local authorities for capital projects such as housebuilding and regeneration schemes. The cost of borrowing was raised by 1%, bringing the rate to 1.8% over gilts, which sit at around 1%.

A spokesperson for the Local Government Association said: 'It presents a real risk that capital schemes, including vital council house building projects, will cease to be affordable and may have to be cancelled as a result.'

Stevenage Borough Council leader Sharon Taylor said the increase meant that plans for a £300m investment in social housing in the borough had been 'trashed'. 'There has been no consultation on this whatsoever and, when we are this close to budget time, a major change like this could absolutely blow our plans out of the water.'

Government rejects offsite advice

The government housing body Homes England has ignored a call for it to insist that any developer being paid from public funds must use modern methods of construction (MMC).

Parliament's Housing Select Committee set out 21 recommendations in a report earlier this year, including a requirement for housebuilders supported by the Help to Buy scheme to use methods like offsite fabrication.

However, Homes England – the public sector 'housing accelerator' – rejected the advice, saying there were 'currently no plans to make the use of MMC a requirement for these funding schemes to ensure we continue to create conditions for the industry to innovate and avoid focusing only on the frontrunners in the sector'.

'We will continue to encourage beneficiaries of the funds to make use of MMC where appropriate,' it said.

It also rejected a recommendation to 'identify types of MMC that work best and can be used at scale'. It said: 'Homes England does not believe that any one type or types of MMC technology will provide the answer to the housing shortage across the country. All types may have a part to play and what is suitable and viable on one site may not be appropriate on another.'

Passivhaus project wins RIBA Stirling Prize

Standard enables average energy savings of 70% on heating bills

The Goldsmith Street Passivhaus-certified low-energy social housing scheme in Norwich has won this year's RIBA Stirling Prize.

The development for Norwich City Council (NCC), designed by Mikhail Riches with Cathy Hawley, comprises around 100 ultra-low energy homes and is the UK's largest social housing project to achieve Passivhaus certification.

The housing scheme – which was described by RIBA judges as a 'modest masterpiece' – is a mix of housing types, with seven terrace blocks arranged in four rows and bookended by three-storey flats.

The Passivhaus approach enables average energy savings of 70% on annual heating bills, which was one of the main reasons why NCC choose to pursue the standard as a way of addressing potential fuel poverty issues.

But as well as reduced fuel bills, the architect also brought a clear social focus to the project. The layout draws inspiration from Victorian terrace housing and a quarter of the site has been reserved for communal space.

Announcing the win in October, the RIBA judges said: 'It is high-quality architecture in its purest, most environmentally and socially conscious form. Behind restrained creamy façades are impeccably detailed, highly sustainable homes – an incredible achievement for a development of this scale. This is proper social housing, over 10 years in the making, delivered by an ambitious and thoughtful council.

'These desirable, spacious, low-energy properties should be the norm for all council housing.'

WORKING TOGETHER ON M&E PASSIVHAUS

Passivhaus design practice Greengauge was appointed to lead the M&E design for the Goldsmith Street project, with specialist design practice Warm appointed for the Passivhaus design.

Greengauge had previously collaborated with Mikhail Riches on a number of other schemes, although this was the most ambitious, comprising around 100 Passivhaus dwellings for social rent. With a range of building types, from one- to four-bedroom houses, it is the UK's largest social rent project that is 100% Passivhaus.

The design of the buildings took priority, and the architects wanted the Passivhaus to work to the design rather than the design being secondary to making the Passivhaus work.

Understanding the amount of information that needed to be delivered and how to manage it was a big challenge, said Hannah Jones, co-founder of Greengauge. 'There were at least 12 different house types, and that posed a different situation as opposed to a typical big housing development where there might be a handful of house types.'

Greengauge designed the complete M&E package for the development, which included the hot and cold-water systems, heating, ventilation and all the electrical systems, such as the power, data, lighting and fire detection.

Warm worked with Greengauge as a sub-contractor on the mechanical side of the project, Jones said. 'For the Passivhaus design, Warm was separately appointed. We have worked closely with them to ensure the mechanical elements are tied in with the Passivhaus requirements and to make sure we don't get any conflicting issues between the two.'

This involved reconciling the inputs of architect Mikhail Riches, which had modelled the Passivhaus scheme in 3D using ArchiCAD, and Warm, which was working in 2D.

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Shimeng An


Yu Fu

Hays President's Prize: CIBSE Undergraduate Award

Yu Fu, from University of Nottingham Ningbo China, was awarded the CIBSE Undergraduate Award 2019. Yu studied for a BEng in architectural environmental engineering and won with his final-year project titled *A machine-learning approach to predict window openings in naturally ventilated buildings*. Judges felt the project was an original idea that attempted to use machine learning across a wide range of locations to optimise natural ventilation window openings. He was presented with a £500 cheque and a certificate.

In acknowledgement of its achievement, a trophy was also awarded to University of Nottingham Ningbo China, accepted by Shimeng An on the university's behalf.

The award, sponsored by Hays Building Services, is designed to encourage students to develop their potential and aim for excellence. It is awarded to final-year students of a CIBSE-accredited building services course and recognises academic achievements.

Happold Brilliant Award

This award recognises excellence in the teaching of building services engineering and, this year, was presented to London South Bank University (LSBU). The judges were impressed by the high quality of graduates produced by the university and felt that project topics covered a wide range of building services areas, including sustainability and renewable systems. They recognised the great links LSBU has with the industry through its advisory panel and staff involvement with knowledge-transfer partnership schemes. Dr Alex Paurine accepted the award on behalf of the university.


Lorraine Milne, of Happold Foundation, with Dr Alex Paurine

Peter Boyce, David Wood and Victor Cheung Chi-Kong receive accolades

Three CIBSE members have been honoured with gold medals, the highest accolade awarded by the Institution.

Peter Boyce, David Wood and Victor Cheung Chi-Kong have all been recognised for their outstanding contribution and service to CIBSE.

James Shove read the citation for Boyce at the President's Dinner in October. He said: 'Boyce has made an outstanding contribution to the world of lighting and the work of the Society of Light and Lighting (SLL). He has been prolific in his production of lighting research papers and lighting guidance. He joined the Illuminating Engineering Society – forerunner of the SLL – in 1966, while working at the Electricity Council Research Centre, and was chair of the CIBSE Lighting Division in 1986-7.

'He first worked on the Code for Lighting in 1977, then contributed to updates over the years; he wrote the majority of the SLL *Handbook* and contributed to the SLL Code. He has been technical editor for *LR&T* since 2008, is an honorary SLL Fellow, and was named Lux Person of the Year in 2017.'

Wood and Cheung Chi-Kong were unable to attend the dinner in London.

Three Bronze Medals were awarded to: David Mather, for his services to the Young Engineers Network; and Andrew Michael Forrest and Steve A Hunt for their services to the Merseyside and North Wales region.


CIBSE President Lynne Jack, Peter Boyce and James Shove

Referees needed for 2020 CIBSE ASHRAE Technical Symposium

After an excellent response to the call for papers for the 2020 Technical Symposium, CIBSE is now seeking volunteer referees to help peer review.

The planning committee has examined all the submitted abstracts and will soon invite full submissions from those presenters who will contribute to what will be an informative and exciting symposium.

Referees are required to help peer review the first drafts of commissioned papers and posters, a process that is expected to start in early December and will require a time commitment of as little as an hour.

Any Members or Fellows willing to review submissions should register their interest at the 'Become a reviewer' link **www.cibse.org/symposium**.

The Technical Symposium 2020 is titled *Engineering Buildings, Systems and Environments for Effective Operation* and will take place on 16-17 April 2020 in Glasgow.

For more information visit **www.cibse.org/symposium**

Aecom's Robert Mitchell and Tracy D'Souza with Lynne Jack (centre)

Aecom crowned Employer of the Year

Consultant named overall winner at Young Engineers Awards

For the second year running, Aecom has been recognised for its progressive strategy for recruiting, nurturing and empowering young people.

Aecom won the Employer of the Year in the large company category – having won it in 2018 – and claimed the overall champion accolade at the Young Engineers Awards in October.

Its commitment to developing junior staff is evident across its 'Advance' programme for graduates and apprentices, work experience placements and Stem ambassadors' engagement with schools. It is second in the *Guardian* UK300 top graduate employers for construction, civil engineering and surveying, as voted by students and graduates.

Aecom has more than 300 Stem ambassadors working with UK schools.

Diversity is core to the development and success of its business. In 2018, 43% of the 359 graduates joining the UK and Ireland graduate programme were female. It has also scored 100 on the Human Rights Campaign Foundation's 2018 Corporate Equality Index and the distinction as one of the 'best places to work for lesbian, gay, bisexual and transgender equality'.

FairHeat won in the small company category. Established four years ago, the heat network consultancy impressed judges with its commitment to ensuring the industry has the skills to meet the UK's low carbon agenda, by developing a graduate scheme. This offers six-month rotations across each of FairHeat's business areas, from design and delivery of heat networks to performance improvement and monitoring.

Troup Bywaters + Anders won the medium company category. It has invested in a formal apprenticeship scheme, which offers a clearly defined progression path, academically and professionally. Now in its seventh year, it has positively impacted the business, with 22% of the workforce now apprentices, graduates or trainees. Recognition of the scheme has also helped it secure new work, attract the best people to the company, and inspire others to develop their roles.

The awards are sponsored by Andrews Water Heaters, Kingspan Industrial Insulation, Swegon and Tamlite, and are supported by CIBSE Patrons.

FairHeat's Gareth Jones and Thomas Naughton, with Lynne Jack

Troup Bywaters + Anders' Kevin Killoran, with Lynne Jack

New CIBSE inclusivity guidance launched

The Inclusivity Panel is excited to launch new guidance for staff and members.

This guidance has been developed to help CIBSE meet its responsibilities to work inclusively and be welcoming to all. It covers a range of issues, from events and accessibility to language and communications, giving actions that are clear and easy to implement.

An inclusive culture brings resilience, creativity and innovation – qualities that deliver better buildings and a stronger building services engineering community.

The guidance is relevant to everyone, whatever their role, and will be reviewed and updated regularly. For more information, go to **www.cibse.org/inclusivity** – and share suggestions and experiences of using these guidelines at **inclusivity@cibse.org**

Apprentices and rising stars to be recognised

CIBSE has announced two new initiatives to recognise the invaluable contribution of graduates and apprentices.

The initiatives will allow the CIBSE community to recognise more of our early career contributors.

Apprentice of the Year will be part of the Young Engineer Awards 2020. CIBSE is working with training providers in colleges and universities to deliver courses for apprenticeships. Investment in apprentices, together with the contribution they make, are critical to the future success of our industry. This initiative recognises the impact that investment has on bringing forward future engineering talent and industry innovators.

The second initiative is the 'CIBSE Rising Stars, 20 under 35'. This will raise the profile and contribution made by building services professionals aged under 35 to building performance and the drive to net zero. Their passion and commitment to the industry during the early stages of their career warrants recognition.

Introducing the new awards at the Young Engineers Awards in October, CIBSE acknowledged the crucial role graduates and apprentices play for employers, emphasising how vital this pool of new talent and future leaders is to the industry and to meeting the challenges faced by the climate crisis.

More information on both new awards initiatives will be available next year.

Be more mindful

We all need to become better listeners, writes CIBSE Patrons' chair **David Fitzpatrick**

A new mental health campaign led by Public Health England and the NHS should help to address an extremely worrying escalation in cases of stress and anxiety – particularly among young people.

'Every Mind Matters' is enjoying powerful support from royalty and celebrities, and by highlighting high-profile sufferers from the worlds of sport, drama and TV, it should help to dispel any stigma.

In our sector, Mates in Mind has achieved great things by showing the particular issues linked to the high-stress construction environment. Young engineers, in particular, have stepped up to this challenge and many have become mental health 'first aiders', trained to reach out to colleagues in trouble.

Stress is an everyday fact of life in professions linked to construction because of the high-octane conditions around projects. The lack of collaboration that regularly leads to them being only partially designed before work begins is not conducive to a smooth and healthy work process. As a result, engineers – often young and inexperienced – are forced to design and redesign on the hoof with project managers and site trades breathing down their necks. We also make it almost impossible for people to switch off, as they are constantly bombarded by emails and social media messages.

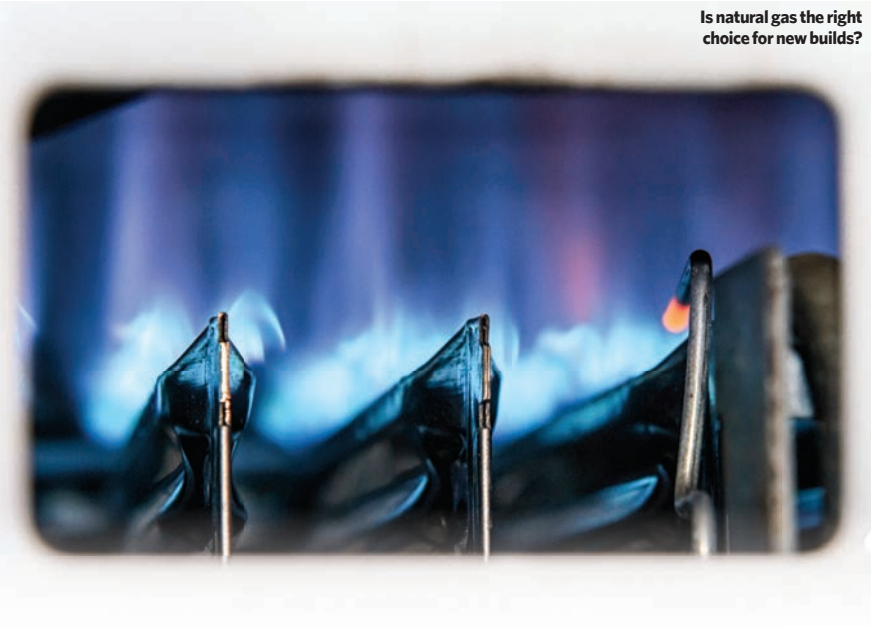
The financial responsibilities piled on young shoulders is another huge issue. The worry of managing a multi-million pound contract or design package is bound to take its toll on anyone – young or old. Late payment also puts unbearable pressure on small business owners in particular, and leads to unpaid wages, insolvency and worse.

If you are feeling stressed, your body will react. Mental symptoms will quickly become physical ones, and the natural human 'fight or flight' response can lead to tragic outcomes.

Ultimately, we all need to talk. The best mental health first aiders are not just good listeners, but are also able to spot the signs and encourage friends and colleagues to open up to them.

CIBSE Patrons is a group of companies, as well as a network of like-minded individuals, who are able to share experiences and problems. At the upcoming Build2Perform event (26-27 November at Olympia, London) we will be celebrating our 40th anniversary, and marking our new status as a CIBSE society. We will also have a 'Patrons Zone', giving delegates the opportunity to learn about our work – and, yes, talk.

- For details on the Patrons Zone, email CIBSE Services managing director Rowan Crowley at **RCrowley@cibse.org**



Is natural gas the right choice for new builds?

Ahead of Build2Perform, CIBSE LinkedIn Group discusses alternatives to natural gas

Are you still designing natural gas heating systems in new builds? The decarbonisation of heat is a critical and urgent challenge for the UK. Existing building stock requires complicated retrofit, but new builds are a comparatively simple problem. Surely there is a tremendous opportunity to get it right first time. Anything built without low carbon heat today is creating retrofit problems for the future. With declarations of climate emergencies, why are we still designing natural gas heating systems in new builds? An obvious answer might be cost, but is that the only answer? What is the case for gas in new builds, and how can built environment professionals accelerate the uptake of low carbon heating?
Andy Ford

Good job there are some great heat pumps out there! Heating, cooling and domestic hot water from ambient loops throughout mixed-use single building and developments offer workable energy sharing/ heat recovery.
William Littlewood

We, with the Department for Education, have created a template for a modular primary school... no gas!
Jeff Anderson

The interseasonal energy-transfer system seems very hopeful; I'm trying to specify it on an office block I'm designing, but there are commercial issues – the extra cost of building the thermal store. However, with annual coefficient of performance (COP) in the order of 8:1, it's all good news.
Gareth Young

I agree, we should not be designing in natural gas systems of any kind now – combined heat and power (CHP) included. By the same token, we need to be cognisant of the global warming effects of refrigerant leakage of heat pump systems. The sooner we get safe low global warming potential (GWP) refrigerants into commercial use the better. Meanwhile, engineers should be getting familiar with the safe design, use and maintenance of natural refrigerants.
Edward Murphy

Ammonia is, to me, the best choice. Ammonia has been around for years; if it leaks, it decays into nitrogen very quickly. With regard to safety, in small quantities, humans react by getting away from the pungent smell. In large quantities, yes, it's toxic – but so is natural gas, and we're relaxed about having that piped into our homes.
Gareth Young

Indeed. Great refrigerant. As you are probably aware, some downsides make it expensive short term, but that is because it's never had the research and development investment it deserves.
Edward Murphy

Heat pumps seem, to me, to be the way forward. I'm currently designing the heating and cooling system for an office block in London without any gas supply.
Gareth Young

Great question – does this include remote gas combustion via heat networks? This is often a planning policy obligation and networks seldom have decarbonisation strategies, as expensive technology such as CHP has been locked into the financial model and requires pay back before any new low carbon technology can be considered.
Greg Jones

To the first question, I would say yes. In many ways, heat networks and existing district heating are the obvious targets to improve the existing stock, but we want to understand what drives new build, and your comment on financial models feels significant.
Andy Ford

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Making the case for direct gas-fired water heaters

High storage risks

The efficiency and performance problems associated with storing high volumes of hot water – flagged up in the article 'Hotel study reveals predicted hot water use is double the reality' (*CIBSE Journal*, April 2019) – could be solved by making better use of direct gas-fired water heaters (DGFWHs).

The problems highlighted in the article appear to be related to indirect hot-water systems with high storage capacity, and it refers to the difficulty some engineers have in sizing the storage requirement accurately. It

stated that 'bulk storage tanks, if oversized, present a risk of poor turnover of water and stagnation, leading to reduced water quality and the risk of increased storage temperatures. With domestic hot water, large storage volumes lead to increased storage losses'.

DGFWHs are well established and designed around low storage and fast recovery of hot water. The largest models can deliver up to 10,000 litres of hot water per hour, so they are capable of meeting the heavy peak demand associated with hotels and other commercial buildings. Unlike the systems described in the article, however, DGFWHs do not require large volumes of stored hot water. An installation, which provides 10,000 litres per hour, could typically be installed with as little as 600 litres of hot-water storage. As a result, DGFWHs are capable of meeting the high hot-water demands of busy buildings, such as the hotels analysed by Elementa Consulting, and they are likely to do so in a more energy efficient way.

There are various types of DGFWH available, most of which employ condensing technology and operate at high efficiency. Based on our experience, commercial buildings, such as hotels, would install multiple water heaters to meet demand and provide standby in the event of component failure. In 2013, Lochinvar supplied four EcoShield, high-efficiency water heaters to a five-star hotel in Marble Arch. In total, the water heaters stored 1,696 litres, but hot-water recovery per hour was 9,744 litres. This setup has comfortably met the hot-water demands of a high-quality 153-bedroom hotel.

The indirect water heaters, or calorifiers referred to, need a heat source and, traditionally, this would be provided by a boiler. The article also referred to CHP, but it is likely that CHP installations would have boiler backup. Modern gas-fired boilers will operate at high mid-90s efficiencies, with a system design based on flow/return temperatures of 50°C/30°C. However, for hot water at 60°C, the system flow/return temperatures would typically be 80°C/60°C and, at these temperatures, the boiler efficiency can reduce substantially – unlike DGFWHs, which retain their level of performance.

DGFWHs can also be integrated with renewables or low carbon technologies, such as heat pumps, solar thermal and CHP, which are often used to provide pre-heated water. None of these technologies has, so far, found a way of providing high volumes of hot water in short peak periods on their own. So, even when a renewable or low carbon method of providing hot water is specified, there is a strong case for combining it with high-efficiency gas-fired water heaters in a wide range of commercial/industrial applications.

David Pepper,
Business development manager, Lochinvar

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or write to: Alex Smith, editor, *CIBSE Journal*, CPL, 1 Cambridge Technopark, Newmarket Road, Cambridge CB5 8PB, UK.
We reserve the right to edit all letters.

Rewriting the rules

Government is consulting on a number of building-related issues addressing safety and climate change, while the Queen's Speech hints at future legislation supporting Dame Judith Hackitt's recommendations, says Hywel Davies

Government is currently in consultation overdrive. Driven primarily by climate-change policy, the package of proposals for the Future Homes Standard, Part L and Part F is summarised on page 24. But there are also proposals on building safety, driven by the recommendations of Dame Judith Hackitt's *Independent Review of Building Regulations and Fire Safety*.

Proposals to change the rules for sprinklers in taller residential buildings are still open for comment. The government's 'preferred option', at least when published, is to reduce the trigger height at which sprinklers are required from 30m to 18m. There is an option for 11m, and opportunity to propose other trigger heights – but why is the proposal 18m and not 16m, or 20m? And why 11m? It is unclear where these numbers have come from, or what the evidence is to support those choices. Interested readers are encouraged to look at the consultation page of the CIBSE website.

Beyond that, the Queen's Speech contained half a sentence about 'laws to implement new building safety standards'. While the exact meaning of this is unclear, it suggests we are likely to see new primary legislation to implement a number of aspects of the Hackitt review, such as the proposed new building safety regulator. That cannot be established without primary legislation.

"We are certainly on the verge of significant change in the legal framework"

The Building Act dates from 1984 and those familiar with it know it is due an overhaul; this could be the perfect opportunity. Certainly, the proposed Gateways under Dame Judith's proposals will be hard to reconcile with the current rules for building notices, so perhaps they will change. While we can only speculate on details, we are certainly on the verge of significant change in the legal framework within which most readers operate. We can expect further consultations in the months ahead.

It looks likely that the initial response will cover 'higher risk' buildings – taller buildings where people sleep, subject to legal definitions yet to be drafted. Initially, this will be a subset of the existing building stock, but all indications suggest that this will, in time, be extended to a wider range of buildings. So, we may be set for a period in which there are two regimes – one for the higher-risk buildings and a less onerous regime for the rest. However, we should not be surprised to find blue-chip commercial clients looking at the new regime and the greater checks on building outcomes, and expect their supply chain to adopt it for them. If a major contractor can follow the new regime for a high-rise residential block on the fringe of the City of London, why can they not deliver that on a prime office tower a short distance away?

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

Arup's Derek Lawrence has been looking into creating digital twins in existing buildings in line with Dame Judith's recommendations. See page 40 for details

Given the commitment to implement all of Dame Judith's recommendations, we can expect further evolution of the Approved Documents. The Future Homes package proposes moving from four Approved Documents and two compliance guides to Part L to two volumes of approved guidance – for dwellings and for buildings other than dwellings. The consultation drafts are also shorter, so some current content has gone. Dame Judith's view was that if industry needed more guidance, industry should produce it, a challenge for CIBSE and the various industry bodies to address.

Between the drive to deliver significant real cuts in carbon emissions from buildings to meet the challenge of climate change and the ongoing reforms post-Grenfell, we have plenty to keep us busy. But there is a third front on which we need to engage.

The world continues to adopt digital technologies and processes. The British, European and international standards for building information modelling build on earlier UK developments to provide an international framework, and further standards to support the digital transformation of the construction sector are being drafted.

The sector needs to embrace these changes alongside the climate and safety-driven ones. All require adaptation, which is never easy and often provokes adverse reactions. One of the keys to managing this change is the provision of knowledge and information, and that is an essential role for CIBSE.

The demands to deliver knowledge as we move to a net zero, digital, post-Hackitt world are considerable, and need contributions from those within the sector, including many who read this *Journal*. Are we all ready for the journey that lies ahead?

One step closer?

Government proposals for improving energy efficiency in buildings show signs of ambition, but regulations need modifications, says **Julie Godefroy**

Government has recently published several consultations on the energy and carbon performance of buildings (see news and page 22):

- For new homes, proposals for Building Regulations, Approved Document L and SAP. By late 2019/early 2020, we also expect proposals covering non-domestic buildings, existing homes, and a new overheating standard
- Proposals for improving the energy efficiency of businesses, possibly requiring Energy Performance Certificate ratings of C by 2030.

Additionally, government is expected to consult in 2020 on mandating operational ratings for commercial buildings.

"We have concerns about the proposal to prevent local authorities from adopting higher standards"

New homes

Government has committed to introduce by 2025 a Future Homes Standard, for new-build homes to be future-proofed with low carbon heating and 'world leading' levels of energy efficiency; no new homes built with gas (or other fossil fuel) heating. Government proposes this would represent a 75-80% improvement on Part L 2013 carbon emissions levels. The stated aim of Part L 2020 is to be a 'meaningful and achievable stepping stone' towards this.

Proposals include:

- **Two options for the overall uplift to carbon performance in 2020:** a 20% improvement, based on very high fabric performance or – the government's preferred option – a 31% improvement based on more minor fabric improvements and the installation of low carbon heating or renewable systems
- **Upgrading minimum energy efficiency standards** for fabric and services
- The introduction of a **primary energy target**, in line with the Energy Performance of Buildings Directive, which would work alongside the carbon target. The fabric energy efficiency target would be removed
- **Tightening as-built and information requirements**, including testing every home for airtightness, and more accurate as-built energy calculations
- **Future-proofing homes to low carbon heating**, with space heating temperatures limited to 55°C
- A new **heating affordability** criterion: government is seeking suggestions
- Aligning **carbon factors** with reality and **removing fuel factors**, which distort the assessment.

While we welcome the stated aims, the following points need to be reviewed:

- AD-L 2020 should deliver a 31% improvement **and** include the best possible fabric to future-proof homes, reduce demand, and limit the costs of low-carbon heating
- Regulations need to shift towards **total operational energy performance**, rather than as-built regulated emissions only – see our briefing at **bit.ly/CJNov19Zero**
- Government proposes to consult on the Future Homes Standard implementation in 2024. This is much too late. It should be available earlier, to allow market leaders to adopt it and **develop expertise and supply chains**. Similarly, while we acknowledge the desire to streamline standards, we have serious concerns about the proposal to prevent local authorities from adopting standards higher than Building Regulations. In places such as London, local authorities should be allowed to lead the way and adopt the Future Homes Standard, subject to viability testing. This would significantly help the rest of the market when the standard is mandated from 2025.

DR JULIE GODEFROY is technical manager at CIBSE

Consultation	Closing date for contributions to the CIBSE response
Amendments to the planning system for electricity storage	29 November 2019
Proposals for the minimum energy efficiency standard for non-domestic private rented sector	6 December 2019
The Future Homes Standard: Changes to Part L and Part F of the Building Regulations for new dwellings	10 December 2019
Changes to the Standard Assessment Procedure (SAP)	10 December 2019
Changes to the approved methodology for testing buildings for air leakage	10 January 2020
Draft revision of CIBSE TM23 *Testing buildings for air leakage*	10 January 2020

Upcoming consultation deadlines

Please send contributions to **technical@cibse.org** Views on these areas would be particularly useful:

- Proposed upgrades to fabric and services efficiency
- SAP methodology and characteristics of the notional building
- Is the proposal for 55°C heating systems sufficient to future-proof for low carbon heat? Should other measures be considered – for example, storage space?
- The notional building, set at the same shape as the proposed building, does not encourage consideration of building form to reduce demand. The fabric energy efficiency rating at least went some way towards this – how effective are the new proposals replacing this?

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Together we can be part of the climate solution

BRIGHT IDEAS

Seven engineers vying to become Graduate of the Year 2019 took to the stage at the IMechE in October, with Laura Luckhurst winning the top prize. **Liza Young** reports

The CIBSE ASHRAE Graduate of the Year Awards – now in its 24th year – challenges young engineers to 'sparkle' in front of an audience by showing off their communication skills.

Of the 54 entries, eight were shortlisted this year, and seven young professionals presented to a capacity crowd at the Institution of Mechanical Engineers on 10 October.

This year's question was: how can building services professionals find the right balance between the needs of the global environment, occupant health, wellbeing and productivity, and best value?

Laura Luckhurst, graduate mechanical engineer at Cundall, won the top prize – a trip to the ASHRAE Winter Conference in Orlando – after impressing the judges with her articulate and confident five-minute presentation.

Second-placed finalist Felix Cox, mechanical engineer at Aecom, and third-placed finalist Tom Lusty, building services engineer at Couch Perry Wilkes, were awarded £600 and £300 respectively from The Rumford Club, while all other finalists received £100 each from The Manly Trust.

Research and experience

In her presentation, Luckhurst said the key to finding the balance between the environment, people and cost was to use existing research and guidance and apply it 'to every single project we work on'. She said: 'It's not about wellbeing and energy competing, but about finding that balance.'

The Well Building Standard is already aligned to certain energy certifications, she continued, and it has highlighted the areas on which engineers need to focus and make judgement calls to achieve optimal design.

To be able to make those judgement calls, engineers need onsite experience, she said. 'We need to be able to understand how buildings are constructed, operated and maintained; it's something we need to push for and encourage our employers to provide.'

Luckhurst, who graduated from Sheffield University in 2018, said spending time with facilities managers on every project was paramount.

'It's about understanding the quirks of the building and looking to design out difficulties in maintenance so we can make facilities managers' lives easier, which also makes the job quicker and cheaper.'

However, she said cost was one of the biggest barriers to designing for optimum balance between wellbeing and the environment.

Back row, from left: Laura Luckhurst; Felix Cox; Ryan Hughes; and Ryan Tough. Front row, from left: Reanna Taylor; CIBSE President Lynne Jack; Sophie Hanson; IMechE president Joe McGeough; Chloe Coradetti; Tom Lusty; and ASHRAE president Darryl Boyce

PANEL DEBATE

A panel debate, organised by the Young Engineers Network, discussed the same topic as the graduates' presentations.

Alexandra Logan, senior mechanical engineer at ChapmanBDSP, said there was 'a fine line between getting it right' when finding a balance between wellbeing, cost and environmental impact.

To do this, user engagement is key, said Rebecca Carr, senior mechanical engineer at Hoare Lea, because 'if the design doesn't serve the building's purpose, it is not valuable'. ASHRAE President Darryl Boyce added: 'You also have to ensure you understand who is going to be operating the building, and their capacity, because great design needs great operation.'

Past graduate winner Reanna Taylor, of NG Bailey, said a project was not just about saving money upfront, but 'about benefiting the bottom line throughout a building's lifetime'. To achieve this, she said educating building users, owners and developers was paramount.

On the issue of thermal comfort, Taylor said: 'It's about training people to be adaptable to change. What's wrong with putting on a cardigan when it's cold? That's ok as long as you're not sitting in a ski coat and hat.'

Carr said data – and assessing what affects people – was key. She said a lot of temperature setpoints are based on outdated standards and that, now, different climates can be achieved in a single space so people can be catered for in different areas of one open-plan office. Surveying people who will move into the space would help, added Logan.


Luckhurst gave a confident speech


The Young Engineers Network panel debated the awards topic

Clients do not always want to pay more for something they can get cheaper, so it was up to engineers to show them the value in designing for wellbeing.

Luckhurst said that, at Cundall, 'we push Well in all our designs and show that this investment is worth making' using the wealth of data and research the firm holds.

After designing and optimising the areas they can directly influence, Luckhurst said engineers should go further and 'make recommendations to the clients to see how we can affect wellbeing in the building as a whole, not just the areas we work on'.

She added that, by getting occupants invested in their spaces, 'we can put pressure on clients from both sides'.

'Using these methods, using the research we already know, knowing our numbers, pushing wellbeing through facts and data gathering, and getting the experience we need, we can create healthy, low energy spaces,' she said.

> "We need to be able to understand how buildings are constructed, operated and maintained; it's something we need to push for and encourage our employers to provide"

All that jazz

Runner-up Felix Cox, who graduated from Queen Mary University in 2018, called the three conflicting agendas – health, wellbeing and productivity; best value; and the global environment – a trilemma.

There is a growing move towards higher standards of wellbeing in a working environment – everything from more social and collaborative spaces to better internal air quality and dynamic lighting, said Cox. And research suggests a little more investment into wellbeing can have a big financial benefit in terms of productivity.

'Traditionally, we might associate best value with driving down the cost of a building, but people are starting to look at value in different ways – they can see the value of things like putting a bit more fresh air into office spaces to increase productivity,' he said.

But what's the point of having excellent indoor air quality if you're suffocating in the London smog on your commute to work every day, he asked. 'We can see how these three areas are inherently linked.'

While considering how to approach the problem, Cox – who previously worked as a jazz clarinet/saxophone session musician – said he even considered 'writing a five-minute piece of music in a moment of desperation' but, in the end, decided to focus on technology.

Cox said exciting new technologies can be used to bring the three corners of the trilemma together to find better alignment. 'We can use smart buildings to monitor building performance and wellbeing, bringing those corners closer together, and virtual and augmented reality to change the way we communicate,' he said.

The construction, operation and maintenance of the built environment accounts for 45% of UK carbon emissions, said Cox, and that means 'we're in a really privileged position, as building services professionals, to »

Winner Laura Luckhurst

Second-placed finalist Felix Cox

Third-placed finalist Tom Lusty

» have a big and positive impact on climate change'. 'That's one of the reasons I am really proud to be an engineer.'

Every single person at the awards has a role to play to have a positive impact on climate change over the course of their whole career in building services, he added.

Technology drive

Third-placed finalist Tom Lusty, who graduated from Coventry University in 2018, said the 'pivot point' on which the three agendas sit, was constantly moving.

'Since I came to this industry in 2013, I've seen the pivot change, the environment change and technology has developed rapidly. Whether we like it or not, the future is going to be technological, and we've got to harness that to strike a balance into the future.'

Lusty said the Internet of Things (IoT) – a new language that can connect almost everything through the internet – lighting controls and Power over Ethernet (PoE) could not only help occupant health and wellbeing, but also drive down energy use and maximise the needs of the global environment.

He said PoE had changed the convention and lighting was becoming a separate entity in building services engineering. 'You can have a data network and everything is interconnected, and that means every light fitting could be a monitoring point or smart sensor,' said Lusty. 'Through this, we can monitor occupants and give feedback to stakeholders.'

Lusty said smart grids, networking and battery storage were helping to manage peak demand 'when the sun isn't shining and the wind isn't blowing', adding that 'technologies like electric vehicles and grid charging could inform the future'.

Lusty said combined heat and power at the right time – in 2013 – was the right energy solution but, as we start to decarbonise, 'we have to start looking at the electrification of heat and the idea that we are going to move away from gas, and electric-source heat pumps are going to become the future'.

He said this, together with vehicle charging, means there will be a higher demand for electricity. 'If renewables are going to plug that gap, we need to come up with a "right time, right place" solution. This is where smart integrated technologies – like IoT – can help us balance the supply and demand problem,' he said. CJ

Read about the Employer of the Year winners on page 17.

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HOW DOES INDUSTRY DELIVER NET ZERO BY 2050?

Ahead of CIBSE's Build2Perform event at Olympia, London, on 26-27 November, we asked expert speakers what should be done to achieve the government's net-zero energy target

Alasdair Donn

Meeting compliance targets 'on paper' is not good enough, says Alasdair Donn, head of building performance at Willmott Dixon

Meeting compliance targets 'on paper' is not good enough.

Delivering the UK's net-zero target in 2050 means, as a design and construction industry, that from this point on we can only provide buildings that actually deliver on performance expectations.

Meeting challenging energy and carbon compliance targets 'on paper' may satisfy our customer and project energy requirements but, unless that translates to actual results, our UK net-zero emissions target is 'toast'.

On new-build projects, we have to show what is possible and what is achievable – if we can push down designed energy use, combine it with renewable generation, and ensure no performance gap in use, we stand a chance of getting to that net-zero target.

Let's embrace new ways of doing things such as Passivhaus, the Better Building Partnership's Design for Performance, the UK Green Building Council's net zero approach, BSRIA's Soft Landings Framework, and Wilmott Dixon's own Energy Synergy processes, to help get us there.

Justin Bere

Government backing is needed to do the right thing today for long-term good, says Justin Bere, director at bere:architects

The year 2050 is too late. We have to do this now in new buildings and in a gigantic roll-out of retrofit. We need all buildings to be 100% electric, with an 80-90% reduction in energy demand so all the energy can come from renewable sources.

Passivhaus is firmly established as the best way to deliver net-zero and plus-energy buildings, and there is a small – but growing – group of Passivhaus experts in the UK that would be willing to run the necessary training to sort out our dire shortage of design and construction skills.

The obstacle is seen to be the price of net-zero buildings because most people and businesses can't afford the upfront cost of major improvements or they want quick returns on their investment.

The solution is very simple: government-backed long-term loans so people and businesses do the right thing today for the long-term good. If retrofit or new work is done to a very high standard, I think people should be financially assisted where needed, to pay only for their period of occupation. This means a pension fund/government-backed charge being put on the building, with negligible monthly repayments that are far less than the energy savings, and paid back by whoever benefits from the improvements over a long payback period of 100-200 years.

Fast-forward 100 years and imagine people discussing the prevailing attitude today: 'In 2020, they thought they couldn't afford to stop wrecking the climate. Instead of fixing the problem, all they could think of was themselves, spending billions of pounds on new power stations which are now – in 2120 – already redundant, apart from a massive legacy of toxic waste they left for us to try to sort out, and billions of pounds spent, particularly by the richest people, on new cars, luxury goods, luxury overseas holidays and heating their homes.

'Just imagine if those selfish people – in 2020 – had instead spent the same money on net-zero and plus-energy buildings that we could still be benefitting from now, all running off a renewable energy infrastructure. We'd have been happy to share the cost.' »

Dave Pearson

District heating and cooling networks are a route to net zero, says Dave Pearson, director at Star Renewable Energy

Delivering net zero by 2050 will come down to many sectors.

There is plenty going on in electricity generation and transport, which is great to see. Heat is now widely acknowledged as 'a key sector' but, actually, very little progress is made. One could ponder why this is, but what about just getting it done?

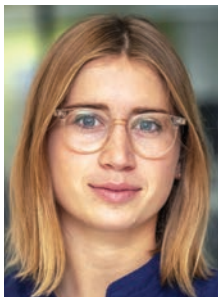
There are five sectors in heat, where actions can be taken. And we should try to involve cooling in these too – they are after all, opposite sides of the same coin.

From the easiest to the hardest, they are:

- **New build low density:** Ban gas boilers and don't allow direct electric – this would alleviate potential stress on the grid.
- **New build high density:** Join district heating, if it exists. If it doesn't, pledge to do so, make the building district heating and cooling-ready (systems, temperatures and connections). In high-density areas – for example, central London – don't try and make the development a 'net-zero island' as it makes adjacent retrofitting of energy networks harder with future 'gap sites'.
- **Older low density residential:** Force utility companies to offer 'pay as you go' heat contracts, then deploy heat pumps with local storage. This is the fastest way to grow our industry while acknowledging the reality that individual home owners won't stump up large amounts of cash, even when it offers a return on investment. There should also be some sort of bonus for selling a house that has been retrofitted.
- **Older high density cities:** Force all buildings to reduce emissions by 15% per annum (the real target ought to be net zero by 2030). If they can't, let them agree to join district heating when it arrives. When there are enough pledges to join in an area of a city, the investment will flow. Note that investment must be in the right sort of district energy: durable, fairly priced and clean. An obvious solution copies the Norwegian city of Drammen, which has river- or sea-sourced heat pumps. If the building doesn't maintain 15% per annum progress, serve a prohibition notice on use of equipment and remind owners the easiest solution is to pledge to join a district scheme. We call this a 'fairopoly', as everyone has to be fairly treated.
- **Industrial:** Many processes use steam when they could use hot water. Many processes simultaneously cool and heat. Join them up. If businesses won't make the investment, force them to agree to an energy supply agreement and let the commercial suppliers carry the technical investment. Underwrite the consumer default with some form of credit risk sharing. For those processes below 150°C, but above 85°C, heat pumps are emerging to do this.

For applications above 150°C, we should plan for the sensible use of high-temperature fuels such as hydrogen, biogas, biomass, and energy from waste.

It all begins with moving forward from gas and playing to stakeholders' strengths and weaknesses.



Louise Hamot

We must tackle whole-life carbon emissions, says Louise Hamot, sustainability consultant at Elementa Consulting

To meet our climate targets, industry needs to tackle a range of subjects such as energy storage; demand response; performance gap mitigation; calculation methodologies; occupants' education; low-energy systems; and passive design measures. However, a deep dive into each subject won't be enough if we don't tackle whole-life carbon emissions.

The industry has long focused on operational carbon – meaning 'in-use energy emissions' – but has ignored emissions related to the rest of the life-cycle stages of buildings.

Manufacturing and transportation, constructing, repairing and maintaining the building, and deconstructing and processing waste are all steps that create CO_2 and other greenhouse gas emissions, referred to as embodied carbon.

Another important factor is refrigerant leakage, which has a high global warming potential and is often not considered.

Engineers, architects, contractors and clients need to understand the key levers to mitigate whole-life carbon emissions and get the full picture of their environmental impact through robust life-cycle assessment as soon as possible.

In order to achieve net zero for all buildings by 2050 all new buildings need to be net zero in operation by 2030. Leti and the UKGBC are running a consultation on the technical requirements for 'operational' net zero for new buildings. They believe that the requirements must include an absolute energy meter target of 35 $kwh \cdot m^{-2}$ per year for residential, verification in-use, fossil fuel free on-site. Any energy consumption not met by onsite renewables should be met by investment in additional renewable capacity off-site.

See **www.leti.london** for further details.

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TAP INNS AND TOUCHDOWNS

The razzamatazz of the American NFL visited north London last month, when Oakland Raiders beat the Chicago Bears 24-21 in a thriller at Tottenham Hotspur's new stadium. **Andy Pearson** looks at the remarkable engineering behind the 3,000-tonne retractable grass pitch that enables the stadium to be used for a multitude of events

Tottenham Hotspur FC's new 62,062-seater stadium in north London is unlike any other in the world. It features a natural turf pitch that can be retracted to reveal an artificial playing surface to enable American football (NFL) games to be played, and concerts and other events to be hosted at the venue.

The first Premier League football match at the stadium took place on 3 April 2019, when Tottenham beat Crystal Palace 2-0. The first NFL game to showcase the stadium's unique ability to host the USA's most popular sport was played last month, when the Chicago Bears lost to the Oakland Raiders.

The stadium bowl's most distinctive feature is its 17,500-capacity South Stand – the largest single-tier stand in the UK – which the stadium's architect, Populous, says will enable the home fans to create a 'wall of sound'. It is supported on two giant, tree-like columns, beneath which is a food and drinks hall containing what is claimed to be Europe's longest bar, at 65m. This is enclosed by the stadium's

62,062

number of seats at Tottenham Hotspur FC's stadium

The South Stand accommodates the 'pitch pocket' – a basement recess into which the grass pitch can be retracted by 68 electric motors in 25 minutes

glazed façade to create a place for fans to congregate before and after matches. The stand is also home to a micro-brewery, operated by Beavertown Brewery (there are 'Tap Inn' bars all over the site). The brewery, along with a cafe, is one of many features designed to draw people to the building on non-match days.

In contrast to the single-tier South Stand, the North, East and West stands incorporate a higher and lower tier of seating, plus a huge variety of private and corporate suites and bars spread over nine levels (see panel, 'Two-tier stands').

'Mechanically, it's a fairly simple scheme,' says Mark Owen, associate director at BuroHappold Engineering, the project's building services engineers. 'The bulk of the mechanical air handling plant, along with eight chillers and 10 boilers, are located in the main mechanical plant spaces on levels six and seven; services drop down risers located in the six main access cores, to feed the various levels.' The access cores are spaced around the stadium; there are two serving each of the East, North and West stands. As well as the mechanical risers, the cores contain electrical risers, lifts and the main access stairs.

The hospitality spaces are kept comfortable using an all-air system, with heated and cooled air supplied from the air handing units located in the level six plant space. Fan coil units (FCUs) provide localised peak-lopping – for example, above bar areas where crowds are expected to gather. FCUs also provide heating and cooling to the individual hospitality boxes, enabling the boxes to be used at times other than on match days.

The sheer number of hospitality floors and spaces means 57 kitchens and catering facilities, spread over the stadium's nine floors are required. To ensure domestic hot water is available to all of these, hot water calorifiers are 'dotted all over the place', says Owen. »

The Chicago Bears and Oakland Raiders were the first NFL teams to play at Tottenham Hotspur's new stadium

The food and drinks hall claims to have Europe's longest bar, at 65m


The stadium can accommodate more than 62,000 spectators

» To cope with the huge variations in domestic hot water demand leading up to, and during, a match, the calorifiers are heated by low temperature hot water (LTHW) with electric backup. Owen quotes a domestic water demand figure of 4L·s^{-1} at three hours before kick-off, rising to 11L·s^{-1} 20 minutes before kick-off. This pales into insignificance, however, when compared with the 55L·s^{-1} to satisfy the half-time rush.

In contrast to the hospitality floors, main concourses on level one and level five are classed as outside spaces, because they incorporate openings to the spectator seating pitch side and feature perforated sections of the façade on the exterior. As a result, piped services in these areas incorporate trace heating.

The area beneath the South Stand is also classed as an external space, although Owen says the large area of glazing means 'it will remain comfortable, even in winter'.

THE STADIUM STANDS, LEVEL BY LEVEL

Starting at the basement, the levels in the North, East and West stands are:

- **Basement: car park**
- **Level 0: pitch level, where the changing rooms and match-day facilities are located**
- **Level 1: main concourse, where the public enters, It is also where many of the bars and food outlets are located**
- **Levels 2, 3 and 4: hospitality floors**
- **Level 5: high-level concourse**
- **Levels 6 and 7: mechanical plant spaces**
- **Levels 8 and 9: additional hospitality, including the level nine Sky Lounges on top of the East and West stands, joined by a glass bridge incorporated into the roof structure to give spectators panoramic views of the pitch.**

Pitch perfect

The South Stand accommodates the 'pitch pocket' – a basement recess into which the grass pitch can be retracted in three sections, each weighing more than 3,000 tonnes, by 68 electric motors in 25 minutes. Being able to roll the pitch into a purpose-designed repository is fundamental to maximising the building's functionality. As well as allowing American football to be played there, it enables the stadium bowl to be easily converted into a venue for concerts and other events.

Environmental conditions are critical to ensure the grass on the pitch is maintained in perfect health while it is stored. Lighting that mimics sunlight and irrigation systems keep it green and watered. 'The grass has to be kept healthy, but they don't want it to grow too much, because it cannot be cut when stored in the pocket,' says Owen. The key is to keep the temperature in the pitch pocket cool while blowing air to agitate the grass. 'In agitation mode, we ramp up the fan speed to blast air out of nozzles so that it ruffles the grass,' adds Owen.

The pitch pocket has two bespoke environmental systems: one humidifies and dehumidifies the space; the other provides heat and cooling. Owen says the cooling load is 'massive', and when the pitch is in storage, energy is diverted from stadium systems to serve the pitch-pocket environmental plant.

'It's a trade-off,' he explains. 'Pre-event, while the stadium is still in

The stadium incorporates a huge amount of IT, from security to pitch lighting


The South Stand's glazing will keep it comfortable, even in winter

setback mode, chilled water and heating are supplied to the pitch-pocket plant; then, hours before the event is due to start, the stadium switches to normal operating mode and the pitch-pocket systems switch to setback mode. There is enough inertia in the pitch pocket for the pitch to sit for a day without any treatment.'

The show will go on

The electrical system has been designed to allow the stadium to continue to host a football game even if the incoming supply fails during a match. Inside the stadium, an 11kV, medium-voltage, three-core supply cable rings the basement to feed four 2.5MVA transformers. Each transformer feeds a main low-voltage (LV) electrical panel, which in turn feeds sub-distribution panels on the upper floors. Unlike the mechanical services, which drop down risers from the Level 6 plantroom, the electrical services are generally distributed at basement level and feed up the risers.

Each of the four main electrical panels is divided into four sections based on the criticality of the loads; these are life-safety, essential, match continuation and non-essential. Two generators, each rated at 2.5MVA, provide a total of 5MVA of back-up power. The generators have 24 hours of fuel storage and each has an additional three-hour day tank in case there is a problem with the main fuel-storage tank.

To add further resilience to the scheme, output from one generator's electrical panel feeds two main LV panels, while output from the second generator's panel feeds the other two main LV panels. An interconnector links the two generator panels so that any main LV panel can be supplied from either generator. The scheme has been designed to cope with various power-loss situations (see panel, 'Emergency power doomsday strategy').

'If a transformer explodes, we'd be able to run its LV panel from either of the two generators,' explains Ryan Carr, electrical engineer at BuroHappold. 'If we lost all power, we could run the life-safety, essential and match continuation sections of the »

> "Environmental conditions are critical to ensure the grass on the pitch is maintained in perfect health while it is stored"

EMERGENCY POWER DOOMSDAY STRATEGY

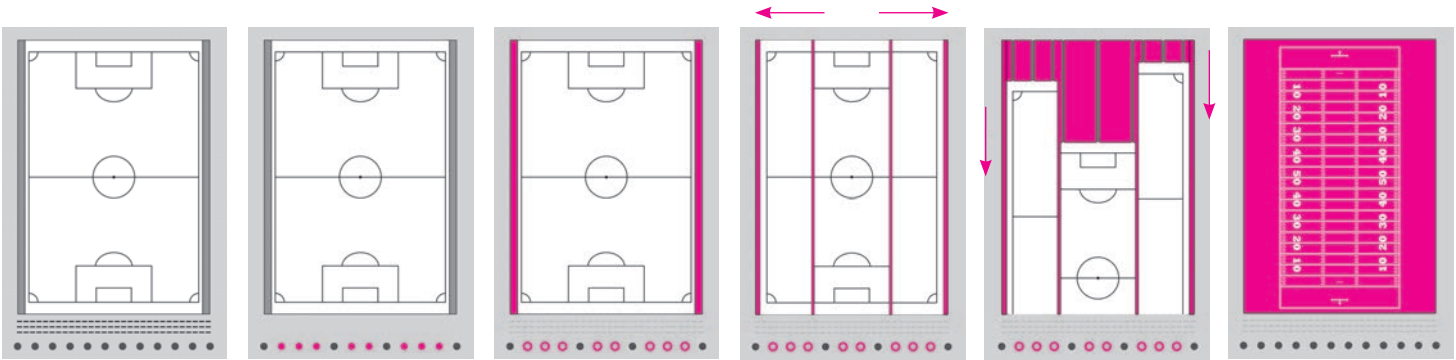
The stadium has been designed to be safe and to operate under various power-loss situations. There are four categories of electrical loads, depending on their importance:

Category 0: Life safety
These loads are the most important and typically comprise smoke control, fire fighting lifts, and emergency lighting.

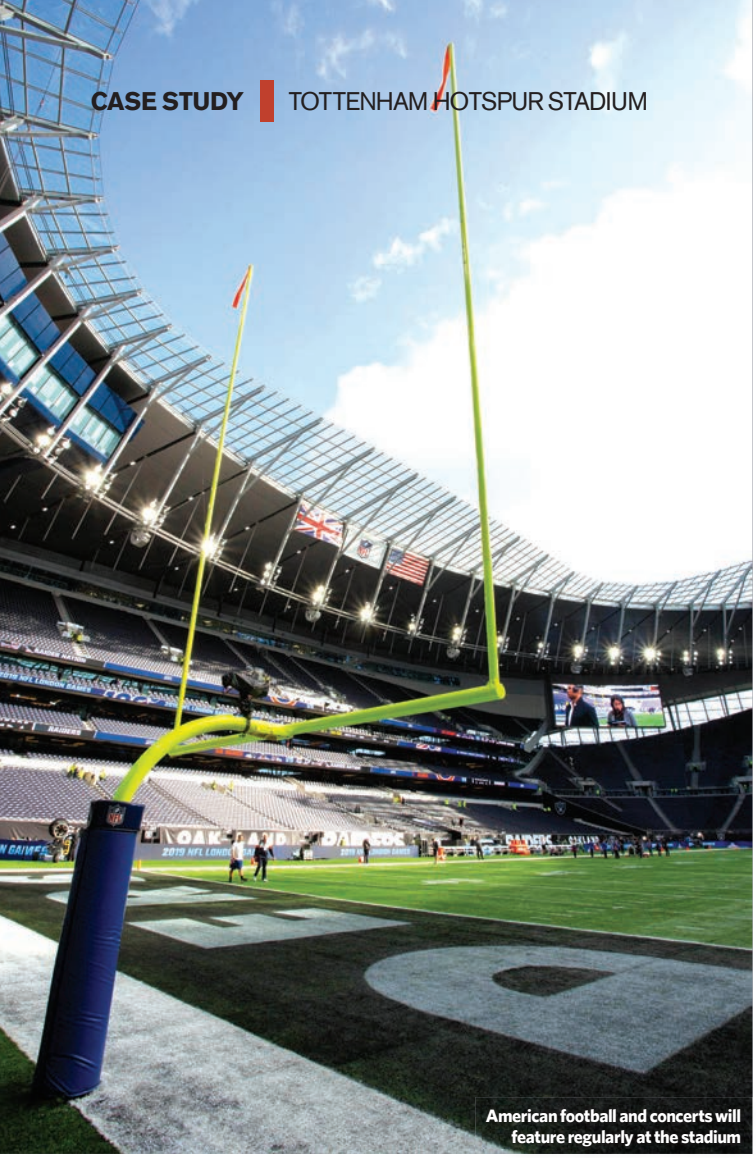
Category 1: Essential
The next most important, they include primary IT, security systems, and UPS equipment. Generally, if either generator is unavailable, or one fails, only life-safety and essential loads will be maintained and the stadium will be evacuated.

Category 2: Match continuation
These loads, along with categories 0 and 1, are required to enable match play to continue in the event of a utility power failure. They include: field-of-play lighting; media lighting and power; hospitality lighting and power (excluding kitchens); and ventilation. When both generators are available the system can support Categories 0, 1 and 2.

Category 3: Non-essential
These loads are the least important and not generally generator-supported. They include façade lighting, escalators, catering chillers, kitchens, and food and beverage areas.


Football pitch in match-day position
Front three rows of seating removed to give sufficient depth for pitch to slide below. Retractable feet
Pitch edges drop to allow space around perimeter for lateral slide
Outer sections of pitch slide laterally to divide pitch into three sections
Pitch slides longitudinally beneath South Stand
Pitch stored beneath South Stand. Retractable feet redeployed

Tottenham's grass football pitch can be retracted in three sections, each weighing more than 3,000 tonnes, by 68 electric motors in 25 minutes



American football and concerts will feature regularly at the stadium

panels on both generators; if one generator failed, we'd still be able to run life-safety systems for the entire building from the one generator.

'We've completed a significant amount of doomsday testing for Building Control to get the stadium's safety certificate.'

Some of the big electrical loads the design has to be able to deal with include lighting and IT. Pitch lighting is based on 324 LED fittings in a 450kW scheme. The scheme also includes façade lighting, while the roof features what Carr describes as a 'halo' of light integrated into the roof eaves, to project colour onto the top of the roof. There are also RGB LED uplighters mounted within the roof structure, to enable the club to project a variety of colours onto the roof's underside.

The stadium incorporates a huge amount of IT, including everything from security to pitch lighting. It also has wireless connectivity across the venue to enable fans inside the stadium to connect with and share their live-event experiences with others around the world. The IT systems are backed up by two, 600kVA uninterruptible power supply (UPS) systems, which will ensure continuity of operation until the standby generators kick into action.

IN A (CIBSE) LEAGUE OF THEIR OWN

BuroHappold Engineering, which designed the building services for Tottenham Hotspur's new home stadium, was the winner of the Building Performance Consultancy (Over 1,000 Employees) category at this year's CIBSE Building Performance Awards.

The focus of the consultancy is on delivering high-performing buildings and cities via six core areas: delivering building performance; health, wellbeing and productivity; BIM for efficient delivery; smart buildings; digital design for the built environment; and design for prefabrication.

The award judges were particularly impressed with the work by the building performance group to create an interactive database for all modelled and measured data across BuroHappold Engineering's global portfolio of projects. This will enable project teams to understand how their buildings are performing in use and on a year-on-year basis.

It is good to see what BuroHappold is doing to address building performance and to get that understanding reflected in what is delivered on site, said the judges.

The stadium's 57 kitchens are classed as non-essential under the criticality classification. The main kitchen, which prepares food for all of the stadium's smaller processing kitchens, has a mighty 1,000-amp supply. 'If there is a power failure during a game, the match can continue, the TV broadcast can continue, but hot food will no longer be available,' Carr says.

Surprisingly, the micro-brewery located beneath the South Stand is classed as non-essential, too. It includes an electric steam boiler fed from two supplies of 520A and 250A. The brewery also has a distribution board to serve pumps, among other things, and this has a 250A supply.

'To keep the loads manageable, the brewery does not brew beer on the same day as a match is scheduled,' explains Carr.

The stadium opened to critical acclaim for the quality of its design, if not for the quality of football played on the night. Now that this major landmark is complete, the second phase of the site's development is set to begin and will include a 180-bedroom hotel, an extreme sports building with the UK's tallest climbing wall, a community health centre, and 222 new affordable homes. Game on. CJ

REALITY CHECK

Creating a digital twin will help maintain a building, but how can existing data be captured? Arup's **Derek Lawrence** explores three methods

Digital information of the Solihull Arup Campus caught using a 3D camera

Keeping a digital record – or 'twin' – of the design, construction and occupation phases of a building is one of the key recommendations in Dame Judith Hackitt's post-Grenfell report into Building Fire Safety Regulations.

A chapter of her report is dedicated to 'the golden thread of building information'. It echoes the challenges faced by many industry professionals when it comes to the effective handover of information after construction and the maintenance of records during the building's life.

Among Dame Judith's other recommendations are having open and non-proprietary formats for digital records, and giving responsibility for transferring and updating information to a duty holder for the life-cycle of a building.

For a new-build design, it should be relatively straightforward to ensure the digital history of a design passes usefully into the hands of the operator – but how do you even start to create a digital twin for an existing building with 'as built' information that might be 30 years old and poorly maintained?

That was a question I asked myself when I began to focus solely on improving existing buildings. For a start, what is a 'digital twin'? While it can be said to be a computerised version of something that exists in the physical world, there is no definition of how computerised something needs to be to reach the increasingly desirable 'digital twin' status. Is a building information model (BIM) a digital twin? What about a tagged PDF plan layout? Depending on what you read or who you speak to, you could conclude they are or they are not.

In 2013, I started working for a large real-estate services company, having just witnessed the process of creating the government's BIM level 2 exemplar project, HMP Cookham Wood. I was ready to tell everyone about the exciting potential of BIM, but two questions I kept facing in my new role were: 'What is BIM and how will investment in it pay back?'

Unable to give a satisfactory reply at the time, I decided to seek answers by trying to create a digital twin – and I started with the question 'what's in our building and how do we capture it'. This sparked my interest in reality-capture techniques, and the routes to, retrospectively, creating a digital twin are listed below, in the order that I discovered them.

LiDAR and trace

In 2013, light detection and ranging

(LiDAR) was not new, but it was incredibly expensive. I was able to get a 'proof of concept' piece of scanning done in a relatively new office space that was changing hands.

After removing a 6m by 6m section of ceiling tiles, I soon realised the **first challenge** of retrospectively capturing existing buildings: most of the purposeless content of the ceiling ended up on the floor.

Capturing everything (visible and hidden) can be disruptive to the building users, so be clear what everything is, for example only what is useful going forward. The LiDAR scan was successful and, after a complicated processing phase, I was ready to recreate what was a data-lite BIM.

At this point, the **second challenge** of retrospective BIM became apparent. The process of translating point clouds into models – even with today's software solutions – is laborious and time-consuming.

The output I had was a simplified digital twin of the space. This, however, generated the **third challenge** – how we present data from a digital twin in a way that engages all stakeholders. If it's not clear and easy to access and maintain, it will lose synchronisation with reality and not be trusted.

Tagged panoramic photography

A former colleague of mine suggested the digital twin may be equally as useful if it is a picture or floor plan with some data tags attached to it. Most existing buildings have layout drawings, even if they are simplified fire plans proudly framed next to main entrances.

At the time, the first generation of cost-effective, one-click panoramic cameras had become commercially viable for pilot projects. Using low-cost images attached to floor plans, I was able to create the skeleton of a digital twin.

The **fourth challenge** had arrived: how could I attach meaningful information from disparate databases into photos? For now, a useful record of the building had been created, which linked floor plans to panoramic pictures. From a maintenance perspective, this later proved to be a level of BIM that was useful to those who operate buildings. It's not unusual for reactive maintenance teams to arrive at a space to fix something at height, only to find that it is 6m off the floor rather than 3m, resulting in abortive trips and inefficiencies.

Equally, tagging key safety features – such as emergency lighting and smoke detectors – makes auditing otherwise unnoticed changes much easier. For example, the panoramic photo shows there should be a smoke detector where there isn't one. Perhaps these are the simple efficiencies we, as an industry, should be trying to address first with our entry-level digital twin.

The static LiDAR scanner image and the point cloud that sit behind it took 1.5 days to capture and process

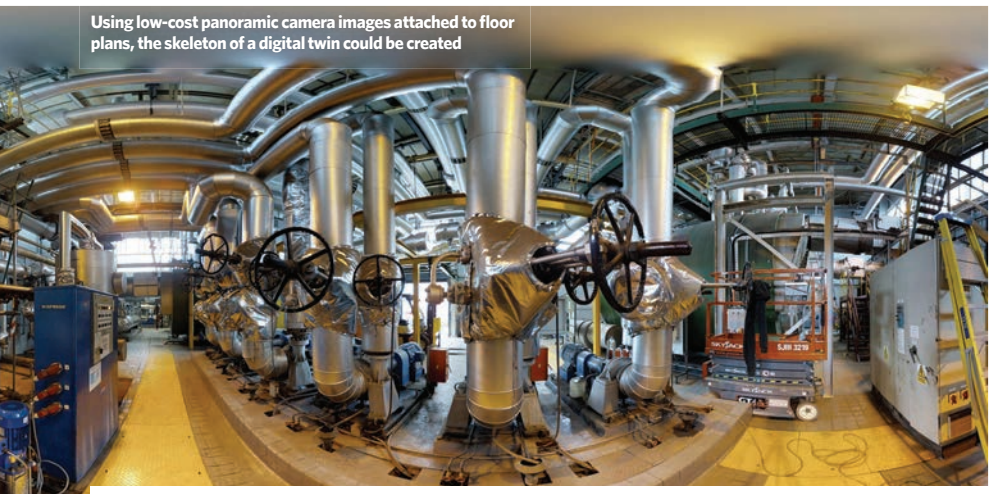
> "At this point, another challenge of retrospective BIM became apparent. The process of translating point clouds into models is laborious and time-consuming"

3D Cameras

The growth in use of 3D capture cameras has been incredible. One such camera, made by Matterport, uses a combination of photos and infrared depth measurements to generate a walk-through environment similar to Google Street View. The capture process is akin to LiDAR.

Once captured, processing to create the final model is all done in the cloud. In addition to the Google Street View-esque environment, Matterport delivers a low-density point cloud that can be used to reconstruct environments with most mainstream modelling tools. »

3D camera image of Matterport boiler can link to useful data



Using low-cost panoramic camera images attached to floor plans, the skeleton of a digital twin could be created

"Reality capture has a part to play in creating the digital twin, which could offer a means to access the golden thread of information"

» More importantly from a digital-twin perspective, the software allows you to deliver web-based content back into the model environment – for example, sensor data. It also clearly highlights the **fifth challenge**: data security, which often pulls in the opposite direction to accessibility and ease of sharing.

With the improvement of handheld, simultaneous localisation and mapping (Slam) technology, more routes to creating a digital twin retrospectively will become available. For fire safety, it could:

- Show clear escape routes for all occupants of the building, which dynamically respond to the building activities
- Highlight important features of fire safety and allow people to visually, or even automatically, check/compare what is actually present with what should be present – for example, fire compartments and smoke detectors
- Provide a visual insight to the building for firefighters before they arrive at the scene
- Deliver a visual index to statutory information and the golden thread of information.

Equally, with minimal reimagination into other sectors, it may:

- Offer the chance for a parent to look around a school if they couldn't make the open day
- Give an autistic person foresight of the potentially stressful environment they could face when going to an unfamiliar place
- Allow wheelchair users to have an improved experience of a hard-to-access listed building.

Reality capture has a part to play in creating the digital twin, which could offer a means to access the golden thread of information mentioned in the Hackitt report.

If we are to create digital twins retrospectively, I would recommend:

- Limiting disruption during the capture process and only capturing what is useful going forward
- Gaining an understanding of the limitation of each capture methodology and the time it takes versus the value it brings to the end user
- Planning how the digital twin will be presented (remember your audience) and how it will be kept current, as this will impact on trust, uptake and future maintenance
- Understanding where the data for the digital twin will come from, and making sure it can receive this data without creating copies (multiple sources of the truth)
- Considering the implications of sharing data, and its sensitivity or potential to create security loopholes in other connected systems. CJ

DEREK LAWRENCE is associate director, Buildings Midlands, at Arup

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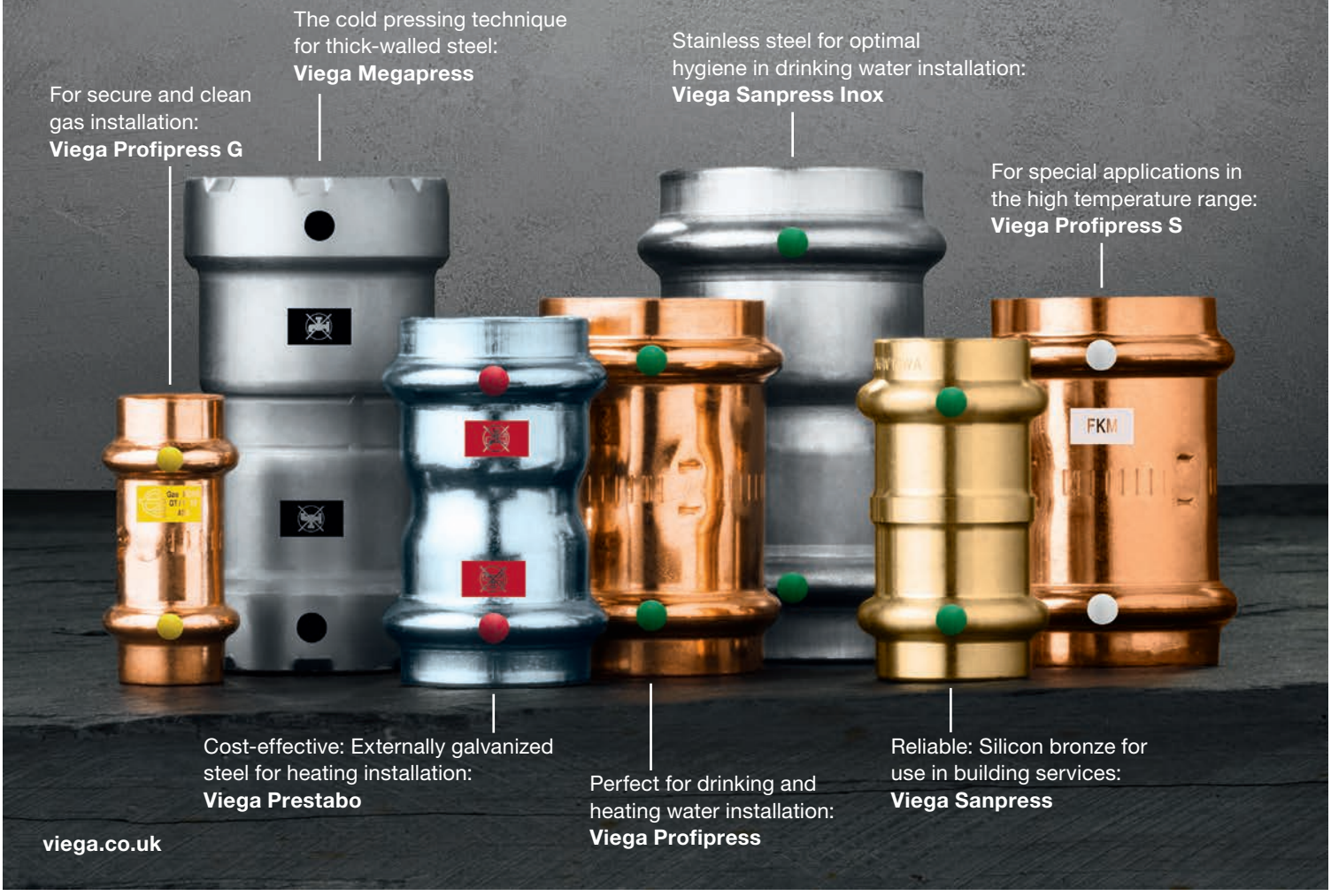

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LEVEL BEST

The 10th Symposium on Lift and Escalator Technologies covered simulation, connectivity and safety, as the Lift and Escalator Industry Association's **Nick Mellor** reports

David Cooper chaired a session on training and education

The 10th Lift and Escalator Symposium was held at Highgate House, near Northampton, on 18 and 19 September, and offered a mix of papers dealing with innovation, design, simulation, education and training, standards and safety, as well as case studies and topical subjects. Professor Stefan Kaczmarczyk, of the University of Northampton, welcomed the audience of 120.

The opening session dealt with two types of products covered by the European Machinery Directive. David Cooper gave an insight into the conformity issues with accessible goods-only lifts (AGOLs), especially where these are not fitted with safety gears. This came after concerns were raised by the Lift and Escalator Industry Association (LEIA) in a Technical Warning Notice (see **leia.co.uk**).

Michael Bottomley followed this with an overview of the other types of lifting appliances covered by the Machinery Directive and questioned whether it offers an equivalent level of safety as the Lifts Directive.

With publication of ISO 8100-32 for the planning and selection of passenger lifts expected soon (revising ISO 4190-6), Marja-Liisa Siikonen – who spoke in the Standards and Safety Session on day two – described the basis for selection of lifts in the draft standard: traditional round-trip time calculations, selection charts, and the use of simulation.

The incorporation of simulation methods into the draft standard has prompted plenty of debate, which was informed by papers from the session on traffic and simulation, chaired by Adam Scott. Janne Sorsa gave an overview of the use of traditional calculation and simulation methods, with wide agreement that a calculation should always be a first step of vertical transportation design. However, for more complex situations, simulation can be a more sophisticated design tool.

Gina Barney's paper raised the question of whether results from simulation can be verifiable, transparent, repeatable and reproducible, highlighting challenges of incorporating simulation into a standard. The results she presented suggested that simulation has shortcomings in repeatability and reproducibility. The session was rounded off by a paper from Lutfi Al-Sharif on the use of Monte Carlo simulation for compiling car load and drive-motor loading data.

A number of papers focused on connectivity issues. Anna Peters looked at the logging and analysis of lift journeys using accelerometers, which are increasingly low cost and, so, readily retrofitted to existing lifts.

In a session chaired by Len Halsey, Fabio Liberal presented the potential for mirrors/large lift-car displays, connected to the Internet of Things (IoT), to display images or information to lift-car users, as well as the possibilities of a touchscreen for controls.

Richard Peters described a lift and escalator management system that could offer a standard interface for acquiring data from existing installations and addressing many of the limitations preventing the widespread adoption of monitoring.

Rory Smith highlighted the development of Chinese GB/T 24476 Specification for IOT

THE LIFT AND ESCALATOR SYMPOSIUM TRUST

The Lift and Escalator Symposium is run by a not-for-profit trust dedicated to improving training and education in our sector. Trustees David Cooper, Stefan Kaczmarczyk, Richard Peters and Nick Mellor reflect the strong commitment to education and training by the University of Northampton, CIBSE Lifts Group, and the Lift and Escalator Industry Association (LEIA).

"John Stopes presented the challenges faced by the development of a vertical transportation strategy for London's 22 Bishopsgate, and how the constraints from the previous design were overcome"

for lifts, escalators and moving walks code, which would require all new and modernised lifts and escalators in China to be fitted with remote monitoring using a standard interface defined in the code. The strategic implications of such a development would surely challenge the rest of the global industry to respond.

A session on engineering, chaired by Barney, included two papers exploring rope resonance effects. Kaczmarczyk reported on work examining the use of active and passive control strategies to mitigate the effects of building sway on rope movement. The problem of ropes becoming caught on equipment in the lift well as a result of building movement, such as from earthquakes, was presented by Suzuko Tamashiro from the Tokyo Denki University.

The session was completed by Barney presenting a paper, from Roland Stawinoga, about the use of wood for machine frames that also looked at sustainability issues raised by the use of timber in buildings.

The second day started with a session on training and education, chaired by Cooper. Al-Sharif talked of the benefits of using lift engineering as a template for an undergraduate final year. He also gave insights into the role of the educator and the use of an open educational resource.

Thomas Ehrl presented on different learning styles and the impact of social media on distance learning, while the final paper was given by Tadeusz Popielas, of the Polish Lift Association. He gave the background to the Polish industry and its response to future skills needs, which involves creating a vocational training programme through secondary technical schools.

Further papers on standards and safety, in a session chaired by Phil Hofer, included Philip Andrew and Kaczmarczyk co-presenting on the impact of dynamic effects on the standard traction calculation – in particular, where rope resonances might cause the applied traction ratios to exceed the critical traction ratio. Cooper returned with a paper on the causes of escalator runaways, and further discussion highlighted the importance of including escalators in statutory inspection/thorough examination.

The final session, chaired by Graham Barker, offered four case studies of novel challenges and developments in design and planning, and how to address these. Adam Scott highlighted the rise in the use of bicycles in cities and the requirements this is placing on vertical transportation design.

His presentation was followed by three speakers making their symposium debuts. Alan Cronin, using London's 'Walkie Talkie' building as a case study, extended the horizontal and vertical journeys holistically, in an informative presentation; John Stopes presented the challenges in developing a vertical transportation strategy for London's 22 Bishopsgate, and how the constraints from the previous design were overcome; and Phil Pearson described the vertical transportation challenges within a new football stand, and how the access, egress and evacuation needs of various user groups were provided.

The 11th Lift and Escalator Symposium will be held in Shanghai, China, on 4-5 May 2020. To submit a paper and to read previous papers, visit **liftsymposium.org** The event will return to Northampton for the 12th symposium on 23-24 September 2020. CJ

- Some papers from the symposium will be published in upcoming issues of *CIBSE Journal*.

- **NICK MELLOR** is managing director at the Lift and Escalator Industry Association

Gina Barney's paper focused on lift simulation

Anna Peters spoke on logging and analysis of lift journeys

Adam Scott on how the use of bicycles affects lift design

EXPLOITATION EXPOSED

The construction industry must engage with as many people as possible, including victims, to improve its understanding of modern slavery, says Stronger Together's **Pamela Zielinski**

Awareness of modern slavery is increasing but, for those who still ask if it means 'not being paid the minimum wage', there is a stark lesson to be had in the cruelty that humans will inflict on fellow humans.

The International Labour Organization (ILO) estimates that, globally, there are 40 million victims of modern slavery, more than half of whom are suspected to be victims of forced labour.[1]

Forced – or compulsory – labour is defined by the ILO as 'all work or service which is exacted from any person under the threat of a penalty and for which the person has not offered himself or herself voluntarily'.[2] Penalties can include physical and/or sexual violence, threats to family and friends, and threats of denunciation to authorities.

> "The common cry of 'how are we supposed to know' is no longer a defence"

Estimates for the number of potential victims in the UK range from 12-14,000 – quoted in a Home Office study published in December 2014[3] – to 136,000, indicated in the 2018 Global Slavery Index.[4] While the figures vary, there is consensus that this crime is happening in the UK, across a range of sectors, including agriculture, food processing and packaging, car washes, nail bars, waste management, and construction.

Construction

The Gangmasters and Labour Abuse Authority recognises construction as a high-risk sector,[5] and the Chartered Institute of Building's *Construction and the Modern Slavery Act*[6] – published in May 2018 – confirmed a growing realisation that victims can be found across the UK supply chain.

Under the Modern Slavery Act 2015, businesses 'should know or ought to know' if forced labour is occurring in their business or supply chain. The common cry of 'how are we supposed to know' is no longer a defence.

Commercial organisations with a turnover of £36m or more are required to publish an annual statement of what they are doing to address the risks in their business and their supply chain, so creating a cascade of statements throughout their supply chain.

The equivalent Scottish legislation goes further, and has provisions for offences committed by a 'body incorporated under

the law of the United Kingdom' and where the offence includes 'aggravation involving a public official'.

Response to the requirements of the act has been variable, however. According to the Transparency in Supply Chains (TISC) Report,[7] about 25% of companies that are required to publish a statement have yet to do so, while the quality of reporting is also inconsistent, says labour standards and human rights consultancy Ergon Associates.[8]

In May 2019, therefore, an independent review of the Modern Slavery Act was published[9] and the government is now consulting on its 80 recommendations, which focus on the operation and effectiveness of the legislation. In his foreword to the report, chair of the review the Rt Hon Frank Field MP summarises the business-related content as 'putting teeth into this part of the act, so that all businesses take seriously their responsibilities to check their supply chains'.

In June, then Prime Minister Theresa May also announced additional measures to tackle modern slavery, including:

- A free, online registry of modern slavery statements, to make it easier for consumers, investors and NGOs to track compliance and the actions that businesses are taking
- Consulting on changes to the transparency in supply chains legislation – specifically, strengthening and improving the transparency statements required of businesses, and expanding the law to cover the public sector and its vast purchasing power.

Take action

The ongoing development of legislation is happening against a backdrop of increasingly high-profile prosecutions. These include three men jailed for a total of 28 years in June, for offences in the construction sector[10] and the UK's biggest case to date, in July this year, with an estimated 400 victims in the Midlands.[11]

Many businesses in the construction sector lack understanding of modern slavery and do not have an effective response in place. A reliance on generic policies, contractual terms, 'zero tolerance' statements, and an assumption that 'right to work' checks are sufficient typifies this lack of comprehension.

Time and again at Stronger Together[12] workshops, delegates look shocked and dismayed when they learn about the reality of modern slavery. They begin to realise how big the gap is between what they are doing and what is needed to put in place an effective response. Of course, we know there are complex supply chains and a lack of transparency – but that is exactly why exploitation occurs. The construction sector has much to learn from the consumer goods and retail sector, where consumers demanded action in advance of government legislation.

> "We know there are complex supply chains and a lack of transparency – but that is exactly why exploitation occurs"

The good news is that we can all take action. Key to tackling modern slavery is engagement, collaboration and transparency. Knowledge is power and that means engaging with as many people as possible, including victims, who don't always identify themselves as such.

Modern slavery is a complex and dynamic issue, and will not disappear of its own accord. So businesses should develop their approach as part of their ongoing business strategy, and take the time and effort to research and engage their supply chains. **CJ**

PAMELA ZIELINSKI is Stronger Together's construction sector programme manager, and managing director of consultancies Zielinski Associates and Ethitas

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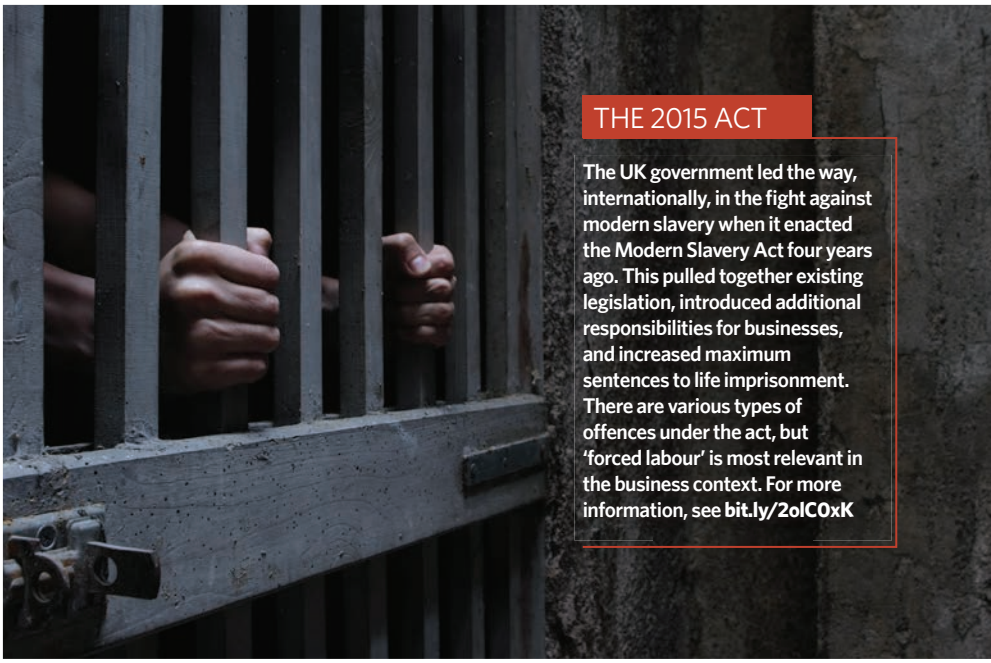
12 **stronger2gether.org/construction**



THE 2015 ACT

The UK government led the way, internationally, in the fight against modern slavery when it enacted the Modern Slavery Act four years ago. This pulled together existing legislation, introduced additional responsibilities for businesses, and increased maximum sentences to life imprisonment. There are various types of offences under the act, but 'forced labour' is most relevant in the business context. For more information, see bit.ly/2olC0xK

Croydon Council responds to climate emergency with ambient heating system

Council aims for 34% cut in borough's emissions by 2025

Croydon Council has launched a pilot scheme with Kensa Contracting to install a low carbon, fifth-generation ground source heat pump (GSHP) system for its residents.

The GSHPs at the council-owned 10-storey residential block in New Addington will aim to cut carbon emissions, help improve air quality, and save up to £300 per home per year on more than 40 households' heating bills.

Croydon Council declared a climate emergency this summer, and the project aims to contribute towards a local target of cutting the borough's carbon emissions by 34% by 2025.

The 44 flats are the first in Croydon to have GSHPs retrofitted, replacing existing electric storage heaters. An individual Kensa Shoebox GSHP will be installed in each flat, connected to an ambient, shared ground loop array.

The ambient nature of the heating distribution system will prevent overheating of communal areas, while the individual heat pump in each flat will give tenants independent control and the freedom to switch fuel suppliers, according to the contractor.

GSHP drill rig

The installations will save each home £260-£300 a year on their bills, according to Kensa, as well as around 1,350kg of carbon dioxide per year – the equivalent of a 242,317-mile car journey.

The £700,000 heating system, expected to be completed by spring 2020, will be funded through the council's ring-fenced housing budget and via energy credits from energy regulator Ofgem.

Stoke £50m district heat network boosts Urban Heat Academy

Construction has started on the second phase of Stoke-on-Trent's low carbon, city-wide district heat network. Sustainable energy specialist Vital Energi is installing the latest £1.9m section of the scheme, while Stoke-On-Trent College's Urban Heat Academy is training the engineers who will be working on the project.

The district heat network scheme, led by Stoke-On-Trent City Council, will see an 18km district heat network, using geothermal thermal energy, installed over the next four to five years in a £50m project that will connect public and commercial buildings first, and then by residential properties.

The district heat network is one of the key components in an overall investment of £500m in a smart energy system planned for the city over the next six to seven years.

Students from the Urban Heat Academy will work with contractors and employers involved in the design, installation, management and maintenance of the district heat network through apprenticeships and work-related training. Vital Energi will be employing a local apprentice from the academy, who will be working on the scheme via day release for the duration of contract works. (See Q&A, page 97, for more on the project).

MMC benefits for Battersea Power Station project

Modern methods of construction (MMC) has been used to install services at Battersea Power Station's 253 new residential apartments.

The power station project comprises the refurbishment and transformation of the Grade II listed building, which will house more than 100 shops, restaurants and cafes, events venue, office space, and 253 residential apartments.

Packaged Plant Solutions – part of Baxi Heating – supplied offsite fabricated service pods for the residential apartments, after setting up a production line at its Milton Keynes plant.

The final pods included a HIU/CIU for heating and cooling; mechanical ventilation heat recovery; underfloor heating; electrical distribution; and metering and billing devices. The pods also included a washing machine.

Ian Lock, business development director at Baxi Heating, said: 'By manufacturing the full solution offsite, the risk of human error was reduced significantly, as were the health and safety risks because of the elimination of hot works on site. It also saved huge amounts of time on the overall project. To put it into context, it takes three hours to connect one unit via MMC, whereas an onsite installation can take up to five days.' See the CPD on page 87 for more on offsite manufacturing of services.

Rinnai aims to double in size

Water heater supplier Rinnai has committed to doubling in size within the next 10 years.

At a Rinnai partner event in London, the firm also revealed it is working with a government body on the future use of hydrogen in water heaters.

In the past year, the company has launched a service plan initiative for customers, which will see any inspections and remedial work carried out by Gas Safe-registered engineers.

Its new N series of Sensei hot-water heating units include a new scale protection and remote monitoring systems designed to enable predictive maintenance.

Rinnai also launched its Zen and Zen Plus home hot-water and heating systems – aimed at the middle and top end of the market – which come with an Internet of Things controller.

Crops are grown on a hydroponics-based vertical system

To minimise carbon emissions, developers behind two huge greenhouses in East Anglia are using heat from nearby wastewater treatment plants to provide perfect growing conditions. **Phil Lattimore** reports on the innovative engineering behind the facilities

GROWING INTEREST

Could two new sustainable giant greenhouses being built in Norfolk and Suffolk be part of the answer to a growing problem? Sustainability and reducing greenhouse gas (GHG) emissions are increasingly important issues for the agricultural sector, which is estimated to account for up to 9% of total GHG emissions produced in the UK.

The National Farmers' Union (NFU) is targeting net-zero emissions in British farming by 2040, and while most of the sector's GHGs come from sources such as methane produced by cattle and nitrous oxide released by fertilisers, the food supply chain – from transport and distribution to infrastructure and buildings – has a key role to play.

The recent announcement that two of the largest greenhouses in the UK are to be powered by low carbon sustainable energy sourced from waste heat from water recycling centres is, therefore, a significant development. And, its backers claim, it could offer a model for the decarbonisation of agriculture in this particularly energy-intensive, and conventionally energy-inefficient, part of the sector.

Sustainability

The two innovative greenhouse developments are located at farmland sites near Norwich and Bury St Edmunds, covering 16 and 13 hectares respectively – a larger area than London's O2 arena – and use more than five times as much glass as The Shard. They are part of a £120m project being developed by Oasthouse Ventures that's backed by asset management firm Greencoat Capital (the UK's largest investor in renewables). The carbon footprint of the food produced there is expected to be 75% lower than equivalent European greenhouses, and Greencoat estimates they will be capable of producing 20 tonnes of tomatoes a day – some 12% of the UK's needs.

The 7m-high greenhouse structures, which are being built by Dutch glasshouse specialist BOM Group, rely on a hydroponics-based vertical growing system that includes 177km of growing gutters for a range of plants and vegetables. Conventional gas warming will be replaced with heating supplied via closed loop heat pumps that use waste heat from nearby wastewater treatment plants run by Anglian Water.

The Smart Energy Services business unit at Irish utility Electricity Supply Board (ESB) has been selected by Greencoat to design, install and manage the closed loop heat pump system, as well as combined heat and power (CHP) plants at each site. The CHP units will provide electricity to power the heat pumps and will also transfer supplementary CO_2 into the greenhouses to accelerate crop growth, recapturing a high proportion of the carbon created. All of the heat and electricity produced by the CHP units will be used on site, making it one of the most efficient CHP systems in the UK, according to ESB.

The systems being developed by ESB will constitute the highest installed capacity of heat pump technology so far in the UK, capable of generating a combined total of 70MW peak of thermal power. The system will also result in the treated water outflows from the recycling centres being cooled sufficiently before they are released back into the river, benefiting local ecosystems. »

The two sites use more than five times as much glass as The Shard

» Concept

Neil Lawson is ESB's head of renewable heat development (and a non-executive director of energy consultant Low Carbon Farming). He has been involved in the project since its inception three years ago, when Oasthouse Ventures began looking into large-scale sustainable greenhouse sites. 'The original concept was for a low carbon centre with ground source, using waste heat from a local water recycling plant without the need for CHP,' Lawson says. 'But as we moved along, we discovered how much CO_2 the plants required.'

> "We're using the outfall from the Anglian Water recycling centres – the clean water discharge that goes to the river"

The ground-source heat pumps (GSHPs) deliver the primary heat capacity required for the greenhouses, while the gas-powered CHP will produce the CO_2, Lawson says. 'We realised it was cheaper to use gas-fired CHPs to produce CO_2 on site than it was to bring bottled gas in.' Sized for CO_2 production, the capacity of the CHP units are 3 x 1.2MWe for the Norwich site and 2 x 1.2MWe for Bury St Edmunds.

In an environment where maintaining heating levels is critical for crop production, emergency backup is provided in the form of a generator, to provide basic power for the greenhouse and heating system circulation pumps, and gas-fired boilers in case of power failure.

Lawson, who also led the project to install GSHPs to the recent V&A Dundee scheme (see 'Playing to the gallery', *CIBSE Journal*, January 2019), was behind the concept of using waste heat from a water treatment works. One of the fundamental requirements for the project was, therefore, to find suitable farmland in proximity to such facilities with sufficient outflow capacity. The Norwich and Bury St Edmunds sites met these criteria, and ticked other boxes – such as being situated on flat, non-flood plain land with access to roads and local labour.

Greencoat claims the sites could produce 12% of the UK's tomato needs

On site

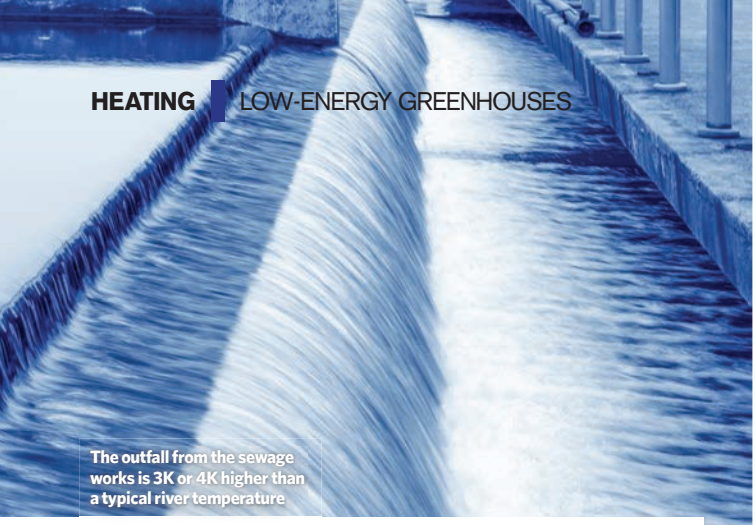
Using waste heat from the Anglian Water recycling facilities is a cost-effective option, says Lawson. 'On the Norwich site, we will have 38MW capacity, while at Bury St Edmunds we have 32MW of ground source. We're using the outfall from the Anglian Water recycling centres – the clean water discharge that goes to the river. For this capacity of installation, one would usually use a river source.

'We're using an ambient loop. The outfall from the sewage treatment works is 3K or 4K higher than the river temperature, and every 1K increase in source temperature is worth about 2.5% efficiency, so our system at these sites is 10% more efficient than if we were using a river source.'

Lawson says: 'We use a plate heat exchanger to extract heat from the discharge. At Norwich, this is 1,000L·s^{-1} and, at Bury St Edmunds, it's 550L·s^{-1}, and we're taking between 3K and 6K out of the water. One of the requirements for Anglian Water's licence is to ensure that the discharge water mustn't be too hot going into the river, as it could have detrimental consequences on the local ecosystem. So taking 3K or more from the outfall, we help them to protect the environment.'

Both greenhouse sites are located around 2.4km from their respective water treatment centres. The heat plate exchanger system extracts the heat energy from the outfall, using a water and heat transfer fluid-based system. A closed circuit then takes this heat transfer fluid directly up to the heat pumps. (The system employs a food-grade fluid anti-freeze mix suitable for food production sites, rather than a traditional medium such as ethanol, to eliminate the risks associated with contamination from potential leaks.)

'One of the simplicities of this system is that we have HDP pipe buried in the ground,' says Lawson. 'Because the temperature gradient between the fluid in the pipe and the ground around is so small, there's very little heat loss into the ground. And, if you don't need to install »



The outfall from the sewage works is 3K or 4K higher than a typical river temperature

CHINA'S GREENHOUSE CITIES

Lolli Olafsson is the founder and CEO of Geyser Thermal Energy, a sustainable energy and water treatment solution specialist that has been working on a huge, low carbon greenhouse project in China along with partners Qanbridge and FreshTeq, led by Tjerk Gorter and plant growth and water specialist Arnoud Tieleman.

Plans are under way to construct massive agroparks across three provinces, covering around 100 hectares, with state-of-the-art greenhouses of 40-50 hectares that are designed to reuse 90% of their energy, with no use of pesticides and minimal use of water.

'We know that the future of food is going to be in sustainable greenhouses that are part of integrated fresh food chains, from seed to eat,' says Olafsson. 'The more we can grow products locally, the more we can reduce our carbon emissions.

'We've been working on a new, flexible, next-generation design that will allow crops to be grown anywhere in the world at any time – a breakthrough that will enable year-round production, which at the moment in many climate zones is not feasible. It will be low cost, and our aim is for them to be carbon neutral and use heat easily from any renewable source available.

'Innovative water treatment systems ensure water can be reused and not wasted. Hydroponic or aeroponic systems can be used, and the water and air treatment systems – which are more effective than UV light – mean the facilities are pesticide and chemical free. Lights above the plants will kill any bacteria or mould that may get in.

'Waste from the plants, such as old root systems, are reused, so no nitrates are released into the atmosphere; they are used to generate heat and "biochar", a natural organic product that is used to clean water and air in the treatment system.

'A new revolution in fresh food is on its way, and it will most likely take place in China .'

» insulated pipe, it makes it very cost-effective. What we potentially lose in the winter, we gain in the summer.' The sites have a thermal store, so on particularly hot days that store can be charged, says Lawson. 'Roughly calculated, it would take around 3.5 days for the heat pumps flat out to charge that store from cold to hot.'

The conventional method of heating a greenhouse would be using a CHP to power an electrically led system, with a lot of the heat energy being discharged. But the systems used at the two sites are far more energy efficient, explains Lawson: 'In these systems, we're supplying just the right amount of heat to meet the demand. We have multiple heat pump units in cascade – 16 on the Norwich site and 13 on the Bury St Edmunds site, each one around 2.4MW – and each has the ability to modulate, so we only have the required heat produced to meet the demands of the greenhouse.'

This system enables maintenance on heat pump units to be carried out at times of lower demand, so as not to affect capacity. The heat exchangers and system circulation pumps at the water recycling plant outflow are also duty/standby to ensure adequate redundancy in the system.

Off the shelf

While the scale of the East Anglian projects is challenging – the current largest open loop ground source heating system in the UK has a 5.8MW capacity, compared with the 38MW and 32MW closed-loop systems that they will employ – ESB will be relying on tried and trusted technology, says Lawson. 'It's based on our own experiences with deploying heat pumps. We're keeping it simple, we're buying readily available off-the-shelf products that we're putting together in a package – there's nothing particularly bespoke about them.'

Within the greenhouses, the heat emitter system has been designed specifically with heat pump temperatures in mind to maximise efficiency. 'There are lower temperature heat emitter circuits,' says Lawson. 'The lower the flow temperature of the heat pump, the more efficient it is. It works the same way as the source temperature – a 1K drop in flow temperature equates to a 2.5% increase in efficiency. So we've sized all the growing rails to have a 50ºC flow temperature at worst case, and then we weather-compensate it from there.

'That means the heat pumps are more efficient than stipulating a 75ºC flow temperature and having to select a really high temperature heat pump. It doesn't really need to be that hot – you can still get the full 38MW into the greenhouse at lower flow temperatures.'

Cost saving

The project will benefit from the UK government's renewable heat incentive scheme. The projected capex cost per kilowatt of installed capacity of the GSHP system, according to ESB, is £249 per kW peak, with water extraction £100 per kW peak. And, with a relatively simple system compared with conventional CHP-based greenhouse heating – with fewer moving parts involved – maintenance costs are considerably lower too; ESB estimates the GSHP annual maintenance at £4.50 per kW peak and the CHP maintenance costs at £100 per kW peak.

At current grid carbon levels, ESB Smart Energy Services projects the design of this energy centre will provide 1.2 million tonnes of carbon savings for both sites over the 20-year life of the project, compared with a standard CHP glasshouse. And as grid decarbonisation gathers pace, total carbon savings are expected to grow accordingly.

As well as its capability to meet a large proportion of the UK's demand for vegetables such as tomatoes, the project will also boost local employment, creating around 360 permanent jobs and bringing a further 120 in high season.

'These greenhouses tick so many boxes when you're talking about Brexit and food security, employment and food miles,' says Lawson. 'Is this type of solution the future of food production? Absolutely.' CJ

The greenhouse developments cover 29 hectares in total

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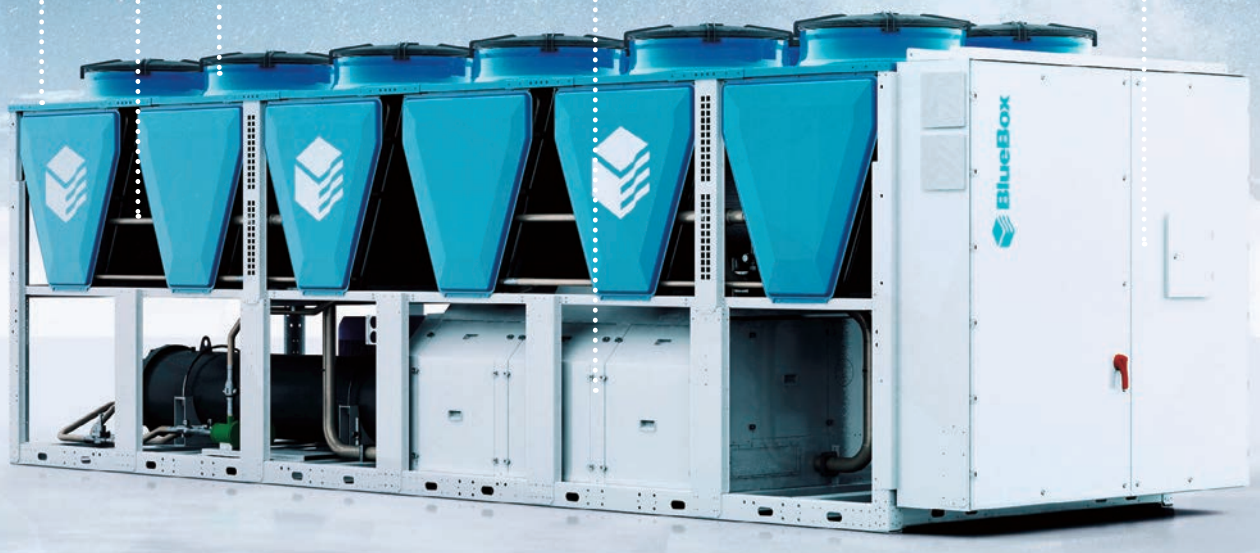

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What is the most effective way of heating our future zero carbon homes? **Chris Twinn** has been researching the issue for five years and has found that standalone 'autonomous' heat recovery systems offer the most benefits when considering high-density homes

AUTONOMOUS STATE

As we ponder the journey to zero carbon for high-density housing, we must consider the most appropriate route for heating our dwellings. A five-year research project has analysed 11 systems for delivering heat and water and concluded that district systems may not be appropriate for the next 50% step-reduction in carbon. The study calculates that alternatives can achieve this with both reduced capital cost and cheaper occupant bills.

This research was prompted by concerns from project collaborators: developers questioned the increasing complexity and cost of installation; housing associations were troubled that occupant energy bills were increasing irrespective of targeted energy use reductions; and there was a wide perception of a focus on 'supply side' systems, rather than on cutting energy demand.

Context

Heating and hot-water systems installation costs have doubled in real terms over the past 10 years (Figure 1). Only a few years ago, the size of a home gas boiler was less than 12kW, but today's boiler/district heating interface unit (HIU) is typically 35kW or larger. So, counterintuitively, as the thermal performance of buildings has improved over time, the systems' capacities and costs have increased.

The requirement of adding combined heat and power (CHP) onto the district heating has added a further layer of complexity, and is locking us into high-temperature distribution systems with their fossil-fuels combustion origins and high standing losses.

While acknowledging that much of the existing building stock may well continue to have a significant heat demand and so benefit from centralised distribution of heat (particularly as carbon-emitting gas boilers are phased out), there is the opportunity to cut the need for delivered heat in new builds.

It has proved difficult to cut the costs and complexity of district systems when serving buildings with reducing demand for delivered heat. Consequently, the service charge portion of the bills – which includes central plant and distribution losses, maintenance and management costs – are becoming as large as the occupants' metered kWh bill (Figure 2).

The expected continued reduction in the grid electricity carbon intensity factor and the acknowledgement of increased network losses in SAP 10 means this situation is only going to intensify. So, this research started with the proposition that there may be benefits in both reduced capital and running costs in lowering energy demand en route to zero carbon.

Analysis

The research programme identified and analysed 11 key system variants (Figure 3),

> "A key energy modelling parameter was to be able to adjust heat-pump COPs based on outdoor air source temperatures as well as sink temperatures"

Capex comparison for residential in London				
2011	2010 measured price converted to 2018	Spons 2011 M&E price book. Includes GFA-NFA/prelims/OH&P	Heat source, space heating and air treatment, ventilation	**£140 per m²**
2019	Budget for 2019 construction start	Housing association development of 400 dwellings, 50% affordable in London	Budget cost for hot water/heating	**£280 per m²**

Figure 1: Doubling of residential heating system capital costs for London over fewer than 10 years – indicative of increasing system complexity

Type of property	Average annual consumption (kWh)	Annual cost of kWh used	Annual standing charge	Total annual cost	Monthly cost
One-bedroom	2,490	£147	£146	**£293**	£24
Two-bedroom	3,683	£217	£146	**£363**	£30
Three-bedroom	3,915	£231	£146	**£377**	£31

Figure 2: Example of actual heat bills for a district heating system with CHP, averaged across a high-density development, illustrating how the annual service charge becomes as large as the energy delivered kWh bill for smaller and for low-energy demand dwellings

modelled them in energy terms, and assessed each for zero carbon future-proofing and for their relative capital costs and operating costs. Real project data was identified for some of the systems to allow spot correlation checking. Those that scored well overall, but are not well known to industry, were further checked to ensure proven kit availability and in-use experience at scale. Where the choice of systems had required implication beyond the system itself – for example, related fabric enhancement – there was detailed investigation to ensure these costs were included in the assessment.

A key energy modelling parameter was to be able to adjust heat-pump coefficient of performances (COPs) based on outdoor air source temperatures as well as sink temperatures. This showed that the same air source heat pump operating mainly in mid-winter (because of enhanced building thermal performance) has a lower yearly averaged COP than the same model heating a less insulated dwelling with a longer heating period carrying over into the milder mid-seasons. However, the lowest energy bills and carbon emissions were for the heat pump working at a lower COP across a shorter heating season. »

System	Key considerations
1. Individual gas boilers in each dwelling	Traditional baseline. No longer London planning carbon-compliant (Part L less 35%). No straightforward adaption to zero carbon future.
2. Gas boiler district heating with dwelling HIU for heating and instantaneous DHW	Conventional high-density solution. Higher efficiency boilers. No longer London planning carbon-compliant (Part L less 35%). Mains losses larger than previously assumed, based on recent operating feedback.
3. Gas boiler and CHP district heating with dwelling HIU for heating and instantaneous DHW	Recent norm. No longer London planning carbon-compliant (using new lower grid carbon factors). Mains losses larger than previously assumed, based on recent operating feedback. High service charges. No straightforward adaption to zero carbon future.
4. Gas boiler and central ASHP district heating with dwelling HIU for heating and instantaneous DHW	Adapts system 3 to allow use of low carbon grid electricity. ASHP not at optimum COP because of relatively high-temperature district heating to serve DHW. High mains standing losses. High service charges.
5. Gas boiler and central GSHP district heating with dwelling HIU for heating and instantaneous DHW	Adapts system 3 to allow use of low carbon grid electricity. GSHP has better winter COP than ASHP, but not optimum because of relatively high-temperature district heating to serve DHW. High mains standing losses. High service charges.
6. Central ASHP with heat network and HIU for heating and direct-electric top-up DHW	Mid-temperature heat network to improve COP of ASHP. Direct-electric used to lift final DHW temperature, often with DHW storage. Higher bills because of direct-electric element. Limited demand-side management options.
7. Central ASHP with heat network and individual WSHP for heating and DHW with storage	Low-temperature heat mains (15-25°C) to improve COP of ASHP. Dwelling WSHP lifts mains temperature for low-temperature heating and to higher temperature only for DHW storage. Low mains losses. Demand management potential is good because of DHW storage and ability for 24/7 trickle heating.
8. Individual dwelling ASHP with DX outdoor unit and direct electric DHW top-up	Generally suited to space temperature heating. Poor COP for generating DHW. May use direct-electric to top-up DHW. Summer heat discharge compromises NV cooling, prompting risk of added mechanical cooling.
9. Dwelling one-stage EAHP with direct-electric heating	Captures heat from extracted exhaust air to heat DHW storage with direct-electric for top-up and heating. Substantial untreated fresh air comfort issues and direct-electric heating very sensitive to incorrect control.
10. Dwelling one-stage EAHP and gas boiler district heating, and HIU for heating and DHW top-up	Captures heat from extracted exhaust air to heat DHW storage, with district heating for space heating. Mains standing losses. Reintroduces capital cost and service charges for centralised system.
11. Dwelling two-stage MVHR and EAHP for heating and DHW	Captures heat from extracted exhaust air using MVHR followed with second stage heat recovery using EAHP. Heats DHW storage and then heats top-up to fresh air supply. Low-capacity system.

Abbreviations

Part L = Building Regulations (England) carbon code-compliant
HIU = heat interface unit
DHW = domestic hot water
CHP = combined heat and power unit (gas-fired)
ASHP = air-source heat pump
COP = coefficient of performance of heat pump
GSHP = ground source heat pump
WSHP = water source heat pump
DX = refrigerant piped (often reverse-cycle)
NV = natural ventilation
EAHP = exhaust air source heat pump
MVHR = mechanical ventilation heat recovery unit

Figure 3: System descriptions and key characteristics

This demonstrated that comparisons based on systems' efficiencies can be misleading. It shows the shortcoming of SAP in its inability to accommodate varying COPs across the year.

To take account of the outdoor environment, a temperature banding annual model was set up. This was run for a representative outdoor temperature in each band to establish a heat balance for a representative dwelling, and permitted an appropriate heat pump COP to be selected for each outdoor temperature band.

A zero carbon future-proofing assessment relates to the ability of a system to switch to 100% zero carbon energy sources within the life of the system. Onsite PV renewable energy generation was assumed to be generally insufficient because the study was focused on high-density development. Biomass and similar renewables were disregarded because of urban air quality concerns. Hence, all renewable energy for heating was assumed to be delivered via the electrical grid.

For assessment of maintenance and service charges, experience has been drawn from the FM side of the construction industry. The level of maintenance was assessed as being broadly in proportion to the number of active components in the system. Network energy standing losses were also considered as part of the standing charge using SAP10 defaults, as these better reflected monitored data from recent completed projects.

Results

Each system was ranked under each characteristic and then these were combined to give an overall rating (Figure 4). This preserved a level of transparency given that each of the different contributing stakeholders had differing opinions on relative importance of each criterion.

The highest-rated shortlisted systems were then tested for market acceptability, proven kit availability and indirect cost implications. This meant systems such as the individual air source heat pumps, although dominant in various markets abroad, were discarded as unsuitable for UK high-density housing.

The system that emerged as most favoured was the one that harnessed most of its heat from that already available inside each dwelling and that avoided needing any site-imported heat deliver. This 'heat autonomy' system uses an in-dwelling unitary two-stage ventilation heat recovery and heat pump (two-stage MVHR+EAHP) (Figure 5). It exploits the waste heat from occupants, appliances, cooking and showers, which is captured via extract ventilation and upgraded using the small exhaust air heat pump.

This has a heating capacity of around 1.5kW for delivering both space heating and hot water. To achieve this requires high dwelling envelope thermal performance, so the assessed cost for this system also included the building fabric enhancements.

This unit was originally developed – and has gained a proven track record – as a Passivhaus-certified product. Many thousands of the units have been installed, largely across southern Scandinavia and Germany. A key aspect of its proven track record is the integration of MVHR, heat pump, hot-water storage and controls in a single unitary box that is factory assembled and tested before delivery to the site.

This is unlike the UK convention of multiple components from various suppliers – such as MVHR, HIU, metering, heating-emitter system, and controls – being assembled and configured under less-than-optimum site conditions.

Its unitary configuration and lack of distribution heat pipework makes it ideal for modular offsite building fabrication. Its electrical power demand is small enough to operate from a standard 13-amp outlet without any enhancement to dwelling electrics.

Enhanced fabric

To allow the use of this two-stage MVHR+EAHP unit, building fabric enhancement was investigated in some depth, and a stripped-down version of Passivhaus was found to deliver a capital cost sweet point.

The modelled housing in London achieved a peak heating capacity closely related to Passivhaus recommendations. This was

System	Zero carbon future	Energy saving	Service charge	Bills	Capital cost	Sum
1. Individual gas boilers	1	1	3	3	5	13
2. Gas boiler district heating	1	1	2	2	2	8
3. Gas boiler + CHP district heating	1	2	1	1	1	6
4. Gas boiler + ASHP district heating	3	3	1	1	1	9
5. Gas boiler + GSHP district heating	3	3	1	1	1	9
6. Central ASHP + heat network + direct-electric DHW	4	3	2	2	3	14
7. Central ASHP + heat network + individual WSHP	5	4	2	4	2	17
8. Individual ASHP with direct-electric DHW top-up	4	3	5	3	5	20
9. One-stage EAHP + direct-electric heating	4	2	4	2	4	16
10. One-stage EAHP + gas boiler district heating	1	3	2	3	2	11
11. Two-stage MVHR+EAHP	5	5	4	5	4	23
Key considerations:	Grid electricity accessibility; peak demand management; smoothing of demand peaks	Code compliance; standing losses; COPs; source temperature; network temperature	System extent; network losses; component count; interface units; billing system; gas servicing	Energy billed; service charges; standing losses; outsourcing overhead	System extent; component count; construction interfaces; modularisation potential	

Ranking: 1 Poor; 2; 3 Mid; 4; 5 Best

Figure 4: Ranking of systems

because of the reduced envelope area of high-density housing in the UK compared with Germany and the smaller floor areas (which had similar heat gains). A milder climate than that in Passivhaus mid-Germany also helped.

The reduced envelope area allowed significant thermal performance relaxation, meaning fabric enhancements where there is little UK experience and costs are high were avoided. Hence, instead of triple-glazing, high-performance double-glazing is used, and there is a more relaxed envelope air leakage of $2m^3 \cdot m^{-2}$ per hour (at 50Pa test pressure) rather than Passivhaus' 0.6 air changes per hour.

Well-insulated buildings have significantly slower thermal response to low temperatures compared with less insulated buildings. Thus, instead of the current conventional -4°C design external conditions, the conduction component of the heat loss can use the value of -1°C according to other CIBSE advice.[1]

Window area was found to be a critical component, and an optimised area of 30% of the façade was identified as meeting the heating criteria, as well as daylighting and summer overheating criteria.

The enhanced façade thermal performance reduces peak space heating by half, from about $25\text{-}30W \cdot m^{-2}$ to $10\text{-}15W \cdot m^{-2}$ (of floor area).

Key to bringing energy demand down is reducing domestic hot-water demand. Low-flow, high-performance hot water outlets rated under the new European Water Labelled (EWL)[2] system were specified throughout. This included shower heads rated at 'A' at 6L per minute, which, overall, almost halved hot-water demands, and reduced storage needs by around 40%.

The capital cost analysis (see Figure 6) identified the cost implication of the recommended two-stage MVHR+EAHP system. Eliminating all the community heating distribution system and its central plant, associated dwelling heat interfaces, conventional heating-emitter system and associated ancillary systems contributed much of the cost savings.

Add-back costs include the two-stage MVHR+EAHP, as well as the selective building envelope enhancements. Even including the building fabric enhancements, overall potential capital cost savings of around £100 per m^2 were identified, equating to 3.3% of overall construction costs for a typical high-density housing scheme at £3,000 per m^2.

Summary

By using a 'heat autonomy' approach, harnessing internal heat gains as the main heat source, delivering heating and hot water using two-stage MVHR+EAHPs for new, high-density housing has the potential for:

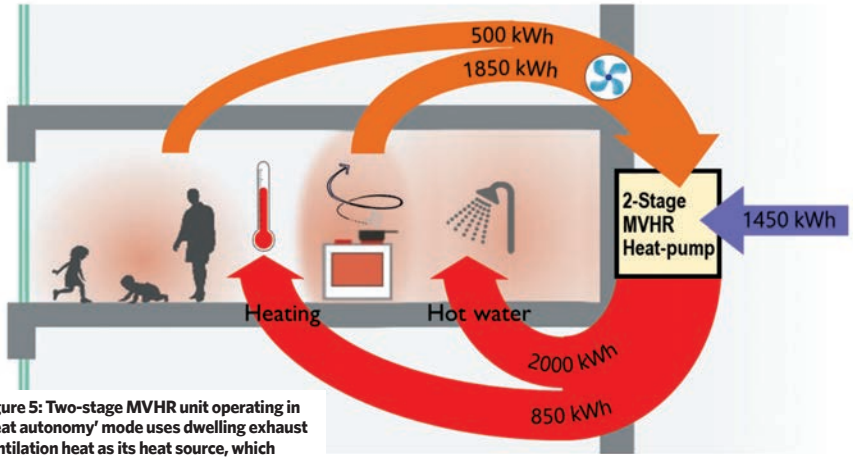

Figure 5: Two-stage MVHR unit operating in 'heat autonomy' mode uses dwelling exhaust ventilation heat as its heat source, which it recycles and upgrades, powered from a standard dwelling 13A electrical supply

> "A stripped-down version of Passivhaus was found to deliver a capital cost sweet point"

- Greater than 50% carbon savings compared with Part L
- 35% reductions in heating and DHW installation costs
- 25% reduction in energy bills
- Future-proofed for zero carbon
- Using readily available and proven components for market acceptability.

As a postscript, the heat autonomy approach is being implemented on various large developments in London where the Energy Assessments submitted to the GLA are indicating 70% savings against Part L using SAP 10 carbon emissions factors – albeit these are calculated using SAP's simplistic assessment of heat pump COPs. **CJ**

CHRIS TWINN FCIBSE is a consultant at Twinn Sustainability Innovation

1 CIBSE A2.1 (1986), External Design Dry-Bulb Temperatures Table 2.1. Explains how different design conditions can be selected based on building thermal response.

2 European Water Label for appliance and outlets. **bit.ly/CJNov19lab** (accessed 13 February 2019).

Summary of capital cost balance		
Reduced capex costs:		**£ per m^2**
1	Omit boilers and CHP plant, including controls and electrics	**-£118**
2	Omit associated mechanical plantroom spaces	**-£8**
3	No gas supply and metering	**-£11**
4	Eliminate hot water mains pipework system	**-£50**
5	Omit associated risers and ceiling space	**-£1**
6	Reduce storey height and cladding area	**-£18**
7	Eliminate dwelling underfloor heating systems	**-£38**
8	Omit dwelling heat interface units	**-£14**
9	Eliminate stand-alone MVHR in each dwelling	**-£21**
10	No hot water metering and billing systems	**-£4**
11	No boiler/CHP flues	**-£5**
12	Reduced summer overheating measures	**-**
13	Reduced GLA carbon offset payments	**-£10**
	Sub-total reductions	**-£298**
Increased capex costs:		
1	Increased envelope insulation: U-value ≈$0.12W \cdot m^{-2} \cdot K^{-1}$	**+£43**
2	Treating thermal bridging	**+£14**
3	Double glazing enhanced: U-value ≈$1.2W \cdot m^{-2} \cdot K^{-1}$	**+£14**
4	Envelope airtightness: ≈2 acph	**+£7**
5	Two-stage MVHR unit in each dwelling	**+£116**
	Sub-total additions	**+£194**

Based on development of around 440 apartments of 80m^2 average floor area

Figure 6: Heat autonomy capital cost implications. These estimates are presented as 'add and omits' to a standard project cost plan, and indicate overall costs saving of around £100 per m^2

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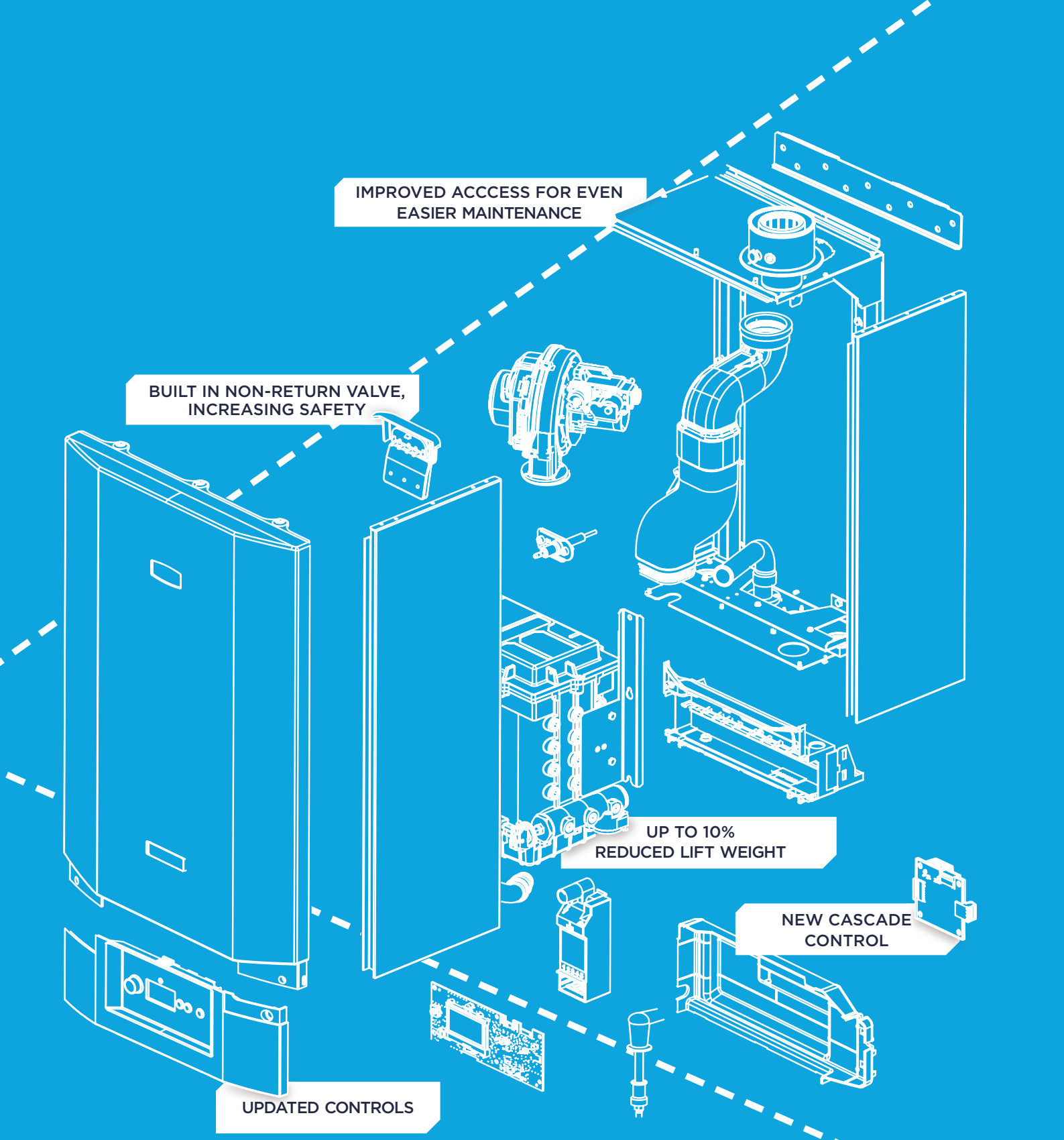

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A CONDENSING GUIDE TO CHP EFFICIENCY

CHP can offer savings in applications with high, constant heat demand, but how designers integrate it will impact on the benefits. Remeha's **Ryan Kirkwood** considers the options in the first of a two-part series

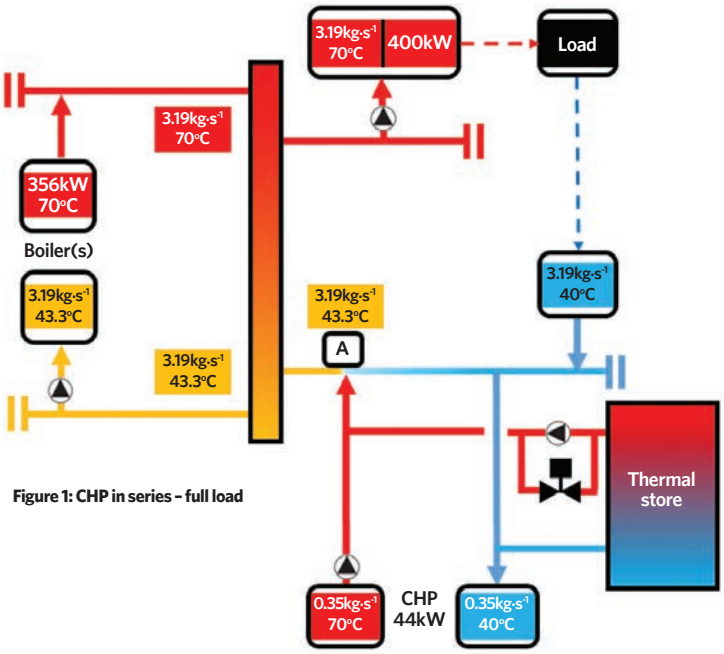

Figure 1: CHP in series – full load

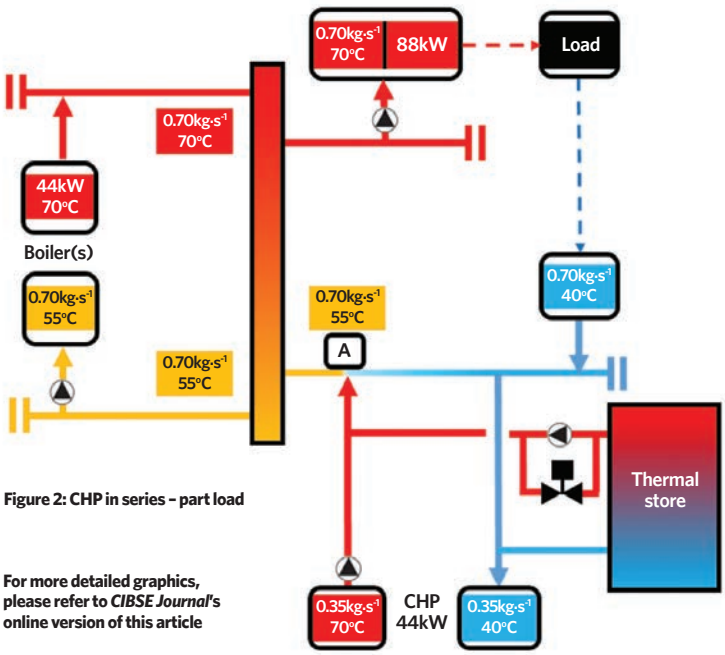

Figure 2: CHP in series – part load

For more detailed graphics, please refer to *CIBSE Journal*'s online version of this article

When integrating combined heat and power (CHP) into new-build and retrofit projects, the most common approach is to use it in series with boilers. This offers a consistent way for the CHP to see load, working as a preheat for boilers when demand is beyond the CHP's reach. It can also mitigate the risk of a high return being fed back to the CHP.

However, during certain load conditions, a series connection can remove the boilers' ability to condense and decrease their efficiency.

We can understand this better with a node-by-node analysis of a typical CHP and boiler set-up, with the CHP sized at approximately 10% of an assumed 400kW peak load (see Figure 1).

This design assumes a flow of 70°C and return of 40°C, which is within the condensing bracket for both boilers and CHP (where the CHP can condense). As the CHP sees a portion of the 400kW load, the 70°C flow from the CHP will increase the boiler return water temperature to 43.3°C at node A.

The smaller temperature difference, or ΔT, reduces the load on the gas boilers, decreasing the firing rate and cutting gas consumption. However, the rise in return water from 40°C to 43.3°C will also affect the boilers' condensing operation, lowering overall boiler efficiency by approximately 2%.

Using the same baseline conditions as in Figure 1, we can see in Figure 2 an assumed part load of 88kW. This example shows the boilers receiving return water at 55°C generated at node A. The higher temperature restricts the boilers' ability to fully condense, reducing efficiency by up to 7%.

In some cases, a minor rise in return temperature at full load can be accepted, as the CHP mass flow rate is small compared to the system return volume. During part load, however, the rise could drastically impact the efficiency of the major source of heat.

As a CHP unit only delivers savings when it is running, carrying out a feasibility study and checking the heat and power demand profiles is critical, as is ensuring that heat is fully used without dumping into the atmosphere.

However, for condensing arrangements, the boilers must also be able to operate in condensing mode. This cannot be achieved practically or fully in preheat-style series designs, as a result of return water blending. For this, a modified parallel arrangement would be required.

By introducing this, we enable hydronic separation between different heat generation »

» devices (see Figures 3 and 4), and separate the heat load from generation via a low loss header with flow and return headers attached.

Applying the same nodal analysis as in Figures 1 and 2, under the same system conditions, there is no preheat to the return water back to the boilers. Both the CHP and boilers are receiving 40°C return and maximising efficiency via condensing operation.

During load transition, there may be a period where the combined primary flow of the boiler(s) and CHP is more than system load. In the low loss header forward flow then occurs, reducing the boilers' ΔT initially prior to them modulating. However, the CHP will continue to condense, isolated from the high temperature return. Based on this design, the main advantage is that, at part load conditions, the additional heat required by the boiler to meet system demands is fully condensing, giving maximum efficiency.

It is important to note that the system philosophy must be qualified prior to application on new and existing systems. As a modified parallel arrangement assumes variable flow on both primary and secondary, with close control load ΔT, older, non-condensing systems with retrofitted CHP will benefit more from a series arrangement. Careful analysis of nodes, temperatures and flow rates is needed to fully understand where the CHP will best fit to improve all heat generation efficiency.

We can also explore the benefits of a thermal store to deliver more heat for longer. Both two-port and four-port stores offer a means of releasing heat stored via charge from the CHP. In a four-pipe store, the CHP flow constantly interfaces with the thermal mass in the tank, while a two-pipe store allows the CHP to bypass the tank straight to load.

In both cases, the discharge pump (shown after the thermal store on Figure 4) can control actively if the tank is charging, discharging or in equilibrium. It does this by adjusting flow rate while observing temperatures in the tank as the thermocline moves.

Most manufacturers will recommend a four-pipe configuration, as the heat source always interacts with the thermal store – this works best under steady state loads. It also adds another layer of protection for the CHP and allows for more flexibility with tank pipework. But where applicable, a two-pipe configuration can be used to allow direct online flow for the CHP at the expense of a slightly more constrained installation. In both examples, this methodology allows for full condensing operation of the CHP and boilers throughout the entire load range without sacrificing the efficiency of either.

This article describes how we approach CHP and boiler design for optimal efficiency, but it is important that the following are considered prior to application: is the overall system condensing? Does the system have a fixed or variable flow rate? Are the boilers condensing or non-condensing? Do the boilers have fixed or variable speed pumps and what controls them?

While there is no 'one-size-fits-all' solution with CHP, applying the right methods at the right time will set you up for project success. CJ

RYAN KIRKWOOD is specification manager at Remeha. Part two of this series, published in spring 2020, will explore thermal store sizing and controls

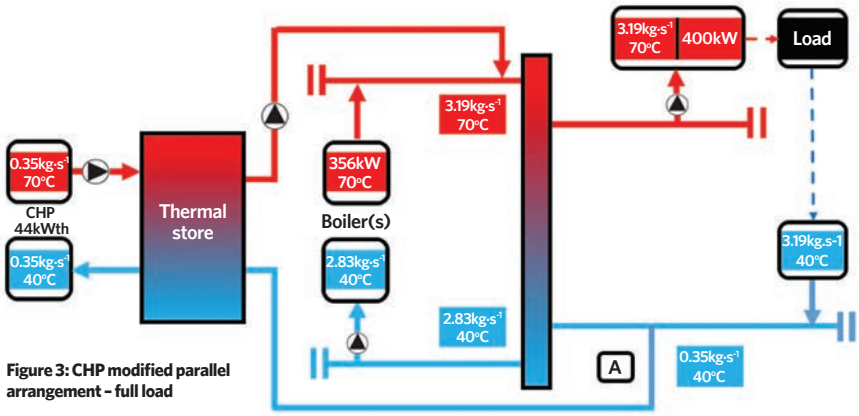

Figure 3: CHP modified parallel arrangement – full load

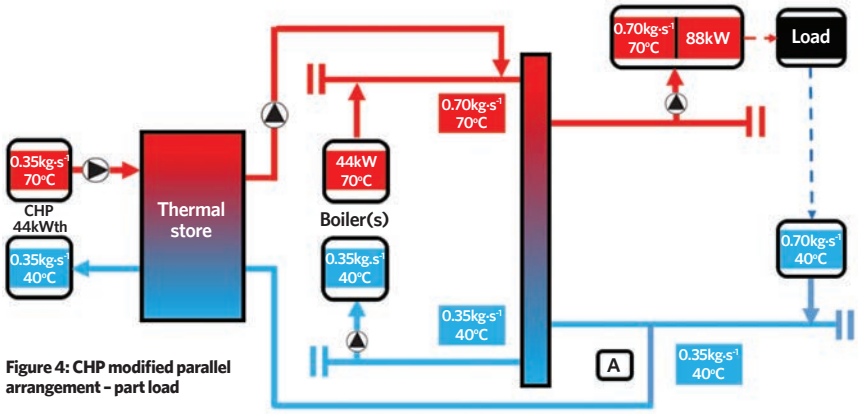

Figure 4: CHP modified parallel arrangement – part load

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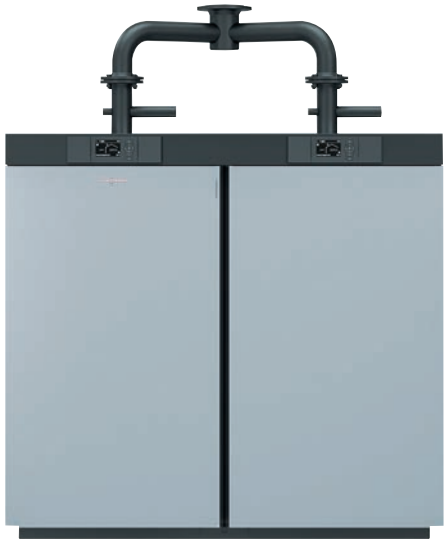

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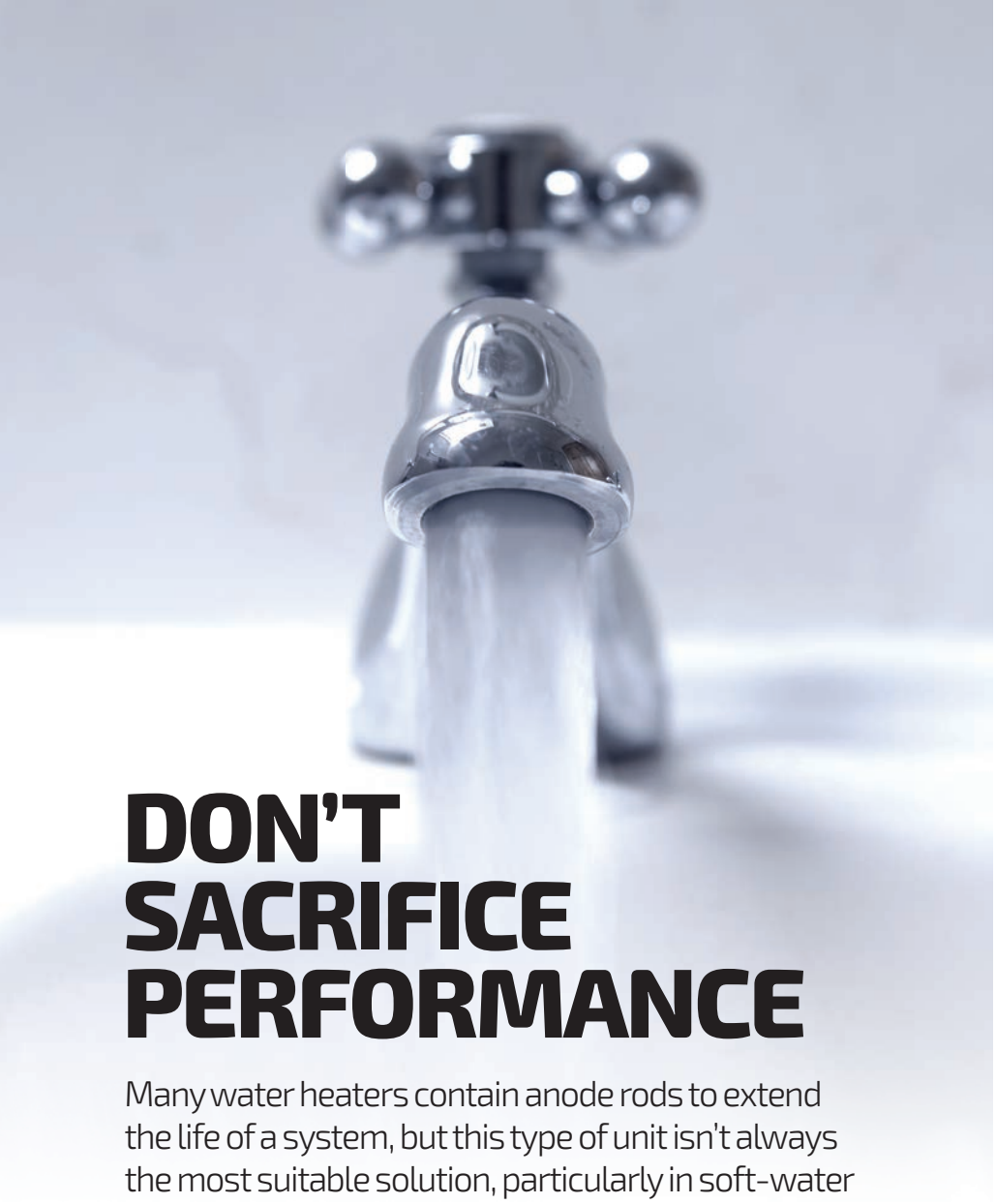


DON'T SACRIFICE PERFORMANCE

Many water heaters contain anode rods to extend the life of a system, but this type of unit isn't always the most suitable solution, particularly in soft-water areas, says Heatrae Sadia's **Alan Clarke**

Many electric water-heating products and cylinders available on the market use sacrificial anodes on steel glass-lined and low-grade stainless steel tanks.

A sacrificial anode is a highly active metal – often magnesium – which is present within a hot-water cylinder and used to protect a less active material surface (the casing of the cylinder) from corrosion. Water within the unit attacks the anode, causing oxidisation and consequent corrosion, but protecting the inner shell of the cylinder – hence the 'sacrifice'.

Water hardness

Water quality – and hardness, in particular – can have an effect on any water appliance, whether that be by leaving residue on taps or showers or contributing to corrosion in water pipes and boilers. Water hardness varies considerably across the UK. Scotland and Newcastle, for example, have soft water, whereas London and Norwich have to contend with hard water.

While sacrificial anodes can work well when installed in hard-water areas, this isn't always the case in soft-water areas. It all comes down to conductivity. Soft water has low electrical conductivity, so the reaction that should take place between the sacrificial anode and cylinder shell does not.

On initial inspection, the anode could appear to be in good condition. There is the possibility, however, that corrosion has already started on the tank itself, with the anode unable to be sacrificed as intended because of the water conditions. In this scenario, a powered anode or a different cylinder would be required. A powered anode is often made of titanium. Instead of being sacrificed, a low electrical current is produced in the water to prevent corrosion and damage to the anode.

Ownership cost

The maintenance of a unit with an anode can be more demanding than for one without, with visual inspection required every six months. Once the anode has been damaged to a certain extent, it has to be replaced.

If the anode is not replaced, damage to the cylinder can be considerable, leading to potential leaks. So while the initial capital cost of these products is often considerably lower than systems without anodes, their long-term costs can be significant because of maintenance requirements.

As an alternative, particularly in soft-water areas, specifiers should consider cylinders that use materials for the inner vessel that are corrosion resistant, removing the need for an anode altogether. Products using high-grade copper or stainless steel have low reactivity and are less susceptible to corrosion in water.

Additional considerations

In a sector where we are increasingly striving for a circular economy and considering the waste and reuse of material resources, it makes environmental sense to seek out heating and hot-water products that prioritise efficient performance and longevity.

While anodes take on damaging chemical reactions to preserve the overall life of a water heater, there will – as with any corrosion – be some residue from the process. The quality of water in the tank can be affected by this corroded residue from the anode, which can be delivered at the tap outlets if disturbed.

There can also be a distinct smell of sulphur from water heaters with an anode because of the chemical reaction that takes place between the water and the magnesium.

Ultimately, there is a place for systems that include sacrificial anodes, powered anodes or no anodes at all. As with any piece of equipment, there is rarely a one-size-fits-all solution, but taking local water composition into consideration before any decisions are made is likely to result in a lower total cost of ownership. CJ

ALAN CLARKE is a technical support manager at Heatrae Sadia

Cost model

Data centre cooling

In this month's cost model, Aecom's engineering services cost-management team explores the options for cooling large data centres – from traditional air cooling with chiller and Crac units, to free cooling and water-based systems

Cooling of data centres has evolved from cooling small clusters of servers to giant server farms. While these modern large data centres are vital components of the information services economy, they consume a formidable amount of energy worldwide.

It's been widely documented that the cooling systems – the chiller, humidifier and computer room air conditioning (Crac) units – account for 45% of the total energy consumption of a data centre, while the IT equipment accounts for 30%. This means that 1kWh consumed by the IT equipment requires another 1kWh of energy to drive the cooling and auxiliary systems.

From environmental and cost-efficiency perspectives, selecting a cooling method that can reduce this energy demand is clearly beneficial.

Traditionally, data centres have been air cooled with chillers, humidifiers and Crac units, in a variety of 'cold aisle/hot aisle' approaches that aren't terribly efficient and that can result in hot spots within the data hall.

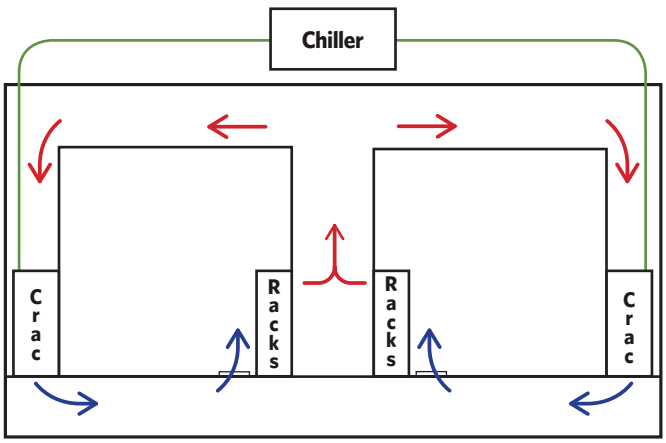
Over the years, server equipment has become more resilient and can now tolerate a greater range in temperature and humidity levels than older technology allowed. These days, legitimate alternatives to cooling are routinely considered in most data centre projects looking for greener and more efficient strategies.

Currently, in the northern hemisphere, air-cooling solutions are looking more towards free cooling, which works by using air from outside combined with reclaimed heat (winter) and evaporative cooling (summer) to provide the total cooling solution throughout the year.

Water-based cooling options are a more modern approach, and cool the inside of the servers by pumping cold water through pipes or plates. Water-cooled rack systems work well, but have an inherent risk of leaks. Understanding the cost drivers and benefits of each are crucial to advising clients effectively.

There are many factors that drive the selection of any particular option, not least capital and life-cycle costs, but also the location of the data centre and the feasibility of incorporating innovations such as free cooling or aquifer thermal energy storage (ATES).

Parameters that drive these decisions include the requirement for power usage efficiency (PUE) levels to hit planning stipulations, and for acoustics and total cost of ownership (TCO) levels to be optimised.



Air cooling by chiller and Crac units

PUE measures how efficiently the data centre uses input power – the larger the number the less efficient the solution. In addition, the selected method of supplying power and power resilience play a role in the PUE calculations – and, hence, in reality, the overall cooling and power solution combined is what is considered against the criteria to finalise the preferred solution for the client.

In this article, we are looking solely at the merits of three cooling solutions that are currently being used on projects, to ascertain the cost drivers of each and understand the cooling-only related costs. These are: air cooling by chiller and Crac units; air cooling by indirect air cooling (IAC) air handling plant; and chilled-water cooling derived from free-cooling, hybrid cooling towers with chiller assist.

Any power-supply solution, associated building works and main contractor prelims are excluded.

Air cooling by chiller and Crac units

This chilled-water solution serves Crac downflow units typically serving cold air to the data hall white space through a floor void. Crac units normally include humidification elements to control the static electricity and all hot air is redirected back into the Crac to remove the heat for redistribution into the white space.

The source of the cooling water is via a traditional refrigeration chiller located externally, usually on the roof. There is no free cooling and chillers are sized for full peak load.

Air cooling by indirect air cooling AHU

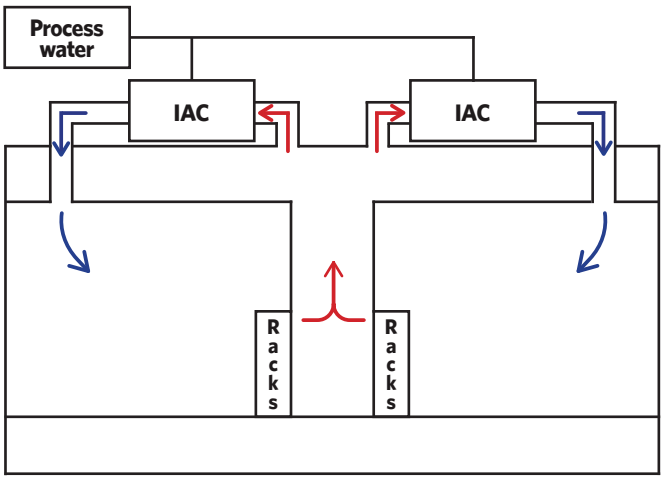
This 'all air'-based cooling solution incorporates air handling plant mounted externally to the white space. Treated air is distributed to the white space via ductwork or through a plenum. Air is supplied at a relatively low velocity to the cold aisle, giving more control than traditional floor-void distribution.

The hot air is returned to the IAC via ductwork and is cooled by the outdoor ambient air at a plate heat exchanger. To assist the cooling process during warm months, the ambient air is adiabatically cooled (water evaporation), which then cools the warm air at the plate heat exchanger in the IAC unit. The water used for adiabatic cooling is bulk-stored in the event of a mains supply outage. The process water is distributed from a central pump plantroom to the IAC units.

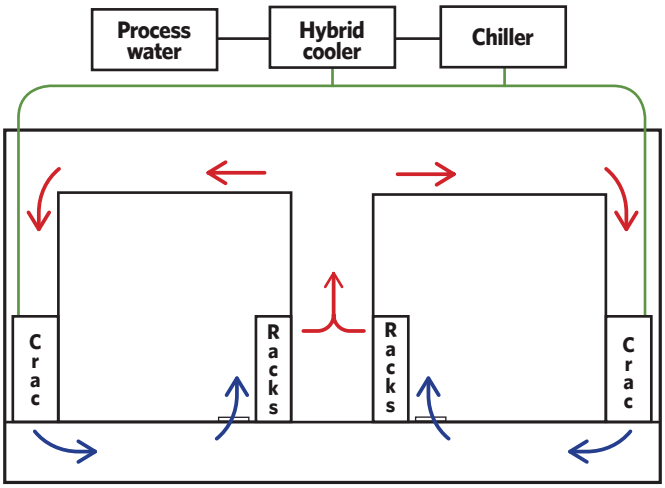
Chilled-water cooling derived from free-cooling, hybrid cooling towers with chiller assist

This chilled-water solution serves Crac downflow units typically supplying cold air to the white space through a floor void. »

> "Many factors drive the selection of any particular option, not least capital and life-cycle costs, but also the location of the data centre"



Air cooling by indirect air cooling AHU



Chilled-water cooling derived from free-cooling hybrid cooling towers with chiller assist

Table 1: Benefits and drawbacks of three data centre cooling systems*

	1 Traditional	2 Indirect air cooling	3 Cool water with chiller assist
Method	Air cooling with chiller and Crac units	Air cooling	CHW cooling with free cooling
PUE range (cooling only)	1.4 to 2.0	1.1 to 1.3	1.1 to 1.3
Pros	Tried and tested Simple controls methodology	Proven technology No risk of leaks in white space Limited maintenance needed Cost-effective for low PUE Better control of supply air distribution	Flexibility for distribution Higher achieved white-space ratio Simple controls methodology
Cons	Hot spots, inefficient Highest PUE range 24/7 operation required No free cooling	Acoustic challenges Impact on net white space for ducts Reduced flexibility in distribution Space for bulk water storage required IAC plant located close to data hall	Large plant space required Increased risk of water leaks Large bulk water storage required Higher maintenance costs

* All based on 1500W·m^{-2} IT load density requirement; Tier III certification. Based on experience of designing data centres

Table 2: Cost comparison of cooling methods in a 3,000m^2 data centre

Notional data centre			
Net technical space (m^2):	3,000	(Four data halls)	
Load density (W·m^{-2}):	1,500		
IT load (kW):	4,500		
Cost/kW of cooling installation	**Crac units and chiller** (£/kW)	**Indirect air cooling** (£/kW)	**Crac units and hybrid cooler with chiller assist** (£/kW)
Crac units (N+2)	240		240
Air-cooled chillers (N+1), including CHW pipework distribution, pumps and other associated plant	890		
IAC units (N+2)		760	
Process water installation to IAC units, including water storage tanks, pumps, water treatment. Supply and return ductwork to IAC units, including attenuation		220	
Hybrid cooler (N+1), water-cooled chillers (N+1), including CHW pipework distribution, process water storage tank and pipework distribution, pumps and other associated plant			1,130
BMS controls and power supplies to above mechanical plant	320	280	350
Total £/kW of cooling installation	1,450	1,260	1,720

Notes on the above cost:

- Hot/cold aisle containment is excluded
- Main contractor prelims and OHP are excluded
- Building/structural/architectural works, dedicated fresh air systems, and electrical infrastructure are excluded

» The source of the cooling water is via 'free cooling' cooling towers located externally, usually on the roof. Ambient air is used to cool the warm return water from the Crac units, with adiabatic cooling added during the warmer months.

At peak times, when approaching the towers' cooling-load limits, refrigeration chillers are used to run in parallel with the cooling towers.

Table 1 is a summary of the pros and cons of each system. Bear in mind that numerous factors work in tandem within any given solution; for example, net-to-gross area, efficiency, power load, capital expenditure (capex) cost, and total cost of ownership (TCO) combine to determine the best solution for the client. Always make sure defined parameters are set to allow measurement of any solution against these critical factors. This will ensure the best-fit solution can be determined.

In reality, most data centres use air- or water-based cooling solutions, and this is where our cost comparison has focused. The future is already in place, however, with some clients opting for immersion cooling, by which servers are immersed into a liquid coolant for direct cooling of the electronic components. Immersing servers has been shown to improve rack density, cooling capacity and other design-critical factors.

Test projects where data centres are located in the sea could result in some significant changes in this industry in the future. Aecom is carrying out advisory work with Atlantis, which proposes to build a data centre on the site of its tidal-energy centre, off the coast of Scotland. It demonstrates how high-power-demand data centres could help fund the emerging tidal-power sector, thereby contributing to the future decarbonisation of the data centre sector. CJ

ABOUT THE AUTHORS

This article has been written by Associates Nichola Gradwell and James Garcia, of Aecom's cost-management team in London, with assistance from Mike Starbuck and Anirban Basak, of Aecom's engineering team.

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Air flow (m³/s x 1,000)

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22
19
16
14
11
5.5
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Professional

0.21 m³/s
up to 40 m³/s

D-AHU
Modular R

0.13 m3/s
up to 6.95 m3/s

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0.13 m³/s
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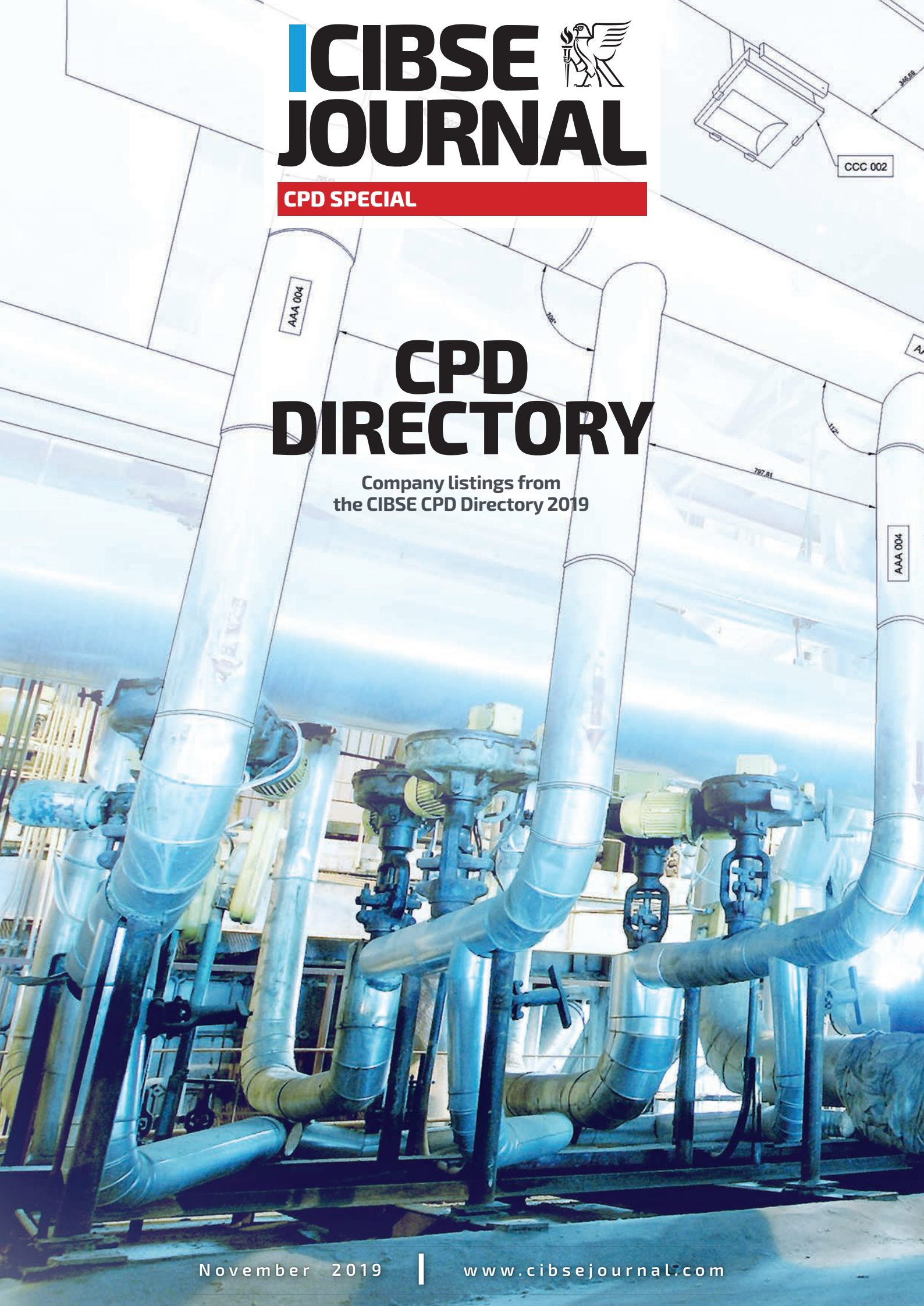
CIBSE JOURNAL

CPD SPECIAL

CPD DIRECTORY

Company listings from the CIBSE CPD Directory 2019



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

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

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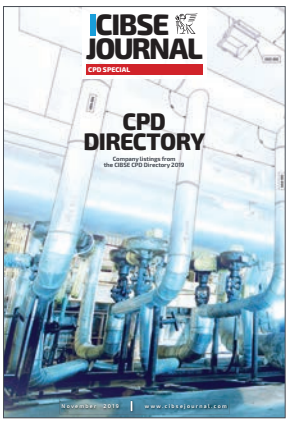


What it takes

Undertaking continuing professional development (CPD) is a fundamental part of being a professional engineer. This valuable part of professional development is vital to ensure that knowledge and skills are up to date as you progress through your career, and it reflects your willingness to maintain industry relevance.

More ownership has been placed on professional bodies, such as CIBSE, to push the importance of CPD among their members.

In her Independent Review of Building Regulations and Fire Safety report, Dame Judith Hackitt calls for greater consistency in the way competence is assessed and verified. She recommends that, as a minimum, any body that 'accredits' competence should, themselves, be accredited by a rigorous, publicly recognised and accepted method.

She also recommends the establishment of an overarching organisation to oversee competence requirements and support the delivery of competent people working on higher-risk residential buildings.

Members of CIBSE make a commitment to maintain their competence through CPD. To assist them, CIBSE – as a professional engineering body that exists to give members and the public first-class knowledge and information – offers a diverse range of opportunities to maintain CPD.

CIBSE continually generates knowledge for the building services community. This is available in different forms, supplying engineers with content through a host of channels to suit their needs, including traditional guides and publications, as well as online learning courses and webinars, which provide greater flexibility. Well-crafted and professionally delivered CPD offers benefits to the individual, their profession and the public.

Employing professionally registered engineers allows companies to enter bid submissions that are able to demonstrate the competence of their staff – for instance, as registered engineering technicians, incorporated engineers and chartered engineers. This can help them win contracts, as well as hire talented engineers.

It's no coincidence that those companies that invest in supporting and mentoring their staff's professional development and training are also the ones that benefit from attracting and retaining industry talent – and that realise more motivated and confident employees.

For individuals, maintaining CPD ensures knowledge and skills are kept up to date as they progress through their career, and can provide proof of their credentials. In today's uncertain economic climate, it can be what puts them ahead of the competition.

CIBSE Journal can also support you with your professional development, with the regular, monthly CPD modules, as well as sponsored webinars, which are available on demand at **www.cibsejournal.com**

Within this special section, you will find listings from some of the 250 companies currently listed in the directory of CPD course providers. This directory has been compiled to assist members in identifying suitable courses to meet their CPD needs. All courses and seminars are reviewed by CIBSE to ensure that the technical content is of a high standard and offers valuable CPD to delegates.

A full list of those companies on the directory can be found at **www.cibse.org/cpddirectory**

Carilyn Burman is director of membership at CIBSE

For a list of all companies on the CIBSE CPD Directory, visit **www.cibse.org/cpddirectory**

ACV – domestic hot-water systems

Phone: 01383 820100
Email: uk.sales@acv.com
Web: www.acv.com/gb

Mechanical

ACV has been designing, developing, manufacturing and distributing heating and hot water products for commercial and residential heating applications since 1922.

The company is a specialist in stainless steel and home of the patented tank-in-tank concept, which it claims gives a reliable domestic hot water (DHW) performance to match the largest of demands. ACV's motto is 'excellence in hot water', which reflects its product range, as well as the support and knowledge it offers, says the company.

While heating requirements have decreased over the years, the demands of modern life have increased the need for a reliable, but economical and environmentally friendly, hot-water supply.

ACV has been delivering CIBSE-accredited CPD seminars for many years, sharing its specialist hot-water knowledge. This CPD training is aimed at anyone involved in the management of hot water in commercial buildings, including consultants, contractors, public health engineers and specifiers.

The following courses are currently available: Domestic hot water (DHW) sizing principles; and tank-in-tank technology explained.

Alfa Laval – heat exchanger technology

Phone: 01276 413627
Email: Gemma.reeves@alfalaval.com
Web: www.alfalaval.com

HVAC solutions

Since 1883, Alfa Laval products and solutions have been involved in treating water, reducing carbon emissions and minimising water and energy consumption, as well as in heating, cooling and separation. These areas represent the core of Alfa Laval's expertise.

The world has never been more focused on saving energy and protecting the environment, and Alfa Laval is committed to these goals. As a global supplier of products and solutions, the company is engaged in crucial areas such as energy optimisation, and its worldwide organisation currently helps customers in nearly 100 countries to optimise their processes. As a company that seeks to focus on innovation, Alfa Laval offers a range of CPD-certified, free technical seminars, which can be held at a client's site at a convenient time to help the organisation learn more about certain key areas.

Topics include: AHRI – what it is, and how system efficiency can be affected by very small changes in the design of the heat exchanger; and heat-transfer theory – an introduction to heat-transfer theory and how it relates to heat exchangers.

Coming soon are CPDs on plate heat exchanger technology and brazed heat exchanger technology.

Andel – leak detection

Phone: 01484 845 000
Email: help@andel.co.uk
Web: www.andel.co.uk

Mechanical

Since 1992, Andel has been helping companies protect their built and natural environments from disaster. It offers expertise in the field of leak detection for water and refrigerant gas systems, with thousands of installations throughout the world carried out directly and through its network of agents.

Andel's products are instrumental in protecting institutions like the British Museum, the Tate, art installations by Damien Hirst, and a growing number of premier apartments, such as 11-15 Grosvenor Crescent, The Footman's Apartments (Buckingham Palace) and the historic Victoria Mills in Shipley, West Yorkshire.

Andel has designed and built its own range of products and services in the UK, and its key staff deliver the firm's CPD offerings so customers can be assured that they are getting the information they need from the source.

The CPD courses run over a lunch break, with a light lunch provided, and cover physical hardware, installation and the theory around leak detection. Participants have the opportunity to build their own leak detection system and test it live.

Armstrong Fluid Technology – HVAC system solutions

Phone: 08444 145145
Email: uksales@armstrongfluidtechnology.com
Web: www.armstrongfluidtechnology.com

Mechanical
HVAC solutions

As a global HVAC company, Armstrong Fluid Technology designs and manufactures innovative fluid-flow equipment and high-efficiency energy solutions for a broad range and scale of applications, including district energy, data centres, fire systems, gas transmission, and high-rise and mixed commercial buildings.

Integrating mechanical equipment and digital controls, Armstrong solutions aim to deliver optimum lifetime building performance with the lowest first cost and life cost. Armstrong is committed to assisting building owners, consultants, specifiers and energy managers find innovative, low-cost solutions for reducing energy consumption and carbon emissions within their property portfolios.

Its expertise comes from an understanding of end-to-end fluid systems and the integration of fluid dynamics, heat transfer, variable speed, and demand-based controls, which is the focus of its CPD programmes:

- **A whole-life sustainable approach to pump and equipment selection without compromising on redundancy**
- **Meeting the needs of the building life-cycle through innovative approaches to variable speed pumping in HVAC systems.**

Armstrong can give free one-hour 'lunch and learn' sessions at clients' offices or at any of its UK sites.

Delmatic – advanced lighting-management systems

Phone: 020 3184 2000
Email: cpd@delmatic.com
Web: www.delmatic.com

- Electrical
- Lighting

Delmatic is a supplier of advanced lighting management systems that aim to reimagine and redefine lighting control within major international projects. Its smart solutions mesh wireless and wired devices across physical or cloud networks, monitoring, analysing and optimising lighting and connected building services performance.

Systems are designed to conserve energy, enhance sustainability, increase comfort, simplify installation, reduce capital and operational costs, and make advanced controls intuitive and accessible to all. According to Delmatic, cutting-edge sensors and controllers combine with powerful visuals, analytics, user interfaces and apps, while application of Lon, BACnet, Dali-2 and IP promise unparalleled monitoring and insights.

Delmatic offers a selection of CIBSE-certified CPD modules ranging from overview seminars to focus sessions. **Modules include:** Overview of lighting management; IoT, wired, wireless and mixed-mode solutions; Dali-2 technology, features and roadmap; Dali-2 application – buswire, broadcast, plug-in and wireless; Dali-2 emergency light testing and monitoring; wired, wireless and mixed-mode solutions; systems architecture and application; smart, integrated solutions; biodynamic tuneable-white control; graphical management and monitoring; heatmaps, spatial occupancy mapping and dashboards.

Domus Ventilation – mechanical ventilation in residential new-build

Phone: 03443 715523
Email: vent.info@domusventilation.co.uk
Web: www.domusventilation.co.uk

- Mechanical

'Residential ventilation principles and best practice' is a CIBSE-accredited CPD from Domus Ventilation that focuses on the importance of mechanical ventilation in the residential new-build industry, in line with Part F of Building Regulations.

The aim of the short course is to explain clearly why ventilation is so important, not only for the health of the occupant, but also for the fabric of the building. Topics covered include why ventilation is necessary; the different types of ventilation available, as well as supporting ductwork and installation practices; and the pertinent regulations/directives relating to this. The course is designed to provide participants with an understanding of what needs to be considered when specifying a mechanical ventilation system and the appropriate project stage.

The CPD runs between 45-60 minutes and can be conducted at a customer's premises or at one of Domus Ventilation's two training centres. To book a course, contact the team by email or phone.

Hamworthy Heating – hot-water and heating

Phone: 01202 662500
Email: enquiries@hamworthy-heating.com
Web: www.hamworthy-heating.com/CPD

- HVAC solutions
- Mechanical
- Sustainability

British commercial boiler manufacturer Hamworthy Heating supplies energy-efficient commercial heating, hot water and renewable solutions to commercial buildings of all shapes and sizes across the UK.

Since introducing the concept of modular boilers in the 1960s, Hamworthy has been at the forefront of the commercial heating market, and the firm is committed to sharing its industry knowledge and best practice with its customers. Each of its CPD presenters has years of experience in the HVAC industry with relevant professional qualifications.

Hamworthy offers the following CIBSE-accredited CPD courses: Best practice heating and hot water plant refurbishment; energy saving in commercial heating and hot water; domestic hot water (DHW) best practice (three modules); new boilers on old systems – hydraulic separation.

These courses are beneficial for anyone wishing to understand the latest industry developments and discover new ways to add value, performance and efficiency to commercial heating and hot water projects.

Ideal Commercial Boilers – specialist heating

Phone: 0844 543 6060
Email: commercial@idealboilers.com
Web: www.idealcommercialboilers.com

- Mechanical

Operating from its Hull manufacturing plant and offices since 1906, British manufacturer Ideal Commercial Boilers continues to deliver a range of high-efficiency commercial heating solutions.

Its years of experience in designing and manufacturing commercial boilers for the UK market have gone into the current range of condensing commercial boilers. Whether choosing a wall-hung or floor-standing model, the product comes with more than 100 years of knowledge and skill as standard.

Ideal Commercial Boilers offers the following CIBSE-accredited CPD courses:

- **An introduction to plant room surveys**
- **A review of commercial boiler heat exchanger materials.**

Ideal Commercial Boilers' team can visit clients' offices to deliver a CPD course – which lasts around one hour – or those wishing to take the course can arrange to come to one of the firm's Training Centres of Excellence in Leeds or Reading.

Jeremias – good flue design and current design standards

Email: mike.griffiths@jeremias.uk
Web: www.jeremias.uk

- HVAC solutions
- Mechanical

Jeremias is offering a 'Good flue design and current design standards' CPD for architects, consultants, and M&E contractors. It has been designed to deliver an understanding of current standards and regulations relating to flue installations that all flue manufacturers should follow as per IGEM/UP 10 Edition 4 (with amendments March 2016 and February 2017), BS6644, and the Clean Air Act and its associated memorandum.

It covers: General overview of combustion – what does a boiler require for complete and proper combustion; design – system calculations; plantroom design, CE marking, boiler positioning, consideration of plant selection; regulations and standards – IGE/UP 10 Edition 4 (with amendments March 2016 and February 2017), Clean Air Act and associated memorandum, radius of concern/termination heights, types of appliances – condensing, pressure-jet, duel-fuel, high-efficiency, CHP and generators, biomass and biogas; types of flue systems – conventional, fan-assisted and fan-dilution; construction of flue – advantages of using Jeremias products, sample product range, single wall (EW-ECO), twin wall (DW-ECO), flanged (DW-FS).

The one-hour CPD encompasses the variety of flue systems, factors that influence performance, and principles of design, heat loss and draught production. Delegates receive a CIBSE certificate towards their CPD hours.

Kohler – UPS

Phone: 01256 386700
Email: uksales.ups@kohler.com
Web: www.kohler-ups.co.uk

- Electrical

Kohler Uninterruptible Power (KUP), formerly Uninterruptible Power Supplies Ltd, has extensive knowledge and experience of designing, specifying, configuring, installing, commissioning and servicing power protection solutions across a wide range of applications. Aimed at consultants and electrical engineers, KUP offers a number of free 'Lunch and Learn' technical seminars that can be held at a client's site. KUP also runs full-day UPS Training Academy courses across the UK that are free to attend and CPD certified. These are suitable for graduate engineers and those looking to refresh their knowledge of UPS.

The courses are designed to improve understanding of the most recent power protection specification and selection requirements, and the latest technology available – while, at the same time, offering invaluable CPD hours and points.

Available lunchtime CPD modules include: Designing resilient UPS systems; true N+1 with DPA UPS systems; configuring a UPS battery system for resilience; configuring a UPS system – checklist; UPS – fault clearance and neutral earthing; how does a UPS react to a downstream fault; fault clearance with and without a static bypass; four-pole changeover; and earth leakage.

Lifescience Products – water-treatment

Phone: 01608 811707
Email: info@lifescience.co.uk
Web: www.lifescience.co.uk

- Pipework

Lifescience Products is an expert in physical water conditioning and chemical-free water treatment technologies. Its CIBSE and CIPHE-accredited training seminars benefit from more than two decades of research and development, as well as the company's extensive real-world experience as a manufacturer and distributor of the Water-King range of water conditioners, Lifeline UV Disinfection systems, major-leak detection equipment and the Nova-Flo flood prevention device.

Lifescience Products' courses provide an impartial and detailed insight into a field of technology that's often misunderstood. It claims that attending the 45-minute seminar should provide all of the information needed to specify and install with confidence a non-chemical water treatment device. **These include:** Hard water and its chemistry; the problem with hard water; requirements of Part L and the Domestic Heating Compliance Guide; methods of treatment: how they work/benefits and limitations/location and installation guidance; testing and technological advances.

If you are unable to attend a presentation, you can contact Lifescience Products for technical advice or information on its e-learning courses. Alternatively, you can book a free training seminar.

Lochinvar – commercial heating and hot-water systems

Phone: 01295 269981
Email: info@lochinvar.ltd.uk
Web: www.lochinvar.ltd.uk

- Mechanical
- Public health
- Sustainability

Lochinvar manufactures and distributes a wide range of equipment for commercial and industrial heating and hot water requirements. In 1976, its gas-fired water heater products were among the first of their type supplied in the UK; since that time the range has expanded and developed to incorporate the latest requirements for higher energy efficiencies and lower NO_x emissions.

The company also offers a wide range of commercial heating boilers and renewable solutions including solar thermal and air source heat pumps.

Lochinvar has provided CIBSE-accredited CPD seminars for many years, and current sessions include the following: Heat pumps for commercial heating and hot water applications; integrating renewable technologies with high-efficiency boilers and water heaters; sizing and selection of direct gas-fired water heaters; making the most of integral boiler controls.

These CPD seminars have been developed to be beneficial to anyone involved in design, installation or project management roles for commercial heating and hot water systems.

BEYOND THE MAGIC BOX

CPD on the provision of on demand hot water in commercial sites measured by cost and fuel efficiency and whole of life costings

In the pursuit of the goal of a low carbon economy, engineered by increasing regulation and standards, the decisions governing the choice, specification and installation of different appliances and fuel sources are rapidly changing. The rise of electricity as a promoted 'less harmful' fuel source, in densely populated geographies is seen by many as a solution to reduce carbon and yield a 'greener' industry.

This CPD explores the robust modelling of student accommodation block, utilising a mixture of technologies. The question begs for an answer of multi-solution systems to deliver reduced operational energy, carbon and lifecycle costs.

The results and findings demonstrate that the deployment of multiple technologies may be a major step in the right direction when considering carbon, energy, lifecycle costing and operational expenditure.

Lifecycle cost and operational carbon comparison of various types of heating systems

by **Dr Michael Lim** PhD, BEng(Hons), CEng, MIMechE and **Simon Law** (Hons), CEng, MCIBSE, both of AECOM LTD and **Chris Goggin**, BSc, MEnt of Rinnai UK Limited

Abstract

A real-life case study of a large student accommodation was carried out to investigate the combination of various gas and electricity heating solutions to determine the respective system capital costs and the lifecycle operational cost, fuel consumption and CO2 emission over a 20-year period.

The study demonstrated that the combination of continuous flow hot water heating with a range of gas and electricity space heating results in a relatively more efficient solution in terms of cost, fuel and CO2. The study also highlighted that distribution and storage heat losses present an opportunity for improvement.

The study also includes the impact of projected grid decarbonisation and changes in energy cost going into the future, giving useful insight on the impact of solution choice on lifecycle performance of building heating systems.

Keywords: Lifecycle, continuous flow system, grid decarbonisation, capital cost

1.0 Introduction

A study was carried out to revisit some of the widely-applied conventions of system solutions to identify opportunities for improvement. This paper describes a joint-study to review the various heating systems typically encountered in the industry today.

The study is based on a real life large student accommodation where the application of various combinations of gas and electricity space heating and hot water systems were investigated to determine the respective system capital and lifecycle operational costs, fuel consumption and CO2 emission over a 20-year period.

2.0 Systems

The study compared the baseline system solution of Low Temperature Hot Water (LTHW) gas boiler for space heating and domestic hot water (DHW) generation against alternatives of continuous flow water heaters, electric heating and air source heat pumps. Table 1 outlines the options that were considered.

Table 1 – Solution options investigated

	Space heating	Domestic hot water (DHW)
Baseline	LTHW with gas boiler	Indirect storage with gas boilers
Option 1	LTHW with gas boiler	Continuous flow water heater
Option 2a	Electric resistance	Electric resistance
Option 2b	Electric resistance	Continuous flow water heater
Option 3a	LTHW with air source heat pump	Air source heat pump
Option 3b	LTHW with air source heat pump	Continuous flow water heater

3.0 Building heating demand

The student accommodation block estimated space heating demand was generated using a dynamic thermal model, which equates to 445 MWh/pa excluding storage and distribution losses. The model was run with CIBSE Test Reference Year for London, and complies with the UK Building Regulations Part L 2013 requirements.

The pipe heat loss are applied to the corridors and risers and varied seasonally with the heating demand and adjusted for both mean corridor temperatures as well as for weather compensation. The daily DHW demand is based on a usage rate of 70 l/person/day and a total of 643 persons, amounting to 1733kWh/day (55K lift).

The DHW demand varied seasonally corresponding to typical university term and the incoming cold water temperature is varied in-line with the average ground temperature at 1.5m deep. Overall the annual demand for DHW is around 536 MWh/year, before allowing for storage and distribution losses.

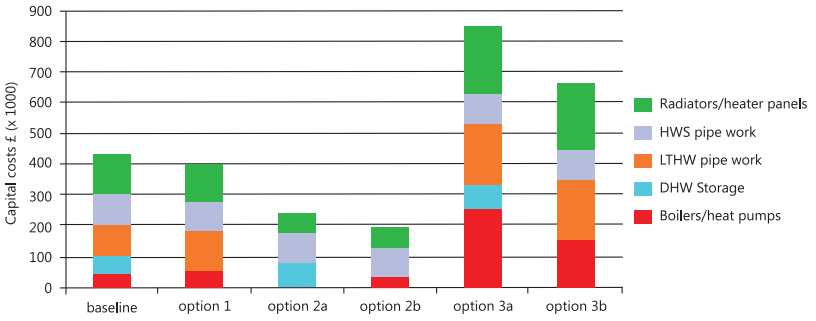
4.0 Results

4.1 Initial and annual costs

Table 2 shows a high-level comparison of annual energy consumption and estimated capital and annual maintenance costs. The options have been ranked (in brackets) for best performance or most favourable solution (bold) and the overall optimal solution is "green" highlighted. A breakdown of the capital costs is shown in Figure 1. Costs are derived from Spon's price book 2017 (1) and data from manufacturers.

Table 2 – High level comparison of anual energy consumption and costs

	Natural gas (MWh/year)	Electricity (MWh/year)	Initial capital costs	Annual fuel costs	Annual maintenance costs
Baseline	1,503	14.8	£432,051 (4)	£50,079 (3)	£875 (4)
Option 1	1,415	13.4	£399,315 (3)	£46,926 (1)	£850 (2)
Option 2a	0	1,178	£241,506 (2)	£148,323 (6)	£300 (1)
Option 2b	759	450	£198,474 (1)	£81,614 (5)	£850 (2)
Option 3a	0	609	£849,595 (6)	£74,273 (4)	£1,575 (5)
Option 3b	759	210	£698,773 (5)	£49,413 (2)	£2,125 (6)



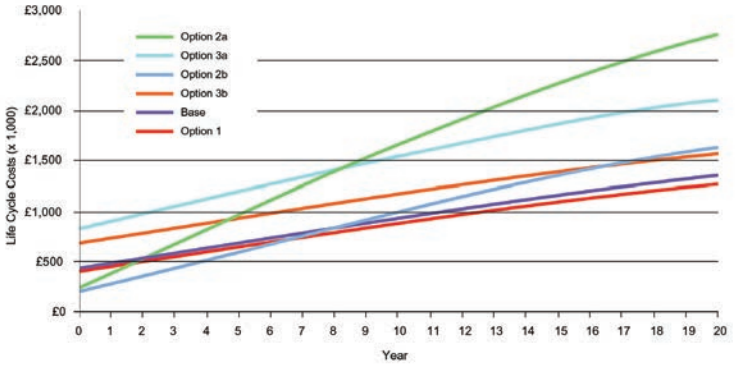
4.2 Lifecycle performance

The lifecycle comparison was carried out for a 20-year period based on the expected system service life prior to any replacement. The net present value (NPV) calculation was based on a discount rate of 3.5% (The GREEN BOOK - HM Treasury) and an inflation rate of 2% for servicing costs. The analysis also used projected retail fuel costs and equivalent CO2 emissions factors (CO2) for electricity published by the Department of Energy and Climate Change (DECC).

As no reliable projections were found when carrying out this work, the equivalent CO2 emission factor for gas was fixed at 0.184 kgCO2/kWh, which is from the UK Government GHG conversion factors for company reporting. Table 3 compares the options in terms of lifecycle cost and operational CO2 emissions, where Option 1 has the lowest cost, while Option 3a has the lower CO2 emission by a significant margin. However, Option 3b with air source heat pump and continuous flow water heater is shown to be the optimal solution in terms of overall lifecycle performance. From cost point of view, a 24% uplift in lifecycle cost results in 34% reduction in lifecycle CO2 emissions.

Table 3 – Net present values and CO2 emmissions over 20 years

	NPV	% savings	CO2 (tonnes)	% savings
Baseline	£1,356,096 (2)	0%	5,439 (6)	0%
Option 1	£1,265,765 (1)	-7%	5,102 (5)	-6%
Option 2a	£2 756,263 (6)	103%	3,943 (3)	-38%
Option 2b	£1,625,863 (4)	20%	4,299 (4)	-25%
Option 3a	£2,103,487 (5)	55%	1,974 (1)	-69%
Option 3b	£1,573,411 (3)	16%	3,443 (2)	-38%



5.0 Discussion and concluding remarks

Despite much lower capital cost, electric panels in Option 2a and 2b have led to high operational cost and hence higher NPV against baseline. In both cases of electric panel and heat pump space heating, Option 2b and 3b demonstrated improved NPV when using continuous flow water heaters instead of electric-based water heaters.

In terms of energy performance and costs, separating the space heating and DHW allows each system to operate more efficiently. In both the base case and Option 1, there are modulating condensing boilers with weather compensation, but whenever there is simultaneous requirement for space heating and DHW, the base case boilers will not operate as efficiently because the DHW results in higher return water temperatures to the boilers.

The seasonal efficiency of the base case boilers doing both heating and DHW is around 89%, compared to the seasonal efficiency of the space heating boilers in Option 1 at around 91%, while the continuous flow water heaters is around 95% as these are optimised for hot water generation.

A similar effect is seen between the options with heat pumps, where Option 3a with heat pumps providing both space heating and DHW has a Seasonal Coefficient of Performance (SCoP) of around 2.4, compared with 3.1 in Option 3b where the heat pumps are only providing space heating.

The costs of distribution pipework generally dominates the capital costs, which is why the options with electric panel point heating have the lowest capital costs (at the expense of very high energy costs and overall lifecycle costs). Between systems with hot water storage and those with continuous flow water heating, the capital cost is generally in favour of the continuous flow water heaters due mainly to the savings in the cost of the storage cylinders.

The operational CO2 emissions over 20 years show dramatic differences between gas and electric based heat sources, with Option 3a generating around a third of the CO2 of the base case with electric-based heating shown to be lower carbon over the medium/long term than gas-based solutions. The projected changes in CO2 intensity seems fairly optimistic and would require continual investment and the uptake in renewable technologies over the longer term to deliver the projected grid decarbonisation, which is highly dependent on political and economic pressures.

Furthermore, in practice, there is unlikely to be sufficient capacity for major shifts in heating fuel from gas to electric due to the limited capacity of the national grid, unless this is supported by urgent aggressive investment in the relevant infrastructure.

The analysis of the annual heat losses in the distribution pipe work show that the heat loss through the space heating pipes is between 22% and 25%, while for DHW pipe work it varies from 35% to 39%. This indicated potential savings could be achieved through distributed instead of centralised generation, both in terms of energy and capital costs due to reduction of distribution pipework.

The study has shown that the various parameters considered vary significantly depending on system type and hence for a more informed view, a lifecycle approach is required. It is prudent to revisit and review the compatibility of current system solutions, accounting for lifecycle factors such as the projected shift in grid carbon content and energy costs, so to be able to make any noticeable improvement in the long term resource efficiency of the built environment.

Full report available on direct request email sales@rinnaiuk.com

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Logstor – district heating solutions

Phone: 07788 284884
Email: chr@logstor.com
Web: www.logstor.com

- HVAC solutions
- Sustainability

It is more than 50 years since Logstor developed the technology behind trailblazing district heating solutions that the firm claims revolutionised the energy sector.

By attending its CIBSE-approved CPD course – Engineering sustainable district heating in modern design – Logstor says delegates will benefit from its expertise as a leading manufacturer of pre-insulated pipe systems backed by constant innovation at the cutting edge of the latest technology.

The seminar covers a multitude of district heating topic areas with specific focus on low-carbon design considerations and tips on refining the design of a heat network.

It highlights adherence to agreed best-practice standards, and provides delegates with valuable knowledge and skills needed to maximise the performance of a heat network.

The Logstor CPD seminar offers the opportunity to enhance existing professional standards and is designed for consultants, contractors, developers, local authorities and housing associations.

As a result of the course's CIBSE-accredited CPD status, it will count towards a delegate's CIBSE CPD requirement.

MCI Specifications – heat pumps

- Air conditioning
- Electrical
- Energy efficiency
- Mechanical

Phone: 01753 376422
Email: info@mhispecifications.co.uk
Web: mhispecifications.co.uk

Mitsubishi Heavy Industries Air Conditioning Europe (MHIAE) offers high-efficiency systems for cooling and heating air and water in residential, commercial and industrial applications. The MHI Specifications team (formerly named 3DPlus) was formed in April 2018 as a joint venture business between MHIAE and its exclusive distribution company in the UK, Beijer Ref.

MHI Specifications provides guidance, education and support to property owners, building services consultants and construction advisers throughout the UK on the application of air conditioning and water heating systems. Its CPD – Understanding CO_2 heat pumps – has been developed to educate consultants on the key features of air to water heat pumps, using the lowest global warming potential (GWP) refrigerant. **The content of the CPD will enable the audience to:** Discover a new, highly efficient method of heating commercial volumes of domestic potable hot water using a low-GWP refrigerant; learn how to reduce carbon usage and energy costs for clients via CO_2 air to water heat pumps; understand the benefits and differences between CO_2 systems and other traditional heat pumps; and plan how to build profiles to size hot water loads for commercial end users including hotels, student accommodation and industrial processes.

Munters – introduction to humidity theory and dehumidification

Phone: 01480 432243
Email: info@munters.co.uk
Web:
www.munters.co.uk/ukseminars

- Air conditioning
- Mechanical

Munters' CIBSE-approved CPD seminar provides a comprehensive introduction to humidity theory and dehumidification. Learn about the impact of moisture, combating seasonal fluctuations, and how to achieve the most cost-effective and energy-efficient climate solution for you or your customer.

Held at the delegates' own premises over lunchtime, the seminar lasts approximately one hour and covers:

- **Dehumidification theory**
- **Methods of dehumidification and its benefits**
- **Introduction to the psychrometric chart**
- **Calculating moisture loads**
- **Energy-saving technology and applications**
- **Dehumidification in industry** – including case study examples.

Suitable for consultants, architects, specifiers, installers and industry professionals alike, this seminar delivers one hour of CIBSE-approved CPD learning, and also includes a free lunch.

Myson – heating systems

Phone: 07850 807 213 or 0191
Email: David.Pittilla@rettigicc.com
Web: www.myson.co.uk

- Mechanical

Myson offers CIBSE-accredited CPD training courses that explore the various points to consider to ensure the end user has a heating system that provides high levels of comfort and economical operation.

Myson CPD modules include: Hydronic underfloor heating – how it works and how to maximise significant fuel-saving and heat-distribution benefits to achieve cost-effective solutions in every type of floor construction; Radiant panels – benefits of using ceiling heating radiant energy to warm objects in a room and achieving comfort conditions at lower air temperatures at reduced running costs, with less dust circulation for a cleaner environment; Low surface temperature (LST) radiators – exploring best practice when it comes to reducing risk to vulnerable people by using LST radiators that comply with National Health Service and Health and Safety Executive regulations; Radiators and low-temperature heating – how radiators can be used efficiently in low-temperature heating systems, covering guidance on energy efficiency, heat loss, emitter selection and heating controls; Plumbing and heating manifold pipe systems – exploring how to use joint-free methods of connection for various mechanical services to eliminate leaking joints in a balanced heating and hot-water system.

Paroc – pipe insulations

Phone: 07488 305 118
Email: john.watt@owenscorning.com
Web: www.paroc.co.uk

- Pipework

Throughout its 80-year history, building and technical insulation specialist Paroc has worked to develop a reputation among construction industry stakeholders across Europe for high product performance, technical expertise and sustainability.

As part of its increasing presence in the UK, and to engage further with the specification community, it is now offering two CIBSE-approved CPD presentations. **They are:**

- **HVAC services pipework insulation** – this aims to give delegates increased knowledge and confidence to ask the correct questions when choosing appropriate insulation to suit a project's needs.
  Topics include: Standards and quality; Breeam; fire; corrosion; legionella; and calculating thicknesses.
- **Pipe insulation thicknesses** – this aims to enable delegates to calculate pipe insulation thicknesses authoritatively, based on the relevant standards. It also offers guidance on how to deal with bespoke situations.

Topics include: Standards; thermal conductivity; interpreting BS5422; manufacturers' tables; calculating bespoke thicknesses; and custom insulation products entry.

Presentations can be carried out over lunchtime at client's offices, with lunch arranged for free on request.

S&S Northern – gas safety

Phone: 01257 470983
Email: cpd@snsnorthern.com
Web: www.snsnorthern.com

- Gas safety
- Electrical
- Mechanical

S&S Northern provides free, CIBSE-accredited CPDs covering gas safety. The firm designs, manufactures and supplies gas-safety products, including gas ventilation and gas interlock systems for use in commercial kitchens. It also designs and manufactures a full range of gas pressure-proving systems and gas-detection systems for school laboratories and boiler houses. All CPD presentations refer to current legislation and indicate impending changes.

The CPDs aim to offer a greater understanding of the following regulations and the safety equipment required:

- **BB100 and IGEM UP/2** – Gas safety in boiler houses/plantrooms
- **IGEM UP/11 edition 3 (2018)** – Gas control in educational establishments, such as food technology rooms and laboratories
- **BB101** – CO_2 monitoring in educational establishments
- **BS6173:2009 and DW172 2018** – Gas interlocking and demand-control ventilation for commercial kitchens
- **IGEM UP/19** – CO_2 monitoring for commercial kitchens.

S&S Northern covers the whole of the UK, and the free CPDs are offered as a lunchtime seminar or webinar.

Seeley International – energy-efficient cooling technologies

Phone: 01159 635 630
Email: uksales@seeleyinternational.com
Web: www.seeleyinternational.com

- HVAC solutions

Seeley International is Australia's largest air conditioning manufacturer and a global developer of innovative energy-efficient evaporative cooling products. Its vision is to lead the world in creating highly innovative climate-control solutions of premium quality that are inspirational in their delivery of energy efficiency.

Seeley International runs one- to two-hour, on-demand training courses on breakthrough, energy-efficient cooling technologies, touching on the principles of evaporative cooling technology and analysing the possible applications. **The CPD module includes:** Types of evaporative cooling technology: direct, indirect and hybrid technologies; benefits and limitations for each type; applications and case studies; sub-wet-bulb evaporative coolers based on Maisotsenko cycle: multistep heat exchanger; particular applications of this technology: pre-cooling, supplementary cooling or stand-alone configuration; energy and cost-saving details; and practical demonstration using a physical model.

The CPD seminar is aimed particularly at mechanical engineers responsible for ventilation and HVAC solutions. According to Seeley International, its CIBSE-approved seminars are very popular, so it advises people who are interested to contact the firm to arrange a free seminar at a convenient location and time.

Socomec – critical systems applications

Email: info.uk@socomec.com
Web: www.socomec.com

- Energy metering

Socomec offers eight comprehensive CPD seminars, delivered by highly experienced critical system application engineers. Hosted at clients' offices and catering for four to 40 participants, the seminars take around one hour, and attendees receive a presentation pack and certificate on completion.

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- **Power quality monitoring: causes, effects and solutions**
- **Automatic transfer switch essentials**
- **Why and where to use fuse protection**
- **General introduction to UPS systems**
- **Earthing and neutrals within transformer and transformer-less UPS**
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Spirax Sarco – steam solutions, carbon reduction and energy efficiency

Email: Daniel Wells, national consultant specialist, UK.Enquiries@uk.spiraxsarco.com
Web: www.spiraxsarco.com/uk

- Energy metering
- Mechanical

Spirax Sarco offers a suite of 15 accredited CPD presentations covering all aspects of the steam and condensate loop. Topics can range from steam generation, system design or improving energy efficiency, to improving process quality, reducing CO_2 and basic good working practice.

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Systemair – ventilation seminars

Phone: 0121 322 0200
Email: info@systemair.co.uk
Web: www.systemair.co.uk

- Mechanical
- Sustainability

Improve and broaden your knowledge, and maintain your professional standards, through Systemair's CIBSE-accredited CPD seminars. **The global ventilation firm offers seminars suitable for industry professionals across a variety of sectors, on subjects including:**

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- **Air curtains** – design and application, to reduce energy loss and improve comfort at building entrances
- **Energy-efficient ventilation** – running cost and carbon-footprint savings using demand-control EC motor technology and energy-recovery components
- **Residential ventilation and MVHR** – how they are designed and integrated into a building
- **Swimming pool ventilation and heat recovery** – technical seminar suitable for mechanical and electrical services engineers designing swimming pool hall ventilation systems or doing energy surveys for swimming pools
- **Data-centre cooling** – Direct and indirect free cooling and its benefits.

The CPD seminars can be conducted at the customer's premises or at Systemair's head office in Birmingham.

Waterloo Air Products – introducing the principles of air movement

Phone: 01622 711500
Email: rachel.roots@waterloo.co.uk
Web: www.waterloo.co.uk/technical

- Air conditioning
- HVAC solutions
- Mechanical

UK air distribution manufacturer Waterloo Air Products offers two free, CIBSE-accredited CPD seminars to introduce building services professionals to the principles of air movement. **The courses are**:

- **An introduction to air distribution** – focusing on the principle of air distribution when using mixed-flow, displacement or variable air volume (VAV) systems. Includes general terms and definitions used in air distribution, typical air movement effects, cooling systems, the effect of heat gains, alternate systems, and selection guidance.
- **An introduction to VAV systems** – Presenting the basics of VAV systems, covering variable heat loads and typical air volume variations. This seminar addresses the whole system, from equipment components, controls and factory calibration, to selection and installation.

The hour-long CPD presentations are delivered by Waterloo's team of highly experienced experts and can be held at the client's premises or at Waterloo's Aylesford factory. For those held in Aylesford, there is the opportunity to extend the session with a tour of Waterloo's factory, including a visit to its test laboratory to see the company's products in action. See the website, email or call for more information and other technical tools.

Zip Industries – energy-efficient hot water

Phone: 07872 376 800
Email: Jody.Lowe@zipindustries.co.uk
Web: www.zipwater.co.uk

- Energy efficiency

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Offsite prefabrication driven by DfMA

This module explores the benefits of the growth in offsite prefabrication resulting from the development of increasingly sophisticated design for manufacture and assembly methods

Offsite fabrication is well established in the building services industry, allowing supply chains to produce a high-quality, repeatable product at a competitive cost. The advent of accessible computer modelling and design tools – as well as the 4D integration offered by BIM tools – have increased the potential to deliver factory-assembled systems and subsystems using methods collectively known as 'design for manufacture and assembly' (DfMA), which minimise onsite construction, as well as potentially offering significant additional benefits. It allows buildings to be constructed more quickly and safely, and in more resource-efficient and cost-effective ways.[1] Bespoke and mass-produced systems and subassemblies can be created in factory-controlled, weather-protected environments, using dry materials where there is less risk of problems associated with moisture, environmental hazards and dirt. Such a properly managed and controlled factory construction environment will also present considerably fewer health and wellbeing risks, accidents and associated liabilities. As discussed in the recent BSRIA[2] report, it is becoming increasingly common to produce plant subsystems in parts or sections, and then combine them on site to provide the complete plantroom or service space. Once in place, the incoming services and distribution systems are connected to the various plant and equipment within the plantroom.

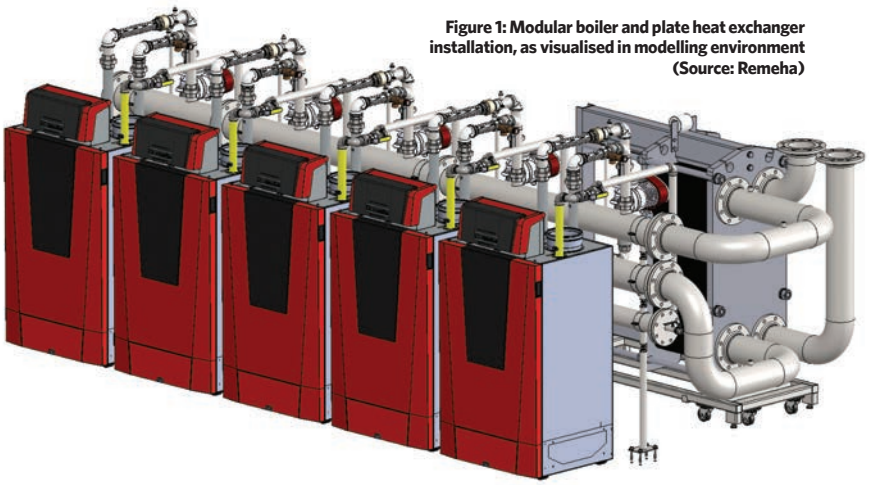

Figure 1: Modular boiler and plate heat exchanger installation, as visualised in modelling environment (Source: Remeha)

There are potential significant economic opportunities in producing systems off site. The UK Government's recent call[3] for evidence (closed July 2019) on how best to adopt and embed a 'platform approach' to design for manufacture and assembly (p-DfMA) indicated that the UK construction sector – encompassing contracting, product manufacturing and professional services – had a turnover of around £370bn. However, the potential of the construction sector is considered to have been held back by poor productivity growth, which has been significantly lower than the wider economy – for example, in manufacturing, which has seen a 50% increase in output per hour worked between 1994 and 2015. Among the many and varied measures of productivity, the potential benefit of offsite production was recently[4] highlighted by a report suggesting the productivity of factory staff is 80% relative »

Figure 2: Bespoke domestic hot-water booster set and associated pipework, controls and fittings mounted on skid (Source: Packaged Plant Solutions)

» to 20% productivity of onsite workers. The wider adoption of offsite manufacturing can benefit from the increasingly sophisticated manufacturing techniques that can deliver quality, customisation and cost benefits with reduced waste. By employing a controlled manufacturing environment and by following appropriate standards, the subassemblies of the structure can be built to a uniform quality to meet the needs of the end user while also conforming to the demands of the regulatory authorities. In Bryden Woods' 2017 document,[4] which considered the creation of a marketplace for manufactured spaces, it was estimated that 'poor productivity and manpower shortage account for up to 37% of delays on site. A DfMA approach reduces hours on site and increases productivity of those hours', and the reduction in the number of site-based workers reduces the need for temporary site accommodation – saving space, time, and associated environmental and cost impacts. That same report indicated that DfMA can reduce site waste by 70-90% and reduce vehicle movements local to the site that, aside from reducing congestion in the neighbouring streets, is considered as contributing to a reduction in local pollution by up to 20%.

By manufacturing off site, fewer decisions are required on site, reducing the potential for delay and improving the opportunity for meaningful monitoring and quality assurance, with standardised solutions encouraging more thorough testing, feedback and development. Improved performance-in-use of environmental controls (better assembly and factory-based commissioning) can result in a reduction of up to 30% in equivalent carbon dioxide emissions.[4] Equipment systems can be assembled in fully accessible manufacturing bays, with purpose-made lifting, tooling and safety equipment, and benefiting from appropriate task lighting, ventilation and noise control. By limiting the number of hours on site, there is an 80% reduction in incidents.[4] The components may be readily tracked through the stages of supply and production (using such methods as attached RFID tags and QR codes), which can follow through into use, maintenance and eventual replacement and disposal. Combined with technologies such as BIM and blockchain, these are, potentially, able to provide permanent and irrefutable records for operational, user feedback and auditing purposes. This can also deliver in-use data, so that life-cycle costs and impact may be more properly measured and, ideally, enhance the opportunities for a meaningful circular economy.

In the UK Health and Safety Executive (HSE) overview document on offsite production,[5] Taylor highlights the significance of the opportunities for creating employment in areas away from the building site. This can be particularly beneficial where there are skill shortages local to the site, and it can expand opportunities for the long-term development of skilled workers, as well as reducing the need for skilled workers to travel (with all the associated environmental and financial impacts). Where projects call for the production of numerous subsystems, there may be a case for a fabrication facility local to the site, which may also encourage and promote the use of local labour resources, as local employment will always benefit where factory units are established.

DfMA does not limit the opportunities for innovative design or require compromise in the quality of the systems. As discussed in the RIBA document that considers DfMA in the standard Plan of Work,[1] such an offsite fabrication approach may encourage 'design rationalisation, materials optimisation, just-in-time delivery or logistics planning in order to achieve high rates of productivity on site'. The goal is to deliver a project that meets the needs of the building user while minimising resources (carbon, cost or time) and optimising the delivery of positive aspects (health and safety, quality and certainty). As reflected in the RIBA document,[1] 'DfMA can be applied to one-off, small-scale projects, as well as to large-scale projects and frameworks. The underlying goal is to use design processes that help facilitate a collaborative approach along the whole value chain, embracing design teams, clients, contractors and offsite manufacturers'. It indicates that a 'concept design that has been developed with DfMA in mind during [RIBA Plan of Work] Stage 2 will be robust, leading to a more efficient design process at Stages 3 and 4'. For larger clients and organisations – such as the UK government – a platform approach to DfMA can mean that a set of digitally designed components may be applied across multiple building types, so minimising the need to design bespoke components. So, for

Figure 3: Internal view of boiler plantroom integrated into standard ISO container. (Source: Remeha)

example, a single component could be used as part of a school, hospital, prison building or railway station.

The concept of 'mass customisation' is based around a manufacturing technique that combines the flexibility and personalisation of custom-made products with the low unit costs associated with mass production. Advances in digital production methods – such as robotics and 3D printing – will further enable economic mass customisation. Each individual prefabricated subsystem can be designed using BIM tools and 3D computer-aided design (CAD) systems, allowing the various stakeholders to collaborate on the system design and to evaluate the functionality before works commence, reducing the risk of project delays.

Figure 4: Boiler plantroom integrated into standard ISO container (Source: Remeha)

For example, Figure 1 shows an example of where 3D modelling tools were applied to optimise the offsite prefabrication for a boiler replacement at Gun Wharf, the Medway Council offices in Chatham, Kent. The programme allowed for a short system downtime, as the offices had to remain operational. The boiler manufacturer worked in conjunction with the contractor to design a customised component and pipework arrangement, integrated boilers, pipework and plate heat exchanger in subassemblies that were manufactured off site, reducing site time and labour and optimising the use of the available space. The contractor was able to prepare the connecting pipework before delivery of the subsystems, which were then wheeled into place, connected and commissioned – bringing the heating system online in a short period of time and meeting the overall project's completion deadline.

The presentation by Drigo and Deadman[6] includes several examples where DfMA has been applied to produce modular plantrooms and services distribution systems. By applying a 'skid-mounted' approach – where components are mounted on a steel framework that can be craned and readily manoeuvred on site – a precisely designed and engineered subassembly can be delivered to site that matches the needs and vagaries of the building structure, while also having dimensions that ensure the prefabricated element can be easily handled via the available access routes. Each skid can incorporate the same services that would otherwise be fixed separately in a traditional in-situ fabrication process – such as boilers, fans, pumps (complete with inertia bases), valves, pipework, ductwork, controls and sensors. The skid can be purpose-designed to ensure that it can be transported without damaging component parts, be accurately located on site, and also be able to compensate for practical uncertainties such as unevenness in floor slabs. Smaller modules can be joined together to provide larger systems that are precommissioned, so reducing the time required on site to bring the systems into operation.

Figure 2, for example, shows a skid-mounted domestic hot-water booster that was custom-designed for a specific building application that had a very short onsite programme. Using this prefabricated and fully tested offsite solution ensured onsite timescales were kept to a minimum.

On a larger scale, the 36,500m^2, 41-storey residential tower that includes 335 apartments at Two Fifty One, Southwark, included – among the many thousands of preconstructed structural elements – 11 offsite-manufactured plantrooms and switchroom units, as well as 11 multiservice vertical riser modules and hundreds of preplumbed bathroom modules. This construction project was reported[7] to have reduced onsite 'man days' by 60% compared with a similar site employing normal in-situ construction techniques, and this contributed to a reduction of site programme time by about a third.

DfMA techniques may be usefully employed to provide bespoke and optimised modules, such as the plant shown in Figure 3 and 4 – a self-contained, packaged boiler house, prefabricated within its own ISO container, designed and constructed to meet the heating requirements for a multi-occupancy building.

The packaged boiler house was fully constructed, tested and recommissioned off site, the prefabricated structure was delivered and craned into position as a single piece, and the contractor made final connections before completion of the final commissioning and the system being put into service.

However, there are important lessons to be taken from the experiences described by Drigo and Deadman. The application of DfMA is not always cheaper, and the cost will depend on the particular programme and project constraints. Evaluating the opportunity for success of offsite prefabrication, a number of elements must be considered, such as:

- The installed comparative 'quality' (which may include multiple parameters) of onsite and offsite fabricated systems
- Repetition will increase the effectiveness of subsystem production
- Effective communication between the site team and factory is vital
- Without appropriately planned and executed logistics, DfMA will probably fail – regardless of the technical 'quality' of the prefabricated system.

In the response[8] coordinated by Constructing Excellence at BRE to the UK Government's recent call[3] for evidence for a platform for DfMA, it was noted that the industry must 'truly embrace manufacturing approaches. This will require manufacturers to invest in new lines, new technology and resources, and require government to support innovation'.

As summarised in the recent House of Lords science and technology committee report,[9] the common thread of the different offsite manufacturing options is that they require everyone involved in the project to think in terms of design for manufacture and assembly from the start of the project, as part of the wider digitalisation and innovation agenda in the construction sector. As explained by Gbadamosi,[10] the concept of 'smart' construction offers a transition from the traditional methods of construction to manufacturing through the increased usage of standardised components and offsite fabrication. The application of BIM develops an inherently collaborative design and evaluation environment that can accelerate the adoption of DfMA. Importantly, the recently published Hackitt review[11] also highlights that 'procuring buildings to deliver better whole-life performance, to increase skills within the industry and support the development and commercialisation of digital and offsite manufacturing technologies, will support the delivery of safer buildings'.

Turn to page 90 for references.

Module 154

November 2019

1. What is the quoted relative productivity of factory versus onsite workers?

- ☐ A 20% factory, 80% on site
- ☐ B 30% factory, 80% on site
- ☐ C 40% factory, 20% on site
- ☐ D 80% factory, 20% on site
- ☐ E 80% factory, 37% on site

2. What was the reported potential reduction in site waste if DfMA is adopted?

- ☐ A 10-20%
- ☐ B 30-40%
- ☐ C 50-70%
- ☐ D 70-90%
- ☐ E 90-100%

3. At which stage of the RIBA Plan of Work should DfMA influence the concept design so as to deliver a robust solution?

- ☐ A Stage 0
- ☐ B Stage 1
- ☐ C Stage 2
- ☐ D Stage 3
- ☐ E Stage 4

4. In the article, which council offices benefited from offsite prefabrication for a boiler replacement to ensure a short downtime?

- ☐ A Maidstone
- ☐ B Margate
- ☐ C Medway
- ☐ D Meopham
- ☐ E Mottingham

5. How many boiler modules were used in the illustrated ISO container prefabricated boiler plantroom?

- ☐ A One
- ☐ B Two
- ☐ C Three
- ☐ D Four
- ☐ E Five

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› Product of the month

Future Designs brings world's longest length of Vane lighting to WPP Amsterdam

The WPP Amsterdam campus building features a 60-metre section of low-energy Vane

Future Designs has completed the lighting for the new WPP Amsterdam campus in the Netherlands, based in the Amsteldok building 3.2km south of the city centre. Designed by BDG architecture + design and consulting engineers Hoare Lea, it features the longest lineage of Vane luminaire in the world.

The Amsteldok building is part of WPP's global colocation strategy, which is to provide world-class spaces that bring together its people and agencies into one location. This is to encourage greater collaboration and give clients easier access to WPP's talent and expertise.

At its time of completion in 1973, Amsteldok was the largest office building in Europe.

The 60m length of Vane luminaire used creates a striking visual link in the expansive and spacious (8m-high) ground-floor reception, café area and lobby.

Other products used throughout the project include 1,672 units of the Beem downlight, and Seel, the IP 65-rated fitting used in the kitchen's food-preparation and clean-room areas.

"The lighting has links with lighting-control systems and power over ethernet"

Future Designs manufactured and supplied:

- 6,500 metres of aluminium profile
- 3,279 LED drivers feeding 29,511 LED boards
- 70,500m of cable
- 183,760 fixing screws

The Amsteldok building brings together 15 WPP agencies from 11 locations into a single building. The previously vacant Rivierstaete building (as it was formerly known) has been transformed from a large traditional office building into a 19,000m^2, innovative and creative workplace to support 1,500 workers.

Redeveloping existing structures instead of constructing new buildings avoids the emission of thousands of tonnes of embodied carbon – equivalent to more than 30% of the building's lifetime carbon emissions. The new WPP campuses have been developed with sustainability at their heart, and are aiming for a Breeam rating of Very Good or higher.

Vane is designed to be sustainable by optimising exceptional lumen output while using minimum wattage. The lighting features low and easy maintenance, links with lighting-control systems and power over ethernet.

Visit www.futuredesigns.co.uk

› Service of the month

Mitsubishi Electric's office supports growing demand for efficient buildings

The Sustainable Bankside office provides fresh venue for new business development team

Mitsubishi Electric has opened a new London office and a specialist team dedicated to delivering energy-efficient HVAC solutions in the capital. The office, located at Sustainable Bankside II in Southwark, near Tate Modern, demonstrates Mitsubishi Electric's commitment to supporting the growing construction market in London and is aimed at bolstering its consultative offering.

London business manager at Mitsubishi Electric Rob Bowden said: 'There are more than 500 towers planned or under construction in the next few years across the capital. Combined with an increase in mixed-use buildings and carbon-reduction targets, consultants and businesses need support to engineer the best solution while being mindful of increasingly stringent legislation.'

Bowden's team is geared to help customers and partners with matters relating to legislation, regulations and sustainable building practices, as well as sharing the latest innovations in cooling, heating, ventilation and smart-controls integration for buildings in and around the capital.

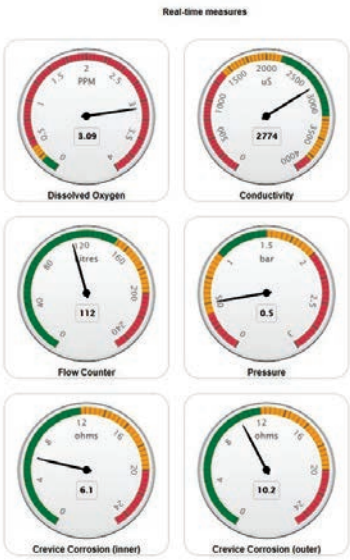
The Sustainable Bankside site offers office space and networking opportunities for sustainable start-ups focusing on new construction methods and technologies, power storage, recycled building materials and eco-design services. Consumer-focused brands include Toast Beer, which is brewed using surplus ingredients from the baking industry, and Halo Coffee, which has developed compostable coffee capsules.

Bowden said: 'Our entire ethos is based around the idea of creating the best and most sustainable living and working conditions for businesses and individuals, so it was vital that our new location embodied this spirit.'

The London team will use its new facility to host a series of customer CPD events over the coming months, where clients will be invited to meet the team, who can offer guidance, support and expertise for major projects.

Email Robert.bowden@meuk.mee.com

"The site offers office and networking space for sustainable start-ups"



New developments in water monitoring

Hevasure's groundbreaking water monitoring technology has been enhanced in order to show the real-time corrosion rate of carbon steel, as well as the total (cumulative) loss over a given timeframe.

These new modes of data collection have been designed to give facilities managers and building owners a better insight into corrosion issues of their important infrastructure, while avoiding knee-jerk reactions to 'normal' fluctuations in monitored parameters.

By expressing corrosion rates of steel in mm per year, as well as showing total metal loss in mm, end users have a much more meaningful way of understanding the effect of corrosion on their systems. As usual, all Hevasure results are available to view in real-time, but prior to this development, the long-term effects of corrosion were hard to quantify. Now, the Hevasure system can determine the cumulative value of certain parameters, such as oxygen and steel corrosion, between certain dates, saving money and time on interventions that are not always necessary.

Visit www.hevasure.com

Workplace facilities for cyclists

Showers, toilets and changing-room facilities may be fitted into almost any company premises using compact and reliable pumping solutions from Pump Technology.

For fully equipped changing rooms with multiple facilities, the Compli wastewater and sewage lifting station is a proven choice, while for single toilets, basin and shower, the WCFIX Plus offers a powerful 'behind the toilet' solution.

Visit www.jung-pumps.co.uk

Reznor air curtain range

Reznor, part of Nortek Global HVAC (UK), continues its tradition of manufacturing high-efficiency warm air heating equipment with the AB range of industrial air curtains. The range is ideal for exceptionally high doors and are the perfect complement to the ErP-compliant heating appliances. AB Industrial air curtains provide a barrier of high-velocity air that helps block incoming winds and stops warm air escaping. They achieve this by delivering a powerful barrier of heated air across the entire width of the doorway. Units can be easily fitted within existing or new buildings and are ideal for doorways, creating a more cost-efficient and comfortable indoor environment.

Nine models are available, for door widths from 2m to 6m and up to 6m high.

Email reznorsales@nortek.com or visit www.reznor.eu

Happy 20th anniversary JS Air Curtains

Founded in 1999, JS Air Curtains is celebrating two decades of preventing doorway draughts across the UK.

Commenting on the anniversary, JS Air Curtains' UK sales manager, Kerry Jones, said: 'The company's successful growth over the past 20 years has largely been down to offering a comprehensive range of air curtain styles, supported by friendly expert advice at very competitive prices.'

In 2011, the Condair Group purchased the companies and, subsequently, rebranded JS Humidifiers as Condair.

Visit www.jsaircurtains.com

Myson introduces T6 Compact and T6 Plan

Myson has introduced two new products to its extensive heating solutions portfolio. The T6 Compact and T6 Plan use central connection technology, which allows for any size radiator to be installed once piping has been placed. The central connection technology is an easy solution for installers, as it creates design-and-install flexibility for any project.

The T6 Compact comes with a traditional panel radiator front, whereas the T6 Plan has a more sophisticated flat front, ideal for projects where additional styling is required.

The T6 Compact and T6 Plan can be specified for a range of projects, including commercial – such as schools, public buildings and offices – and in domestic settings such as living areas and communal facilities.

Both the T6 Compact and the T6 Plan are the only radiators designed with a patented T distribution system, aiding even heat-up of the panel and allowing for the most effective water distribution.

Visit www.myson.co.uk

Viessmann launches the UK's lowest output system boiler as new Vitodens 200 range arrives

Viessmann is introducing the UK's lowest output system boiler this month, as its new Vitodens 200 domestic boiler range arrives in merchants across the country. The new 11kW Vitodens 200-W responds to demand from installers for system boilers that closely match the heat demand of the majority of modest-sized, well-insulated homes.

Viessmann marketing director Darren McMahon said: 'Not many homes have a heat load of more than 10kW, yet most system boiler ranges start at an output of around 19kW. This means that the majority of system boilers in the UK are oversized. Homeowners are buying larger boilers than they need and, once installed, the boiler cycles more than it needs to, increasing running costs and wear and tear.'

German-manufactured and *Which?* Best Buy-awarded Viessmann Vitodens 200 gas-condensing boilers are available as a wall-hung boiler (Vitodens 200-W) and floor-standing storage boiler (Vitodens 222-F), with outputs from 11kW to 60kW.

Call 01952 675000, email info-uk@viessmann.com or visit www.viessmann.co.uk

Swegon increases AHU installation flexibility

Swegon has launched two new modular versions of its popular Gold air handling unit (AHU).

The Gold Top and Gold L-Concept address a problem encountered all too frequently by design engineers – the shortage of space made available for building services plant.

Swegon's new Gold Top and L-Concept have been designed to allow specifiers and installers to customise the AHU in a way that gives them much greater installation flexibility. It is easy to combine the units to suit the space available. They can work with right or left, one-, two-, three- or four-duct connections that are side-mounted or top-connected, and – depending on the application – the specifier can also choose a rotary or counterflow heat exchanger.

These new designs are part of Swegon's drive to simplify project delivery and help create improved indoor climates. It aims to ease the process from early-stage design through installation and commissioning, to ensure best results throughout the product's operational life.

Visit www.swegon.com

Vokèra by Riello launches AquaNova LE

Vokèra by Riello launches AquaNova LE, a simple and energy-efficient solution for providing instantaneous domestic hot water to multiple outlets at a high flowrate. With low nitrogen oxides emissions, this new addition is classified under the Ecodesign of Energy-related Product Directive (ErP) Class A, making it fully compliant with the latest ErP Tier 3 requirements. It is ideal for domestic and small, light commercial applications that require an instant and reliable hot water supply, such as restaurants and shops.

Visit www.vokera.co.uk or follow Vokèra on Facebook, Twitter, and LinkedIn

Eaton's new sounder and sounder beacon range reduces the risk of downtime

Eaton has launched a new range of sounders and sounder beacons for the industrial process and control market that mitigates the risk of downtime from EMC discharge and overloaded loops on low-voltage systems. The X10 range is also able to withstand a jet wash of 5bar at a temperature of 80°C.

The X10 operates in the most demanding environments, protecting people and property in temperatures as low as -40°C through to the extremes of 70°C heat and 100% humidity.

Visit www.eaton.com

Underfloor air conditioning by AET Flexible Space

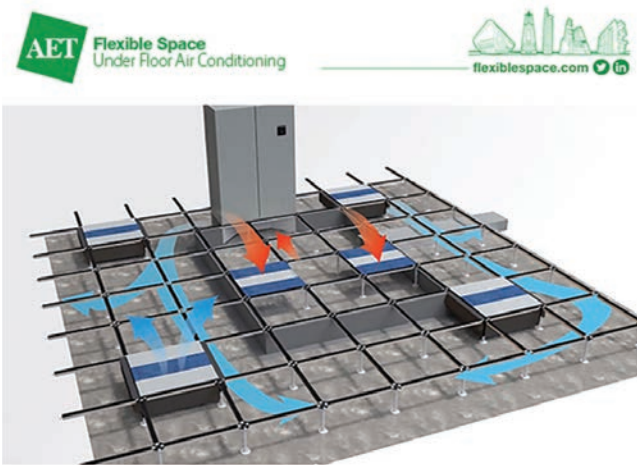
Underfloor air conditioning systems, used worldwide, make use of the space beneath a 200mm raised-access floor void to create the air supply route without ducts, eliminating the need for ceiling-based services and associated duct and pipework. This allows increased headroom in refurbishments and can reduce height in new builds, bringing dramatic cost savings and tax benefits.

Ideal for workspace, inherently flexible, easy to adapt and maintain, underfloor systems are suited to Cat-A and Cat-B installations.

The 'How UfAC Works' section on Flexible Space's website includes a product overview of the different system types: the Cam-C system, a fully underfloor design, ideal for maximising headroom in height-restricted buildings; and the Cam-V system, which allows complete freedom to maximise a floor plate, along with all other components.

Interested to learn more? Why not arrange a CPD at your office, which includes a 15-minute Q&A session? The sessions will cover: how UfAC works; raised access floor as a duct; and benefits and sustainability.

Call 01342 310400, email gbt@flexiblespace.com or visit www.flexiblespace.com



Carrier's AquaEdge chiller wins Air Conditioning Product of the Year Award

Carrier's AquaEdge 19DV water-cooled centrifugal chiller has won the Air Conditioning Product of the Year Award – System/Standalone in the Cooling Industry Awards 2019.

Carrier's award for the AquaEdge came in one of the most hotly contested categories, and follows last year's win for its AquaForce 30KAV as Chiller of the Year.

The AquaEdge chiller is designed to offer the ultimate in flexible and efficient cooling and heating technology. It is designed to minimise impact on the environment and future-proof buildings from changes in F-Gas-related legislation.

Visit www.carrieraircon.co.uk/product/19dv

Air hidden in the shadows

The new High Flow diffusers from Waterloo Air Products have been created so architects can incorporate a shadow gap feature and hide air-terminal devices from view. This follows trends in architecture to create vents, grilles and diffusers that make it easier for architects to complement their designs.

The new diffusers are available in a single slot, with three sized slots to choose from as standard.

High Flow can use multiple sections for a continuous linear run.

Visit www.waterloo.co.uk

A compact steam-generator solution for small recesses

HeaterSlim is a steam generator that produces mineral-free and hygienic steam, and is designed for applications where space is limited.

The compact dimensions and low weight of the HeaterSlim unit mean assembly is possible in nearly all recesses. It comes with an output of 6kg or 10kg per hour, making it particularly suitable for domestic, private and commercial suite spas.

As part of its intelligent design, the HeaterSlim unit uses an insulated stainless steel cylinder to reduce heat loss. The cylinder is also reusable.

Call 02380 443127, email info@hygromatik.co.uk or visit www.hygromatik.com

Hospital targets energy savings

So much is written about hospital waiting times and the many pressures that the health services are under, that it is very easy to overlook the fact there are many positive developments taking place behind closed doors.

Republic of Ireland Sligo University Hospital has had its efforts to reduce energy use recognised by the Sustainable Energy Authority of Ireland when it won the Sustainable Energy Public Sector Award for delivering savings of 20%.

Grundfos Pumps was delighted to play its part by providing the hospital with a detailed energy check report that outlined the energy savings that were achievable by replacing its existing pumps with intelligent Magna3 and TPE3 pumps. These pumps, now in-situ, are remotely monitored via Grundfos CIM300 BACnet cards, which allow the operators to monitor and trend individual pump performance. The hospital has also taken advantage of the integrated heat-energy monitors available on all Grundfos Magna3 and TPE3 model pumps.

Visit www.grundfos.co.uk

Dunham-Bush radiant panels a 'natural' selection at Charles Darwin School

It was a case of natural selection when Dunham-Bush Evolution radiant panels were installed at the recently refurbished sports hall and gymnasium at the Charles Darwin School in Biggin Hill, Kent.

The installation included 144 metres of Evolution with a total output of 80kW for the main sports hall, which includes a full-size basketball court, and 60m of Evolution with a total heat output of 33kW for the gymnasium, which also features a trampoline facility.

Call 023 9247 7700, email info@dunham-bush.co.uk or visit www.dunham-bush.co.uk

Make sure you keep warm this winter by installing the Aquatech Pressmain Minipack

This intelligent pressurisation unit for small heating systems ensures they run at the correct pressure, avoiding any breakdowns.

The versatile Minipack maintains a precise pressure in any small heating system up to 5,000L.

Wall- or floor-mounted, the Minipack saves energy, protects and is easily serviceable.

With single or twin pump versions available, it is designed for systems with temperatures up to 90°C and cold-fill pressure up to 3.5bar.

Call 01206 21512, email marketing@aquatechpressmain.co.uk or visit www.aquatechpressmain.co.uk

Vent-Axia Named a Business Superbrand for 2019

British ventilation manufacturer Vent-Axia is delighted to have been named in the UK Business Superbrand list for 2019. The award follows robust independent research commissioned by The Centre for Brand Analysis (TCBA), which identifies the UK's superbrands in an annual league table. The ranking, which has been tracking the UK's leading business-to-business brands since 2001, recognises the company for quality, reliability and distinction.

Companies with superbrand status are considered to offer customers significant emotional and/or tangible advantages over their competitors, which customers want and recognise.

Call 0844 856 0590 or visit www.vent-axia.com

Panasonic offers first CO_2 solution for refrigerated trailer rental

Panasonic CO_2 cold-chain condenser units provided the perfect mobile refrigeration solution for cooling specialists Greencold when it was looking for a reliable, efficient and eco-friendly way to cool and freeze a mobile trailer.

The Panasonic CO_2 units that have now been installed in the trailer are compact, lightweight, have low noise levels (a range of 35.5 dB(A) to 36dB(A)), and are designed to fit into smaller spaces, with dimensions of 930 x 800 x 350mm (HxWxD) and weighing only 67kg.

Visit www.aircon.panasonic.co.uk

Rinnai strengthens technical service team with new London-based applications engineer

Rinnai, a UK manufacturer and supplier of continuous-flow hot-water heating units and delivery systems for residential and commercial sites, has strengthened its technical service department with the appointment of Danny Madagwa to the post of applications engineer.

Madagwa will be based at Rinnai's London office but will be liaising with customers nationwide. He holds a Master's degree in engineering.

Rinnai operations head Chris Goggin said: 'We are delighted to have Danny join us; he will be dealing directly with installers, contractors and end-users.'

Visit www.rinnaiuk.com

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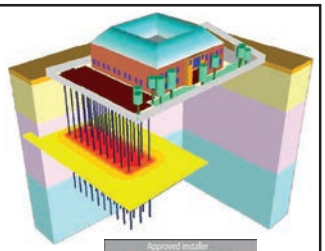
Air Handling

Energy Efficiency



Air Conditioning

The Stoke-on-Trent district heating scheme is boosting opportunities for young people


Ryan Johnson

Hot prospects

Ryan Johnson, Stoke-on-Trent College campus director, discusses the city's major district heat network project that is tapping into local resources

A multi-million pound district heating network under construction in Stoke-on-Trent is not only bringing businesses and homes cleaner, greener geothermal energy, sourced from under the city, but it is also tapping into another local resource – young people.

The development of the low carbon city-wide network is offering young engineers from Stoke-on-Trent College's Urban Heat Academy the opportunity to learn the latest industry skills in this new area of low carbon construction technology. The academy is working with employers involved in the design, installation, management and maintenance of the project to supply apprenticeships and work-related training.

Ryan Johnson, campus director at Stoke-on-Trent College, is keen to get the message across to local people and the rest of the UK that the city is leading the way in developing greener energy systems – and the opportunities this presents for young people to get involved in the sector.

What is significant about this district heat network?

Stoke-on-Trent is one of the first cities in the UK to install a new district heat network geothermal heating system. More than 18km of pipe will be laid to source water heated naturally by the earth from as far as 3km underground. The first pipes were laid in the university quarter last September, with Vital Energi the main contractor for the network.

Stoke-on-Trent City Council and the various partners in the project have worked to ensure the city becomes one of the very first in the UK to secure government funding for the £50m district heat network – one of the key components in an overall investment of £500m in a smart energy system in Stoke over the next six to seven years. Not only will this reduce carbon emissions and cut energy prices for people locally, it will create major employment opportunities.

What skills shortages have been identified?

A huge number of skills are essential to construction operations – from planning, and delivery to evaluation. The Stoke-on-Trent College works closely with employers to identify the future skills that will be needed and where the biggest shortages are; key areas include groundworks, project planning, site management and surveying.

Another vital skill is fusion welding. Danish company Logstor supplies the preinsulated pipes to most groundworks projects in the world, and these pipes will form the backbone of the city's new energy infrastructure. However, specialist welding training is needed to work on these and only a small number of people have this skill. The college has already sent two people to Denmark to receive specialist training.

What else is Stoke-on-Trent College doing?

Stoke-on-Trent College's new Urban Heat Academy, funded by the Stoke-on-Trent and Staffordshire Local Enterprise Partnership, is training people on the design, supply and installation of the district heat network. The first of its kind in the UK, the academy will teach a huge range of skills, including building services, engineering, welding, plumbing, groundworks, highways maintenance, and heating and ventilation.

The college has teamed up with highly experienced Scandinavian professionals who are pioneers in district energy. These experts are passing on their skills and experience to college lecturers and teaching staff, so they can train a whole generation in the skills needed to design, supply and maintain the new geothermal energy networks.

What opportunities will be available for students?

Graduates from the Urban Heat Academy will not only have the skills to work on the city's district heat network, but many other doors will open for them. As more cities sign up to this new way of delivering energy, demand for these skills will increase. With district heat networks set to be a key long-term development in the UK's energy industry over the next 15-20 years, job prospects really are heating up for local young people, as well as for adults looking for opportunities to upskill or retrain.

How important are district heat networks for the UK?

When you look at the district heat network, it's part of a much bigger picture. Reducing the UK's carbon footprint is high on the government's agenda, and there are a number of projects aimed at reducing emissions and saving energy. This is the future of construction.

RYAN JOHNSON is campus director at Stoke-on-Trent College

EVENTS

HIGHLIGHTS

Professor John Mardaljevic will present at the Daylight Group event on 13 November

Dr Eleonora Brembilla will speak at the SLL LightBytes event in Dublin on 21 November

NATIONAL EVENTS AND CONFERENCES

LuxLive
13 November, London
Supported by the Society of Light and Lighting (SLL), LuxLive is Europe's biggest annual lighting event. Visit SLL's stand for discounted membership and publications.

SLL LightBytes series 2019-2020 – People, Space, Time, Place
21 November, Dublin
The series will focus on light and wellness, with presentations across four sessions: People, Space, Time & Place. Speakers will be joined by Dr Eleonora Brembilla, research associate in advanced building daylight modelling at Loughborough University.
www.cibse.org/sll

CIBSE TRAINING

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

Mentoring skills workshop
1 November, London

Earthing and bonding
4 November, London

Energy Savings Opportunity Scheme
4 November, London

Variable flow water system design
5 November, London

Mechanical services explained
6-8 November, London

Lighting: legislation and energy efficiency
8 November, London

Gas safety regulations (designing for compliance)
11 November, London

Overview of current fire legislation and guidance
12 November, London

Energy surveys
13 November, London

Low carbon consultant design training
13-14 November, London

Understanding and application of psychrometric charts
14 November, London

Designing water efficient hot and cold supplies
15 November, London

Low carbon consultant energy management system ISO 50001
19-20 November, London

Building services explained
20-22 November, Manchester

Fundamentals of digital engineering (including BIM)
22 November, London

Electrical services explained
26-28 November, Manchester

Design of ductwork systems
26 November, London

Practical controls for HVAC systems
27 November, London

Overview of IET wiring regulations
27 November, London

Fire sprinkler systems: design to BS EN 12845
28 November, London

Above-ground building drainage
28 November, London

Introduction to combined heat and power
29 November, London

Air conditioning and cooling systems
2 December, London

Low carbon consultant building operations
3-5 December, London

Building services explained
4-6 December, London

CIBSE GROUPS, SOCIETIES AND REGIONS

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

South Wales: Membership briefing
4 November, Cardiff
Focusing on routes into CIBSE Associate and Member grades, and registration with the Engineering Council at Incorporated and Chartered Engineer levels.

CIBSE Application workshop
5 November, London
Workshop to help start your Engineering Practice Report for Associate and Member applications, with an experienced CIBSE interviewer.

West Midlands: Membership briefing
6 November, Birmingham
Focusing on the routes into CIBSE Associate and Member grades, and registration with the Engineering Council at Incorporated and Chartered Engineer levels.

HCSW: Advancing 'net zero' development
6 November, London
With speakers from Transport for London, Hoare Lea and Laing O'Rourke, on how we can accelerate the adoption of technologies and techniques to reduce carbon emissions.

SoPHE annual London dinner
7 November, London
The Society of Public Health Engineers (SoPHE) and SoPHE Industrial Working Group dinner, with guest speaker explorer Laura Bingham, leader of the first successful descent of the Essequibo River in Guyana.

Western Australia: Data centre immersive cooling
12 November, Perth
With speaker Mark Lommers, chief engineer at DownUnder GeoSolutions.

Lifts Group annual seminar
12 November, London
Covering: cycle lifts; technical challenges with designing vertical transport in a large football stand; lift simulators and logging; and analysis of lift journeys.

Daylight Group: Aperture-based daylight modelling
13 November, London
Presentation by Professor John Mardaljevic in discussion with Andrew Bissell. Preceded by the Daylight Group AGM.

North East: Membership briefing
14 November, Newcastle
Routes into CIBSE Associate and Member grades, and registration with the Engineering Council at Incorporated and Chartered Engineer levels.

CIBSE Yorkshire awards
15 November, Leeds
In their fourth year, the awards recognise excellent projects and people in the region.

SLL and North West: Perfect light and the perfect light experience
19 November, Manchester
Screening of second film in the Perfect Light Project, following five lighting designers to Japan to seek out a perfect light experience.

West Midlands: Roundtable discussion on use of digital technology
20 November, Birmingham
Roundtable by Ramboll.

HCNW: Active attenuation – combined attenuation and rainwater harvesting
21 November, Milton Keynes
Primarily covering the Storm Harvester active attenuation system, which enables water to be held in attenuation tanks and then reused on site.

HCNE: Edge computing
26 November, London
Looking at how the requirement of data processing near the source of generation is driving a need for more resilient infrastructures close to the user.

South West: Membership development lunch
2 December, London
Helping CIBSE members and non-members learn about the CIBSE membership process, including benefits, grades and routes into membership.

Build2Perform Live

26-27 November, London Olympia

The free-to-attend event brings people together to learn about, discuss and collaborate on the issues that are vital for delivering better building performance. With more than 60 sessions, 90-plus speakers – including keynote speaker Baroness Brown of Cambridge – and 70 exhibitors from major manufacturers and suppliers, Build2Perform Live is the meeting place for forward-thinking industry professionals, visionary speakers, leading exhibitors and young talent. For the full programme and to register, visit **www.cibse.org/b2plive**

Baroness Brown

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CIBSE LIVE BUILD2 PERFORM

26-27 Nov 2019 Olympia London

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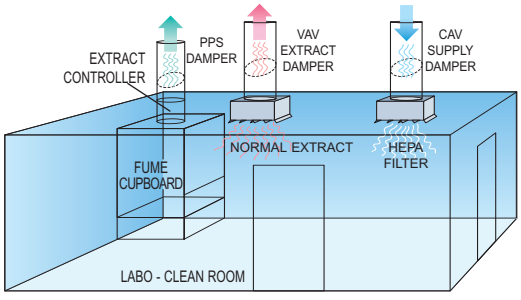

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