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January 2020

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Green goals of Blue PM

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Boris Johnson's big election victory has put wind in the Conservative's sails – and for good reason. Their large parliamentary majority will allow them to push through legislation relatively unopposed. The Brexit blockage has finally been unclogged and, for good or bad, the UK will be leaving the EU at the end of this month. Uncertainty over the kind of deal the government will be able to negotiate with the EU, however, means Brexit will continue to dominate the headlines in 2020.

Last month's Queen's Speech laid out the ambitions of Prime Minister Johnson's government. Climate change and the built environment were prominent in the accompanying 151-page briefing note, but there was

a distinct lack of detail. On climate change, the government said it would continue to work towards net-zero greenhouse gas emissions by 2050, and will use its first budget to prioritise the environment. It confirmed its manifesto pledge of investing £9.2bn in improving the energy efficiency of homes, schools and hospitals, and investing £800m to deploy a carbon-storage cluster by the 2020s. The government also said it will create a £640m Nature for Climate fund ahead of this year's Climate Change Summit in Glasgow, to focus on nature-based solutions.

The Queen's Speech stated that Building Safety and Fire Safety Bills will be introduced. The government confirmed it will take forward Dame Judith Hackitt's recommendations after the Grenfell fire and strengthen the regulatory regimes for building safety and construction products, as well as change industry culture to ensure accountability and responsibility. It will also create a stronger framework to 'ensure all products meet high performance standards'.

For now, there is the opportunity for CIBSE and others to respond to the consultation proposals for Part L and the Future Homes Standard, which will set the direction of travel towards zero carbon homes. CIBSE, and other bodies, say the proposals do not go far enough, and that the proposed carbon reductions could see us building new homes that will need fabric retrofitting later (see page 18 for a summary of CIBSE's response).

There may be uncertainty over government policy pledges, but 2020 will be a year of change, and the industry needs to be ready to adapt. A good sign is the amount of cross-industry collaboration taking place. The Building Performance Network's call for the regulation of operational energy is backed by CIBSE, RIBA, LETI, the UKGBC and Good Homes Alliance – and there was plenty of evidence of this collaborative thinking at Build2Perform Live recently. Plenty more will be needed in the years ahead if we are to avert a climate disaster (page 24).

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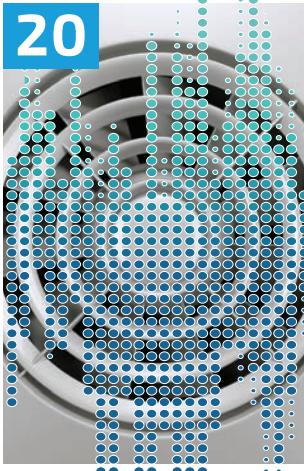
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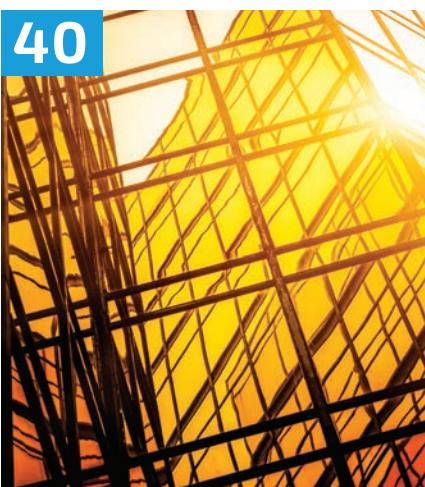
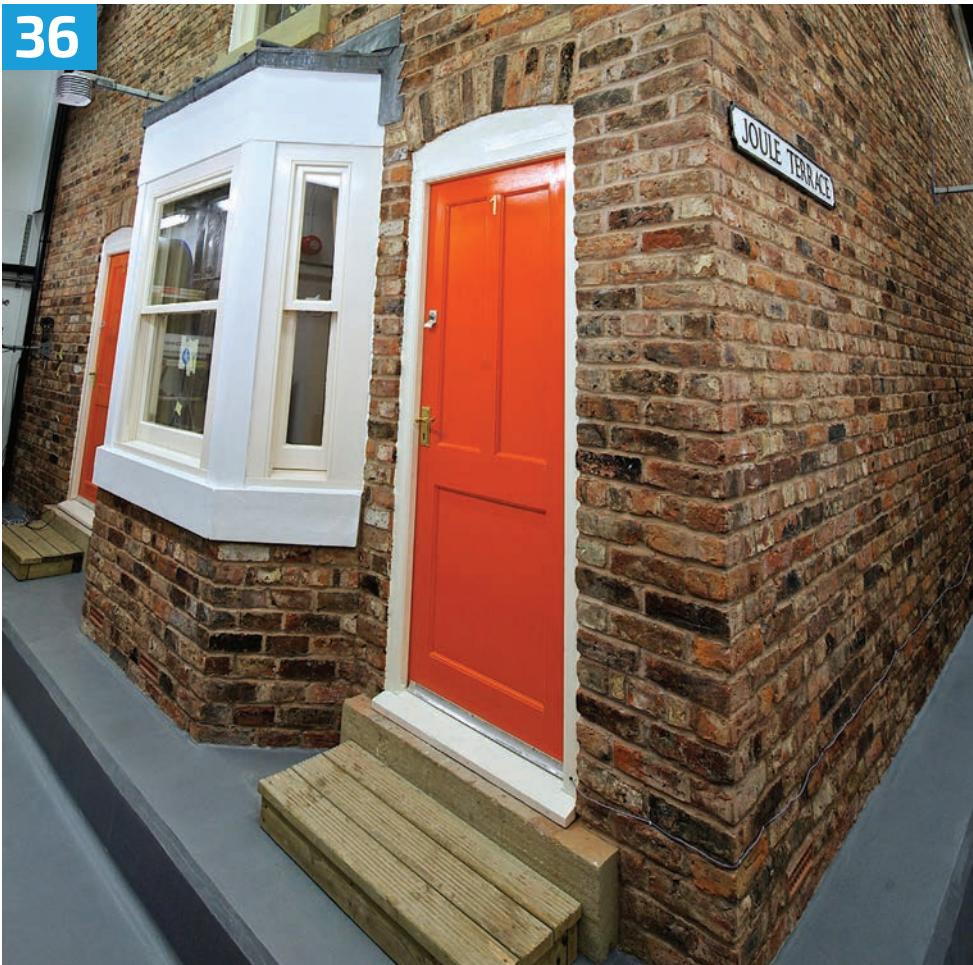
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IN BRIEF**Eight countries could overtake US in air conditioning use**

Eight countries have the potential to overtake the US as the largest consumer of electricity for air conditioning, according to research carried out by the Energy Institute at Haas, part of the Haas School of Business at the University of California, Berkeley.

The study ranked 219 countries and 1,692 cities on 'air conditioning potential' and found that India, China, Indonesia, Nigeria, Pakistan, Brazil, Bangladesh, and the Philippines had more air conditioning potential than the US.

It said the US currently consumes 400TWh of electricity annually for air conditioning – around 1.5% of total global electricity use.

Rumford legacy backs youth training

The Cambridge Academy for Science and Technology (Cast) is the latest provider to deliver the Design Engineer Construct! (DEC) learning programme and qualifications. These have been developed by social business Class of Your Own (Coyo) to address the lack of young talent coming into careers in the built environment.

The Cast course is being made possible with support from the Rumford 70th Legacy (R70L) fund. This has facilitated a grant from the Engineering Services Training Trust Limited (ESTTL) and Morgan Sindall Construction, with support from the Cambridge Forum for the Construction Industry (CFCI).

It offers project-based education to 14-19 year olds at its site close to the Cambridge Biomedical Campus.

Chinese firm claims largest 3D printed structure

Chinese 3D printing specialist WinSun has created a 432m-long revetment wall for a river in Suzhou, near Shanghai. It believes the 1.5m-high wall is the largest 3D-printed structure in the world.

The wall was assembled using modules created from construction and steel waste products, which were heated, ground up and mixed with printing 'ink'. The method allowed designers to follow the river's curves more easily and cheaply than using conventional techniques, WinSun said.

Hybrids are key to net zero future, says Baroness Brown

Hydrogen and heat pumps will replace natural gas, said Baroness Brown at Build2Perform

The vice-chair of the Committee on Climate Change (CCC) believes hybrid heat pump solutions and increasing amounts of hydrogen heating will prove pivotal in the push towards net-zero carbon.

Speaking at the CIBSE Build2Perform Live event, Baroness Brown of Cambridge said the government had been advised to combine Building Regulations for heating and

ventilation to ensure higher levels of insulation and airtightness did not lead to an epidemic of overheating and sick building syndrome (SBS).

She said current levels of greenhouse gas emissions had no precedent in the past 800,000 years and that potential future scenarios were 'scary'. Current projections suggest the planet is on course for a 4°C rise in temperatures – far above the 1.5°C target outlined in the Paris Agreement.

However, she believes the worst is not inevitable and urged the building services sector to focus on 'avoiding the unmanageable and managing the unavoidable' through a combination of technical innovations and mitigation strategies for buildings.

The CCC has written an open letter to Prime Minister Boris Johnson urging the new administration to address the climate crisis.

The CCC warned that UK efforts had so far 'fallen short', but with the country hosting the 2020 UN Climate Summit in Glasgow, the government's actions over the next year would have 'a lasting global impact'.

The letter, signed by CCC chairman Lord Deben and Lady Brown, said the UK must get back on track to delivering net zero emissions.

The CCC identified five key priorities for cutting UK emissions: removing fossil fuels in existing buildings; phase out of petrol and diesel cars; 40GW of offshore wind by 2030; developing hydrogen and a mechanism to pay for emissions reductions; and cutting emissions from agriculture.



Baroness Brown: 'Avoid the unmanageable and manage the unavoidable'

UK 'should use green spaces for heat'

The UK could cut its carbon emissions by more than 2% and meet almost 10% of its peak heat demand by installing heat pumps in public parks and other green spaces, according to research by the climate charity Possible and the London Borough of Hackney.

The move, which would deliver around 30GW of heat while improving air quality and providing a source of income for councils, is part of a project backed by the National Lottery Community Fund, National Lottery Heritage Fund, and innovation foundation Nesta.

The funders plan to install a heat pump as part of a pilot project to prove that the idea works and then share the outcomes with other local authorities.

'Heating is a carbon bomb in the UK,' said Neil Jones, project manager at Possible. 'A third of all UK greenhouse gas emissions comes from heating and yet it's often overlooked. What's so exciting about this report is that it not only offers a way to kick-start a society built on clean heat, but it also offers economic and health benefits at the same time.'





Tories commit to bills on building and fire safety

Queen's Speech confirms commitment to zero carbon

The government committed to introducing two bills on building and fire safety in last month's Queen's Speech.

The Building Safety Bill will put in place new and enhanced regulatory regimes for building safety and construction products, while the Fire Safety Bill will implement recommendations from the Grenfell Tower Public Inquiry Phase 1 report.

The government also said a National Infrastructure Strategy would be published alongside the first Budget, where details of its £100bn spending plans would be revealed. It said it would be aimed at addressing climate change challenges, while 'levelling up and connecting every part of the country'.

In its election manifesto, the government said the bulk of the money will be spent on transport infrastructure, but it also intends to invest £2.7bn in six

new hospitals with a possible 34 more to be built in the next 10 years.

The Queen's Speech confirmed that a further £9.2bn will be invested in the energy efficiency of homes, schools and hospitals – including grants for insulation and boiler upgrades.

It confirmed its commitment to 2050 zero carbon targets and announced an Environmental Bill, which would aim to restore biodiversity and manage water resource. It said it would include legally binding targets for air quality

In the manifesto, the government said it intended to build 300,000 new homes every year and has extended the Help to Buy scheme until 2023. It said it would revisit planning rules to ensure infrastructure is in place before new home developments are completed. This will be backed by a new £10bn Single Housing Infrastructure fund. It also pledged to introduce tax breaks for construction and research and development.

Government must 'obey its law' on climate change

Very little has happened 'beyond talking' since the government passed legislation to support its 2050 net-zero carbon target last summer, according to the chief executive of the Committee on Climate Change.

Chris Stark told delegates at an industry conference that the new administration would need to make some 'tough decisions' during 2020 and 'obey its own law'.

'The plans we have now are insufficient,' he said. 'The next six months in this country are more important than any six months since we started focusing on climate change. I hope the new administration will have a set of policies that make sense. If they don't, they will hear from us more and more.'

'If we don't have the conditions right in the next 10 years, the next millennium looks pretty ropey. Policy needs to happen very quickly or the transition starts to look extremely difficult.'

Stark added that it was important the government had some credible plans in place before Glasgow hosts the next round of the UN climate change talks (COP 26) this year. However, he warned that the failure of the COP 25 talks in Madrid at the end of 2019 meant it would be challenging to make progress at the Glasgow meeting.

New administration must legislate on Hackitt and late payments

The new government should use its parliamentary majority to reform the engineering and construction industries, according to two leading trade bodies.

The Building Engineering Services Association (BESA) and the Electrical Contractors' Association (ECA) said the size of the Conservative majority was an opportunity for policy-makers to help SMEs by clamping down on late payment and bringing through legislation that would ensure cash retentions are held in trust.

They also believe the new government should quickly deliver fire-safety legislation that reflects the recommendations of the Hackitt Review. A joint statement said that Hackitt's proposed new building regulation regime 'could cement a better culture of competence and compliance... and save lives' if it was developed 'in close consultation with the industry'.

BESA and the ECA also called for 'prompt action this year' on the 2050 net-zero commitment, along with long-term investment in general infrastructure and new homes. However, the government would also have to provide more support for training and apprentice recruitment, with any 'Australian points-based system' for migrant labour recognising the nature of the UK's skills shortages, they said.

The return of DECC

Prime Minister Boris Johnson is planning to reinstate the Department of Energy and Climate Change (DECC), which was abolished by Theresa May.

According to Whitehall sources, the plan is to separate business policy from the energy and climate change debate as part of sweeping reforms likely to take place in February, once Brexit is out of the way.

DECC and the Department for Business, Enterprise and Regulatory Reform were two separate departments until July 2016, when May created the Department for Business, Energy and Industrial Strategy (BEIS). She was widely criticised at the time for appearing to downgrade climate issues.

It is understood that Johnson and his advisers believe a dedicated department will be needed to deliver their promise of a net-zero economy by 2050. The new DECC will be charged with delivering Conservative manifesto promises on carbon capture, nuclear fusion, tree planting, energy efficiency, and 'green' infrastructure.

The Prime Minister has also confirmed that he will chair the new Cabinet committee on climate change.

IN BRIEF**Shading must 'resist spread of fire'**

Shading, blinds and awnings will need to resist the spread of fire on tall buildings, despite the High Court finding the consultation process for a 2018 amendment to Building Regulations to be inadequate.

In November 2018, the government amended the Building Regulations 2010 and banned combustible materials from being used in – or on – the external walls of accommodation buildings more than 18m high. After a challenge to the ban's consultation process, the High Court ruled that the consultation was inadequate in relation to products 'intended to reduce heat gain within a building', such as blinds. It quashed the part of the amendment applying to devices 'deflecting sunlight'.

After the ruling, however, the Ministry of Housing, Communities and Local Government reiterated Building Regulations requirement B4, that 'the external walls of the building shall adequately resist the spread of fire over the walls and from one building to another.'

Future Homes consultation extended

The government has extended the deadline for responses to the consultation document on the proposed Future Homes Standard from 10 January to 7 February.

Future Homes Standard: The changes to Part L and Part F of the Building Regulations for new dwellings calls for the removal of gas-fired heating in all new homes from 2025. It proposes a reduction in carbon emissions of 20–31% and says planning authorities' carbon-reduction targets should not go beyond Building Regulations.

Climate action needed in Scotland, says CCC

The Committee on Climate Change (CCC) has urged Scotland to match the ambition of its 'net zero by 2045' target with decisive action to strengthen climate change policy in all parts of the economy.

The CCC 2019 Progress Report to the Scottish Parliament showed greenhouse gas emissions down 3% in 2017, compared with a 10% fall in 2016 – led by the power sector. However, other sectors showed only incremental improvement at best, putting 2020 emission goals at risk.

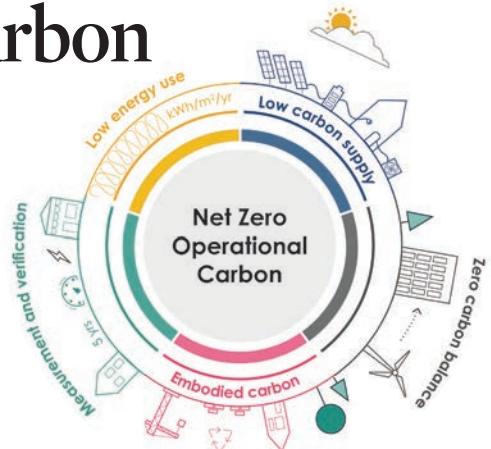
Industry defines net-zero operational carbon

Collaboration through LETI results in 10 targets for buildings

Leading industry bodies have co-published the key targets for an operational net-zero building, via an initiative organised by the London Energy Transformation Initiative (LETI).

The document states that fossil fuels cannot be used for heating and hot water if government zero carbon targets are to be met. It says the average annual carbon content of the heat supplied (gCO_2/kWh) should be reported.

The targets were developed in collaboration with the Better Buildings Partnership, CIBSE, RIBA, Good Homes Alliance and UKGBC. The joint paper says total energy use intensity should be no more than $35\text{kWh}\cdot\text{m}^{-2}$ per year gross internal area for homes and $55\text{kWh}\cdot\text{m}^{-2}$ per year for offices, while fabric should be highly insulated to ensure space heating demand is less than $15\text{kWh}\cdot\text{m}^{-2}$ per year for all

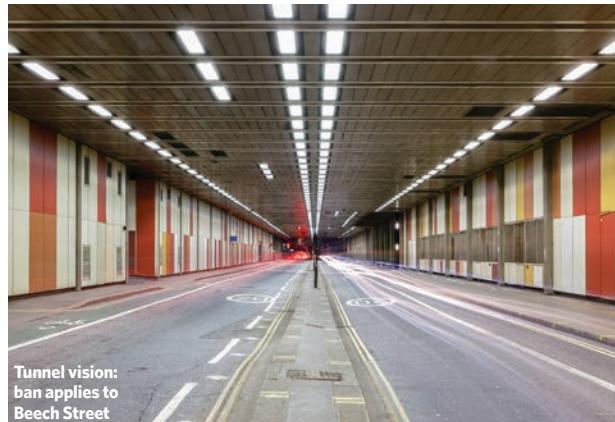


building types. It calls for annual energy use and renewable energy generation on site to be reported and independently verified in use, every year for the first five years.

Any energy use not met by onsite renewables should be met by investment into additional renewable energy capacity off site or a 15-year power purchase agreement.

Find the requirements at bit.ly/CJJan20Leti

POLLUTING CARS TO BE BANNED FROM TOXIC LONDON STREET



Petrol and diesel vehicles are to be banned from a busy London street that runs under the Barbican Estate.

The City of London Corporation's measure to cut pollution on Beech Street will be the first 24-hour, zero-emissions road, although emergency, refuse collection and delivery vehicles will be exempt from the traffic order.

The air quality and traffic will be monitored for 18 months before the order is reviewed.

BPN: 'Regulate operational energy'

The Building Performance Network (BPN) has called on the government to regulate the operational performance of buildings. The network, managed by CIBSE, said that legislation should cover energy consumption and carbon emissions as a minimum and, in 'the near future', should be expanded to cover other aspects of performance, such as indoor air quality and thermal comfort.

It said that the public sector should adopt operational building performance minimum requirements and government should require building performance disclosure, and support the appropriate methodology for assessing and reporting performance.

The BPN suggested that, as the Building Act is expected to be modified as part of the implementation of the Hackitt review, it could extend the scope of Building Regulations to cover the operational stage.

Operational energy performance could also be part of the proposed New Homes Ombudsman and Code of Practice for developers, according to BPN.

The joint statement has been signed by the Good Homes Alliance, LETI, RIBA, and the UKGBC (bit.ly/CJJan20BPN). The network is supported by the Sustainable Development Foundation.

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IN BRIEF**Australia gets affordable heating and cooling hub**

The Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) has launched an 'innovation hub for affordable heating and cooling' (i-Hub) in conjunction with academic institutions, and supported by the Australian Renewable Energy Agency.

The three-year project has a budget of \$18m, includes cash and in-kind contributions of nearly \$12m from the participating institutions, and is designed to help the industry transition to a low carbon future.

'The objective of i-Hub is to support the industry with knowledge dissemination, skills development and capacity building,' said AIRAH chief executive officer Tony Gleeson. 'By facilitating a collaborative approach to innovation, i-Hub brings together leading universities, researchers, consultants, building owners and equipment manufacturers to create a connected research and development community in Australia.'

The i-Hub will focus on healthcare, education and data-centre projects.

In December, a new heat record was broken in Australia

**MOVERS AND MAKERS****Mirko Farnetani joins Hilson Moran**

Hilson Moran has appointed whole-life carbon expert Mirko Farnetani as a senior sustainability consultant.

The qualified architect will join the whole-life embodied carbon workstream team, which is currently preparing guidance for the GLA relating to the draft London Plan.

Farnetani worked for the BRE Research & Strategic Advisory Group, where he was involved in the Building as Material Banks (BAMB 2020) research project, which aims to enable a circular economy approach at building level.

Contractor market grows, but cost and pay worries persist**Survey finds one in 10 paid after 60 days despite payment-clause contracts**

Business growth in the building engineering sector was steady during the third quarter of 2019, despite rises in material and labour costs, a trade association members' survey has said.

The latest Building Engineering Business Survey, which included data from the ECA, BESA, SELECT and SNIPEF, found that 79%

of businesses reported their turnover had increased or stayed the same compared with the previous quarter – although late payment continued to undermine confidence.

The commercial outlook for the final quarter of the year was broadly similar, although slightly more businesses (25%) thought their turnover would fall.

Around 60% of respondents said the cost of materials had continued to rise during the period and the survey showed there would be further short-term price uncertainty in the event of a 'no deal' Brexit, with delays and complications on availability of materials and labour.

Late payment remains a major headache for contractors, with nearly six in 10 respondents (59%) saying that up to 10% of their turnover could be tied up in retentions. That figure had risen slightly from the previous survey.

For public sector work, 59% are paid later than 30 days, and almost one in 10 is paid after more than 60 days. This is despite around half of public sector clients stating that they put under-30-day payment clauses in their contracts.

Whitehall 'terrified of another Carillion'

The new government must do everything it can to solve the late payment problems that continue to undermine construction supply chains, according to the chief executive officer of the Building Engineering Services Association (BESA).

David Frise told BESA's National Conference that Whitehall was 'terrified of another Carillion-style collapse' and the huge damage that would cause to public sector infrastructure plans. But repeated failures to reform the industry's 'payment culture' meant another major insolvency was very possible.

Frise told delegates at the Millennium Gloucester Hotel in London that poor payment behaviour was part of a culture highlighted in the Hackitt Review that led to 'broken buildings and broken people'. 'The huge burden of debt created by the ongoing abuse of cash retentions is forcing many SMEs out of business and robbing our country of their vital expertise,' said Frise.

Surveys carried out by BESA and the ECA found that nine out of 10 small business owners were suffering from mental health conditions because of late payment. Half of all owners and managing directors had stopped their own pay and one in 10 admitted to being forced to pay their staff late.

**Hoare Lea appoints Vernon**

Andy Vernon has joined Hoare Lea as director of its healthcare division.

He brings more than 30 years of experience to the role and has worked on £750m worth of healthcare schemes, ranging from refurbishment programmes to large-scale PFI, for NHS and private clients.

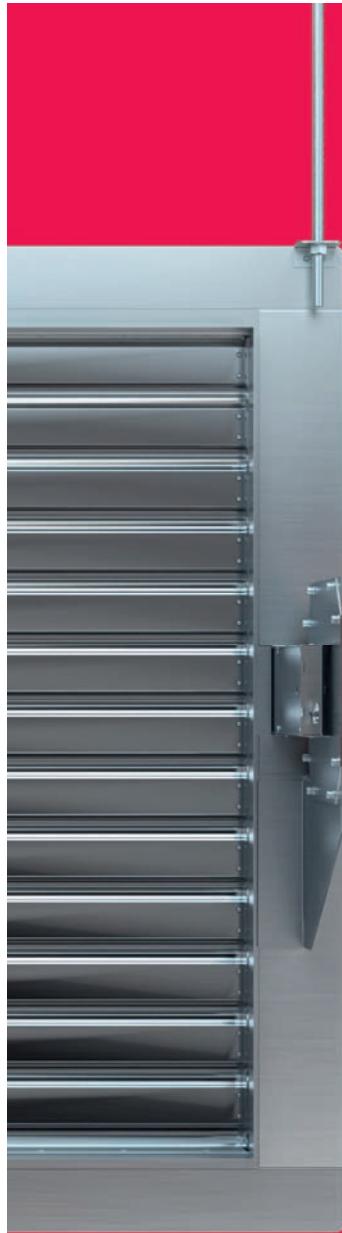
The healthcare group at Hoare Lea is headed up by partners Steve Clifford and Graham Cossons.

**HDR | Hurley Palmer Flatt appoints two**

HDR | Hurley Palmer Flatt Group has appointed Giles Korner as head of Smart Buildings, and Matthew Voaden (top) as divisional director of MEP.



Korner brings more than 25 years of experience in the IT industry and consultancy sector. Voaden has more than 17 years' experience and will be focusing on developing the group's work in the hospitality sector.



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New chartered members celebrated

CIBSE Ireland recently held an event celebrating its new chartered members.

Fourteen CIBSE members who had achieved corporate grade in the past two years were invited to a lunch hosted by CIBSE Ireland chair Mona Holtkötter at the prestigious RDS Members Club, in recognition and celebration of their achievement.

Despite the grandeur of the venue, the event was informal and relaxed, with an emphasis on networking. The new corporate members also had the opportunity to meet members of the CIBSE Ireland interview panel and some of the current committee.

Is your membership application ready?

The next UK closing date for the Associate (ACIBSE) and Member (MCIBSE) grades is 1 February.

Please ensure your application is complete before submission and includes: the application form signed and checked by your sponsor; work experience listing/CV; Engineering Practice Report (4,000-5,000 words excluding projects/career episodes, introduction and listings); organisation chart; development action plan; qualification certificates, if required, signed by your sponsor; and the relevant fees.

Visit www.cibse.org/closingdate for further information. For details of the requirements and application processes for ACIBSE and MCIBSE membership, visit www.cibse.org/membership

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BuroHappold crowned overall digital champion

Awards show what can be achieved with strength of collaborative working

BuroHappold Engineering was crowned overall digital engineering champion at the Digital Engineering Awards, presented at Build2Perform Live in November.

The awards, set up by the Society of Digital Engineering (SDE) and in their second year, recognise innovation, leadership and best practice in digital engineering.

BuroHappold was recognised as the overall champion after judges noted that the firm achieved excellent technical solutions, and had taken a truly collaborative approach to developing its toolsets and processes.

The firm also won in three other categories: best consultancy; best innovation; and best process and application.

Arcadis took the award in the best project/collaboration - small category for



Best Digital Engineer Jagannatha Reddy, of Arcadis, accepts his award via Skype on a phone

its project 'London Underground, step-free access tranche-2', while Jagannatha Reddy, of Arcadis, was singled out as best digital engineer. He impressed the judges with the sheer breadth and depth of digital engineering that he pioneered and championed for Arcadis.

Full list of winners:

- Best process and application: BuroHappold – Parametric dwelling optioneering
- Best innovation: BuroHappold – Building and habitats object model
- Best project/collaboration – small: Arcadis – London Underground, step-free access tranche-2
- Best project/collaboration – large: Ramboll and JG Ingenieros – Proyecto 5 Estrella
- Best consultancy: BuroHappold
- Best contractor: SES Engineering Services
- Best manufacturer: Schindler
- Best digital engineer: Jagannatha Reddy, Arcadis
- Digital engineering champion: BuroHappold.



... and Building Simulation Group award winners announced

The CIBSE Building Simulation Group (BSG) hosted the annual Building Simulation Awards 2019 at Build2Perform in London last November.

Each entry was reviewed by three different reviewers before a final shortlist of six was selected. The finalists were then asked to present their projects in front of an audience and judging panel at Build2Perform.

There was fantastic depth and breadth, showcasing the state of the art in building simulation software, practices and techniques applied to real buildings. An entry from Griffin Consultants, from the UAE, called in live to present.

The final three were Bryden Wood, DSSR and Arup. The overall winner was Liam Harrington, of DSSR, for presenting a 'Multi-tool building simulation modelling for Rolls-Royce factory ventilation retrofit' case study. The judges were impressed with the use of CFD and building simulation tools to solve a complex problem in a difficult building with industrial uses.

All the shortlisted presentations will be available at bit.ly/CJJan20BSG

The awards were sponsored by Monodraught, IES, DesignBuilder and EDSL.

The global chairs of the Young Engineers Network met in the Far East for their annual conference in November and had the opportunity to see the latest mega developments in Singapore and Kuala Lumpur, as well as a green Heriot-Watt campus in Putrajaya

NETWORK FAR EAST



On 11 November 2019, 23 chairs and vice-chairs from CIBSE's Young Engineers Network (YEN) headed to Malaysia for a week of activities to learn about building services in the region.

Included in the group were young engineers from across the UK, Hong Kong, New Zealand and UAE. Young Engineers of ASHRAE (YEA) chair Vanessa Freidberg also attended, along with CIBSE President Professor Lynne Jack and Roisin Sweeney, of CIBSE Membership Services.

First port of call was a trip to Putrajaya, where the young engineers learned about the town's masterplanning by architect Serina Hijjas. The city has 38% designated green space and the plans have spare utility tunnel provisions under the main promenade to allow for future expansion.

The town's masterplan also has a requirement for educational buildings, and this is where the Heriot-Watt University Malaysia campus has been established. There is 67% green space with several sustainability features. Located at the edge of Putrajaya Lake, the campus is naturally ventilated, and the breeze coming off the lake enabled the designers to pursue a cross-flow ventilation strategy. Shading facing the lake minimised solar gains.

An arcing green roof rises from the ground floor of the university and extends the length of the building. At around 9,000m², it offers an area for students to gather, and was positioned so any buildings overlooking the campus would only see the green of the roof as they looked towards the lake. The presentation was followed by a tour of the campus to see these systems in operation, explore the plantrooms and walk across the massive green roof.

The mix of nature and technology on the campus typifies the design philosophy of the Putrajaya masterplan. There was further evidence of this in the

Above: YEN and YEA chairs and vice-chairs, and CIBSE president Lynne Jack

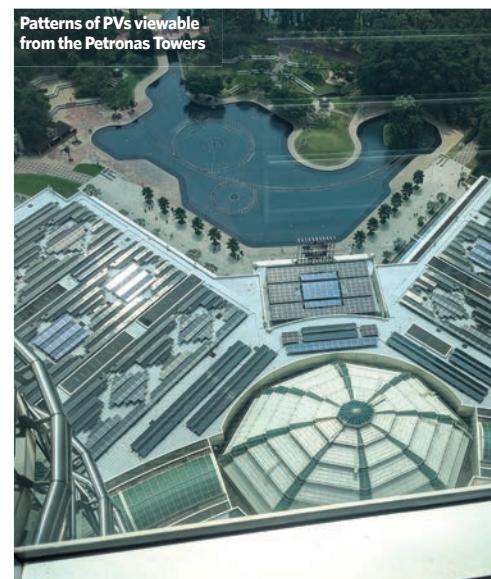
group's next destination, the Diamond Building, which is the home of Suruhanjaya Tenaga, the Malaysian Energy Commission.

Here, the head of facilities management told the group about the history of the organisation, the legislation it had passed and the energy efficiency measures used in its building.

The building optimises daylight from the dome at the top of the building, which serves the central atrium space, to the diamond shape of the building itself where the external glazing is sloped downwards with low emissivity-level glazing to minimise the risk of high solar gain.

Other measures include PVs on the sloping roof, trees planted on the street to shade the entrance and slab cooling overnight.

"The mix of nature and technology on the campus typifies the design philosophy of the Putrajaya masterplan"



Heriot-Watt University Malaysia campus green roof





Next day began with a tour of the famous Petronas Twin Towers. Starting out on the skybridge, which links the two towers 170 metres above ground, there was the opportunity to see the staggered perforated ductwork that ventilates internal spaces.

Even though the double-storey bridge is not attached to the building and has a nine-inch expansion gap to account for the towers' movement, it was noted by YEN members that the ventilation had been designed so each tower served half the bridge. The bird's eye-view of the city allowed the group to see other services considerations such as PVs that had been placed in patterns to minimise the visual impacts for overlooking buildings.

Next on the agenda was a visit to the new Bukit Bintang City Centre (BBCC) development. YEN had the opportunity to listen to the developers' approach to the huge mixed-use project, including their consideration of services, along with presentations from the M&E engineers involved in the design.

During a tour of the site, the group saw construction of the stage area in the entertainment hub and a mock-up of an office section. In the evening, they attended a dinner with ASHRAE YEA Malaysia, where they had the chance to network and hear the challenges of working in a different country.

The next day, they headed to Singapore. Starting at the Gardens by the Bay, the group had an opportunity to see the sky trees, which house PVs for powering lighting, and a collection of rainwater and irrigation displays within the development (see Climate creation, August 2012 *CIBSE Journal*). Inside the domes, they experienced the temperature-conditioning methods within the spaces, which included fabric cooling to all hard flooring, active shading on the façade, direct evaporative humidification (or misting) and so much more, that it prompted a game of 'spot the services'.

A boat tour followed with local engineers who explained the buildings and local industry visible from the water, before visiting the Urban Redevelopment Authority (URA) Centre.

The URA Centre had a number of features that celebrated the built environment in Singapore, such as the island-wide model, which had projections showing distribution routes for various transport modes, along with utilities and all the other planning considerations made throughout the city.

We also visited the Central Area model, which is the largest architectural model of its kind and hosts models of all developments within the city. Areas still in planning were presented as wooden structures, and the model is constantly updated to ensure it reflects the latest cityscape.

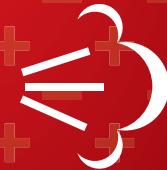
To cap off the week, the regional YEN chairs' meeting was held to discuss what was happening within their regions, and learned from each other. The activities ensured the YEN chairs and vice-chairs could bring back a great deal of technical knowledge and ideas to improve their local activities further. 

- Thanks to Lynne Jack; Roisin Sweeney; Alexandra Logan, YEN Global chair; and Munis Hameed, YEN Global immediate past-chair, as without their hard work this conference would not have been possible.

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Getting zero done, too!

With a new government settling in, and another Queen's Speech and royal broadcast to digest, Hywel Davies looks forward to the year(s) ahead

We live in unusual times in the UK. For the first time in more than a decade, we have a government with a clear majority and a full parliamentary term (although the Fixed-term Parliaments Act 2011 looks set to be repealed). We also have a Prime Minister with a clear mandate, and a new and unique electoral map of the UK.

Politically, the top priority is to 'get Brexit done', closely followed by commitments to improve the NHS and deliver better public services. There is also the need to protect the environment, deliver net-zero carbon emissions by 2050, and implement Dame Judith Hackitt's recommendations.

Although it did not feature highly in election coverage, one of the six headline pledges of the Conservative manifesto is 'reaching net zero by 2050 with investment in clean-energy solutions and green infrastructure to reduce carbon emissions and pollution'. The new government may have seized the political momentum, but it knows it still faces a real and present challenge in Extinction Rebellion, and continued calls to move further and faster on climate change.

Its manifesto acknowledged those who 'risk their savings and their future by becoming entrepreneurs', recognising 'they invent the new goods and services that improve our lives. From decarbonisation to expanding the frontiers of artificial intelligence, they are tackling some of the great challenges of our time'.

'Decarbonisation' is, indeed, one of the great challenges of our time, and the briefing on the Queen's Speech promises that action on emissions is an 'absolute priority'.

The Environment Bill and National Infrastructure Strategy will address emissions targets, so it's astonishing that the new government can intend to defer tackling this challenge until well into 2021 – yet this is what the consultation on the proposed Future Homes Standard (FHS), issued by the previous government, is suggesting. It says research for the new standard is not due to begin until mid-2021. This is absurd, and is inconsistent with the manifesto commitments and the UK hosting the Conference of Parties (COP) 26 in Glasgow next year, as well as with the commitment to 'world-leading standards of energy efficiency by 2025'.

It is also inconsistent with the manifesto promise to 'invest in Britain's people'. This says: 'Our plan to deliver clean energy and a carbon-neutral future means new kinds of jobs in new industries. Our departure from the EU



"Many respondents will be objecting unequivocally to limits on local energy requirements"

means we can develop forward-looking regulations to ensure we are first in line to develop and benefit from the technologies of the future.'

If the ambition to deliver clean energy and carbon neutrality is serious, we must start developing the FHS – and the products, skills and supply chains to deliver it in 200,000 or more new homes a year – now, not in a couple of years' time.

In 'Fighting climate change and protecting the environment', the manifesto commits to:

- Delivering on our target of net-zero greenhouse gas emissions by 2050
- Decarbonisation schemes
- Electric vehicle infrastructure, including a national plug-in clean energy network
- Two million new jobs in clean growth
- £9.2bn investment in energy efficiency to lower fuel bills in homes, schools and hospitals.

These are all relevant to CIBSE. We need more skilled people to deliver these goals, which requires investment, clear demand for those skills, a stable business environment and a reliable, forward outlook for investors. This government must give businesses clarity and confidence in its plans, then let them get on and get it done. Getting the FHS started right away is key to this.

The manifesto commits to 'ask every community to decide on its own design standards for new development, allowing residents a greater say on the style and design of development in their area, with local councils encouraged to build more beautiful architecture'. Really? Local people to determine what houses look like? The FHS consultation suggests they should have no say in how energy efficient it is, beyond the bare legal minimum determined nationally by Building Regulations. The London Plan has driven innovation by setting local standards. Many respondents to the FHS consultation will be objecting unequivocally to limits on local energy requirements (see page 18).

The evidence of the performance gap between design aspiration and what gets built is clear-cut. If we want zero-emissions homes, this quality failure must be addressed. It underlines the need for 'strengthening enforcement and sanctions to deter non-compliance' with Building Regulations, promised as part of the measures to improve building safety.

If we are serious about tackling climate change and meeting our net-zero emissions target, we must get on with a FHS for 200,000 homes a year to 2025.

Defining 'non-combustible'; and finding guidance on vivaria lighting

Defining moment

Thanks for the useful articles in the news digest on page 7 of the December issue of the *Journal*. They underline the need for a very clear definition, or set of definitions, surrounding the terms 'combustibility', 'combustible' and 'non-combustible'.

Clearly, the Oxford English Dictionary definitions are not achievable in practical buildings – it would leave us with stone as the only permissible material, as even steel will burn at high enough temperatures. But, equally, there needs to be a more satisfactory definition than the fire-resistance grades based on current test standards. They have little significance for the average HVAC engineer, let alone the public. Some of these grades would not have been adequate to deal with the Grenfell Tower fire, even with careful and correct detailing of items such as fire stops and fire barriers, so the regulation system – and the tests it allows – must be more specific.

Clear definitions of these terms (and tests) would allow much simpler and more easily understood regulations and their dependent 'parts'. Design with reference to adequate tests would not be precluded, and would still give reasonable security and reasonable design freedom. Without clarity, however, the dangers are not lessened and the incompetent and near criminals will cause yet more disasters.

For the moment, the argument about sprinklers needs revisiting, but there is an equally valid case for insisting the fire-resistant properties of a high-rise dwelling's contents should be regulated too, to a level that is accurately covered by the appropriate standard fire used in the fire design. Perhaps we are not yet ready for this!

John Moss MCIBSE

CIBSE LinkedIn Group discusses guidance for vivaria lighting

Where can I find UK/European published guidance on lighting and lighting controls for scientific vivaria?

Neil McLean

The *Code of Practice for the housing and care of animals bred, supplied or used for scientific purposes*, Section 2.2 of the December 2014 document (bit.ly/CJDec19ani2).

Bob Bohannon

Try arcadiareptile.com which is a specialist in this area.
Ian Major

A colleague pointed me to Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes (bit.ly/CJDec19ani).

Neil McLean

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Same issues, new solutions?

CIBSE Patrons is celebrating its 40th anniversary. Chair **Nick Mead** says it is time to nail some perennial issues

Four decades of working together to support CIBSE has given Patrons members insight into our sector's biggest challenges... many of which never seem to go away.

Our 40th anniversary celebration takes place at the end of this month, at Tower Bridge, and will feature business speaker Jay Surti, trustee and Women's Engineering Society (WES) director.

Last year, we developed a closer working relationship with WES during its centenary, as part of a campaign to improve our industry's lamentable record on gender diversity. Only about 12% of engineers in the UK are female – the lowest proportion in Europe – and just 15% of our engineering undergraduates are women, with the number of female engineering and physics students remaining static since 2012.

Our industry's workforce does not reflect the society it serves in terms of gender, ethnicity, age, disability or most other measures. As a result, we are recruiting from a very narrow slice of the available workforce at a time of acute skills shortage. In an attempt to finally solve this long-running puzzle, we will be supporting the WES campaign to raise the proportion of women in engineering to 30% by 2030.

The confused regulatory picture after the General Election, the Hackitt Review, and our imminent departure from the EU will also be in the spotlight during our annual legislation review in February, with CIBSE technical director Hywel Davies. His insights (and warnings) will be more valuable than ever for our membership as we face continued economic uncertainty.

As we pointed out during the General Election campaign, it is all very well competing with your political rivals to have the most ambitious carbon-reduction targets, but how do you turn rhetoric into meaningful action? This year will be pivotal if net zero by 2050 is going to be viable. Baroness Brown, vice-chair of the Committee on Climate Change, emphasised that point when she opened CIBSE's Build2Perform event. As host of the annual Patrons House of Lords lunch on 21 April, she will again offer crucial insights into how we can work with the new government to deliver a low carbon future.

This is also the date of our first AGM as a CIBSE Society since our change of status last year. This means Patrons members can now nominate themselves and colleagues to join our committee – and elect my successor as chair.

- To be part of our new era and new approach to old problems, contact cbrown@cibse.org



Action and data for 2020

Government must act if it is to reach net-zero carbon. CIBSE's Julie Godefroy outlines how Part L 2020 and the Future Homes Standard should be amended

A large majority, prominent public concern about the environment, and cross-party support for the Climate Change Act: the new government has no excuse for inaction towards net-zero carbon. With the UN Conference of the Parties (COP) due in Glasgow in late 2020, it also has the perfect incentive and opportunity to show leadership.

This should start with substantially amending the consultation proposals for Part L 2020 and the Future Homes Standard, which currently fall well short.

The proposed carbon reductions (20% and 31% options) and fabric efficiency requirements mean we could still be building new homes that will later need fabric retrofitting, at much greater disruption and cost to the owners. The no-regrets option is the most efficient fabric possible for new buildings, alongside consideration of air quality and overheating.

The notional building is currently proposed to have a gas boiler. This does not send a strong signal to transition away from gas. More importantly, because electricity has a lower carbon factor than gas under the new draft SAP, a Part L 2020-compliant dwelling with direct electric heating could have worse fabric performance than under Part L 2013. This is clearly a step in the wrong direction, and raises concerns about peak electricity demand and fuel poverty.

The proposal to omit the Fabric Energy Efficiency Standard (Fees) could not only lead to relaxed performance of individual fabric elements, but also remove the incentive to consider building form, the first step of passive design.

We need compliance metrics that relate to building performance itself. Compliance is currently based on 'two-system' metrics – carbon emissions and primary energy. Ultimately, it should relate to metered energy to directly reflect building performance and better connect with householders; carbon emissions should remain as the other compliance metric, possibly supplemented by heating demand (for example Fees, or similar).

The Future Homes Standard should be available much earlier than the proposed 2024. It could then be adopted by leaders from local authorities and industry, an essential step before widespread implementation. A key learning area is to achieve better standards of airtightness and ventilation installations, to deliver carbon savings without detriment to health and wellbeing.



"Government needs to establish a clear trajectory towards in-use performance requirements"

Local authorities should be allowed to set requirements beyond minimum regulations, subject to the usual viability testing. This is another important way to build expertise and supply chains. The current proposed ban would be a significant brake on carbon reductions, and a backward step for some local authorities, such as London.

Government needs to establish a clear trajectory towards in-use performance requirements covering all energy uses, starting in 2020 with a requirement for disclosure of performance. This could be done on an aggregate basis for schemes above a certain number of dwellings, to protect privacy and reflect building performance trends independently from the behaviour of individual householders.

These are no doubt challenging, in particular the shift to in-use performance and total energy use. However, this is in line with the task of achieving net-zero carbon. Of course, in-use performance is not currently covered by Building Regulations, and only in a very limited way by the Energy Performance of Buildings Regulations (through Display

Energy Certificates and air conditioning inspections). A framework would be needed to safeguard privacy, define responsibilities, set procedures for reporting and enforcement, and all of this will probably require changes to primary legislation.

So what? Mr Johnson certainly has not seemed overly constrained by existing regulations so far. By comparison with his government's rumoured ambitions for reforming the civil service and the House of Lords, or revoking the Fixed Terms Parliament Act, a change – such as amending the Building Act – shouldn't be an insurmountable challenge.

You can support the CIBSE response to the Part L and Future Homes consultation. A huge thanks to all who have already sent thoughts and supporting material. The response deadline has been extended to 7 February, so keep sending us contributions. We are particularly interested in SAP sensitivity analysis and in-use performance data (this can be anonymous). For full details, see the CIBSE consultation page at bit.ly/CJJan20Con

- Submit your own response: A current draft of the CIBSE response is available on the CIBSE consultation page, as an example.
- Support the Building Performance Network joint statement on operational performance, signed by CIBSE and other organisations, at bit.ly/CJJan20BPN

State of independence

Verification of product information is needed to ensure equipment delivers on makers' performance claims, says Geyser Thermal Energy's Lolli Olafsson

As the recent emission scandal from a major car manufacturer demonstrated, fuel-consumption data from the car industry is highly questionable. No matter what the conditions, or how I drive, I can't achieve even 50% of the mileage my car is supposed to do. But what about the products and equipment we buy for our heating and hot-water systems? How much can we trust the makers and their claims that appear so attractive and supposedly 'great for the environment'?

Unfortunately, this information can vary tremendously. It is not always easy for experienced engineers – let alone homeowners – to verify the data. Take limescale, for example; it is one of the worst offenders when it comes to energy, water and resource waste. Limescale destroys equipment such as pumps, valves, shower mixers and heat exchangers; it increases the risk of legionella by providing insulation and food for the bacteria – and it wastes energy by insulating heat exchangers and temperature sensors. These facts are well documented – yet the legislation around limescale protection is almost non-existent. Manufacturers can more or less claim whatever they want, without having to provide a shred of evidence to back up their claims.

Independent tests have shown that devices claiming to be 95-100% effective in limescale protection were, in fact, as low as 45% effective. How are customers supposed to know who to believe when there is no official verification of the equipment they are buying? In the end, most people buy the cheapest option, even if it tends to be the worst offender, which will cost them and the environment the most.

'Genuinely independent testing'

Dame Judith Hackitt's *Independent Review of Building Regulations and Fire Safety* states in Recommendation 7.1 that 'a clearer, more transparent and more effective specification and testing regime of construction products must be developed. This should include products as they are put together as part of a system'.

True – because unlike in countries such as Sweden, Iceland and Germany, where gaining approval for product capability is much tougher, equipment manufacturers and salespeople in the UK can claim almost anything they



"Manufacturers can more or less claim whatever they want without having to provide a shred of evidence to back up their claims"

want, and refer to approvals and 'research' that are not worth the paper they are written on. Without a truly independent body, the chaos will continue.

If you don't know what you're looking at, you simply won't be able to tell the difference. What's worse is that less effective and fake equipment can give the whole industry a bad name. The vast majority of people don't understand the operation of their heating at home, let alone the equipment itself – but if they want to learn, where do they go?

Even if you are keen to spend time on researching products to improve energy efficiency, there are too few independent sources. If you don't know who to trust, you might abandon your plans to make those purchases and do nothing at all.

Sadly, and frustratingly, the current status hinders innovation. Inventors working out of their 'garden shed' have much more difficulty getting their products to market, unless they have substantial funds to pay for their 'independent' verification.

This could easily be rectified; there are research centres in the UK – such as BRE and BSRIA – that could verify products and equipment and their efficiencies. They have the skills and facilities to provide the support end customers need.

However, instead of being financed and supported by the government, so that they can be 100% independent and focus on research, development, education and verification of products, they are commercially driven, having to spend valuable resources on funding themselves.

If we go back to the limescale example, a standard could be established where manufacturers have to achieve a minimum efficiency and/or have an efficiency label (such as the current scheme for electrical equipment) – and research institutions such as BRE and BSRIA could verify their claims. This would enable customers to at least make an informed decision before buying the products.

In the meantime, despite all the hype and all the claims, energy continues to get wasted. So long as the UK does not have a government-funded and supported, genuinely independent testing regime, this will continue to be the case, sadly.

LOLLI OLAFSSON
founder and
CEO of Geyser
Thermal Energy

Loud and clear

Excessive noise from mechanical ventilation systems can have a detrimental effect on the comfort of building occupants, but Apex Acoustics' Jack Harvie-Clark believes the proposed Approved Document F fails to address the issue

As part of the government's consultation on the Future Homes Standard, Approved Document F (AD F) is also out for consultation.¹ This is a great opportunity for the government to go beyond the current position, in paragraph 4.34 of AD F 2010, that 'noise caused by ventilation systems is not controlled under the Building Regulations'.

Most people have personal experience of annoying noise from mechanical ventilation systems, which causes them to turn it down or off. In older, less airtight houses, there is likely to be sufficient ventilation from infiltration to avoid really poor indoor air quality. In modern, airtight houses, however, occupants rely on the effective operation of their ventilation systems to enable good indoor air quality.

The research for our 2019 article, 'How loud is too loud: noise from domestic mechanical ventilation systems',² in the *International Journal of Ventilation*, was issued with the consultation,³ and reinforces the risks that excessive noise causes for occupants. So how does the consultation draft AD F help prevent this unintended adverse consequence? (See panel 'AD F consultation draft wording'). For one thing, it omits the line that indicates noise is not controlled under the Building Regulations – but how does it propose to control noise in the future?

Bizarre issues

The current proposal in the draft AD F (see panel) is entirely inadequate to address noise from mechanical systems. There are no objective standards to meet and, rather bizarrely, the issues highlighted in paragraph 1.5 don't mention noise from the fan. Why use terms such as 'minimise noise' and 'not unduly noisy', rather than state objective noise levels that we can measure?

Also surprisingly, reference is made to taking account of outside noise when considering the suitability of opening windows for purge ventilation. Is this purge ventilation, as described in AD F, to rapidly dilute pollutants and/or water vapour? From an acoustic perspective, there would be few concerns about external noise ingress when using it in this way. The more common use of purge ventilation is to mitigate overheating, but that is a separate issue.

Why does this draft talk about 'sizing and jointing ducts correctly', rather than simply stating noise criteria to be achieved? If noise is controlled under the Building Regulations, contractors will quickly find out how to make sure their designs and installations work. The Building



Control body can check or ask for third-party verification; measurements of noise levels can easily be made if there is any doubt about whether they comply with the criteria.

Need for regulation

The necessity to include noise from ventilation systems within the Building Regulations is evident to stop occupants suffering poor indoor environmental quality (IEQ) as a result of intolerable noise. There needs to be:

- Performance standards for sound from ventilation systems
- Demonstration of compliance at the design stage
- Demonstration of compliance on completion.

We suggest the minimum performance standard to prevent most people being annoyed is:

Whole dwelling ventilation: sound from any type of mechanical ventilation system – when measured according to BS EN ISO 16032 – should not exceed:

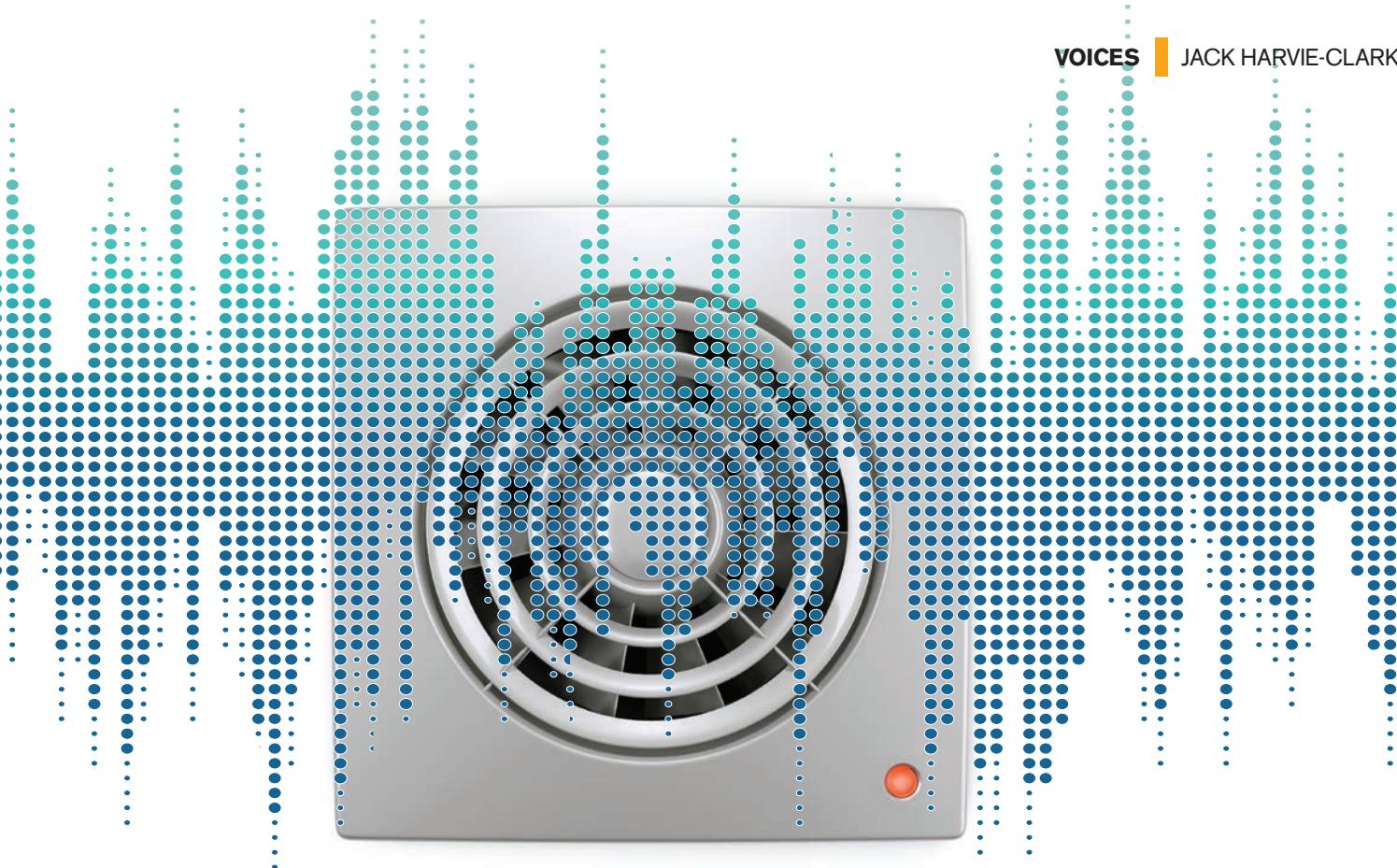
- 26 dB LAeq, T in bedrooms, and
- 30 dB LAeq, T living rooms.

Extract ventilation: sound from any type of mechanical ventilation system – when measured according to BS EN ISO 16032 – should not exceed:

- 26 dB LAeq, T in bedrooms, and
- 35 dB LAeq, T in living rooms, and
- 45 dB LAeq, T in kitchens, sanitary accommodation and bathrooms.

The requirement relating to whole-dwelling ventilation should include sound from mechanical extract ventilation (MEV) and mechanical ventilation with heat recovery (MVHR) systems. The one relating to extract ventilation

"It would be useful to have a consistent approach to describing sound levels, so designers can compare products and building control bodies can determine compliance"



should include intermittent extract fans used with natural ventilation, as well as MEV and MVHR systems. The performance requirement should apply with all doors (and windows) closed, and be adopted for the measurements. Although recirculating kitchen canopies do not provide ventilation, they should meet the same noise standards.

Design-stage compliance

Manufacturers, generally, have sound data for their products, but quote the values in different and often confusing ways – for example, quoting levels at 3m in the freefield, which may be 18dB lower than the level the same product makes in a small room.

It would be useful to have a consistent approach to describing sound levels, so designers can compare products, and building control bodies can determine compliance. For extract fans that are ‘in the room’, for example, describe the standardised sound level in a room of 15m³, to represent the probable worst-case condition of a small room.

For MVHR systems, duct length and bends reduce the transmitted sound. A calculation can be given for a particular dwelling based on the ductwork layout and the source sound power level at the calculated operating point. Manufacturers or system designers can provide these calculations; manufacturers currently propose the operation point of their equipment, so this calculation could be added to that or determined from the proposed ductwork layout.

Demonstrating compliance at completion

Commissioning measurements of sound should be taken at the same time as those for ventilation airflow. All data should be lodged online, in a database linked to the SAP and Energy Performance Certificate, along with the airtightness test result and other evidence of compliance.

A less onerous regime could give building control bodies the power to demand commissioning sound measurements be carried out by a suitably qualified person if they have any concerns over the sound levels, based on an aural assessment.

Responses to the Approved Document F consultation must be received by 7 February 2020. The government needs our opinions. Let’s not waste this opportunity to help it make appropriate regulations that protect people.

References:

- 1 *Building Regulations: Approved Documents L and F (consultation version)*, bit.ly/CJJan20ADLF
- 2 How loud is too loud? Noise from domestic mechanical ventilation systems, *International Journal of Ventilation*, bit.ly/CJJan20vent
- 3 *Ventilation and indoor air quality in new homes*, Ministry of Housing, Communities & Local Government, bit.ly/CJJan20IAQ

AD F CONSULTATION DRAFT WORDING

To prevent excessive noise, the consultation draft AD F states:

Performance

In the Secretary of State's view, requirement F1(1) will be met if the dwelling is provided with a means of ventilation which... provides... as far as reasonably practicable:

- Low levels of noise, by following guidance in paragraphs 1.5 to 1.7...

Noise

1.5 Mechanical ventilation systems, including both continuous and intermittent mechanical ventilation, should be designed and installed to minimise noise.

This includes:

- Sizing and jointing ducts correctly
- Ensuring that equipment is appropriately and securely fixed
- Selecting appropriate equipment, including following paragraph 1.6.

1.6 For mechanical ventilation systems, fan units should be appropriately sized so that fans operating in normal background ventilation mode are not unduly noisy. This might require fans to be sized so they do not operate near the maximum capacity of the fan when operating in normal background ventilation mode.

1.7 Account should be taken of outside noise when considering the suitability of opening windows for purge ventilation.

DOWN TO ZERO

The government has set a 'net zero by 2050' target, but many industry professionals have committed to achieving this by 2030. We asked five experts what they are looking forward to in 2020, and what the priority will be to ensure we're on the path to zero carbon



Jennifer Elias, senior engineer at Cundall, on behalf of LETI

It's been a really exciting year for the London Energy Transformation Initiative (LETI). We published our one-page guide to net-zero operational carbon in 2019 and are gearing up to release our full *Climate Emergency Design Guide* in January. We're looking forward to the industry building on, developing, and collaborating on solutions to move towards net-zero carbon in 2020.

To work towards net zero, start by reading our *Design Guide*. Prepared by professionals from across the industry, it highlights some of the solutions we can put in place now for new buildings. There are many high-impact things we can implement in the buildings we're designing. We need to:

- Optimise window-to-wall ratio. For residential, this should be 10-30% depending on orientation and, for commercial buildings, 40-50%. Full-height, full-width glass should end with 2010 buildings
- Eliminate onsite fossil-fuel combustion for heating and hot water
- Design all buildings so they are capable of being naturally ventilated when outdoor conditions permit
- Do a full embodied-carbon study, and implement solutions to reduce embodied carbon and construction impacts.

For buildings operating now, we need to:

- Publicly disclose operational energy performance on an annual basis
- Undertake efficiency audits and ensure controls regimes are set, to maximise efficiency



■ As plant reaches its end of life, carefully consider alternatives to like-for-like replacement with net zero in mind.

All parts of the industry have a role to play – we're looking forward to further collaboration on net-zero carbon solutions in 2020.



Dave Cheshire, regional director at Aecom

The past six months have been transformative, with policy-makers, construction clients, designers, local authorities, investors and owners all committing to net-zero targets and declaring climate emergencies. Many of our clients are asking for advice and inviting us to help them translate

policy into action. Next year, I'm looking forward to this new enthusiasm being turned into real change.

I'm excited about the launch of the new edition of CIBSE Guide L: *Sustainability*, as this aims to respond to the rapidly evolving agenda. The Publication Committee that I chair ensured the revision addressed the climate crisis when the rewrite started three years ago, well before the rapid change in public awareness.

An important step in delivering low energy and net-zero carbon buildings is to understand how the buildings we design are actually performing. So, next year, we are starting by pushing our new EVOL+VE initiative, which includes revisiting more of the completed projects we have designed to understand how they are performing, and to learn lessons that we can use to inform our new designs.

I believe we have to take a more holistic view of buildings, to ensure we are considering the whole-life impacts of design decisions, including the circular economy agenda.

This moves beyond simply cutting operational energy use and reducing embodied carbon impacts, towards concepts such as designing for adaptability and designing for disassembly, to ensure we retain the value of buildings, and their components in perpetuity.



"Technology helps with the capabilities, now we also need to develop the incentives"

– Tom Randall



Sara Kassam, head of sustainability development at CIBSE

I am looking forward to being part of the team refreshing the Engineering Council's *Guidance on sustainability for the engineering profession*, published in 2009. Providing guidance for individual

engineers and technicians, to support them in meeting their professional obligations, is more important than ever, and is challenging professionals to step up when it comes to sustainability, in all senses of the term. I'm also looking forward to the release of modular CIBSE resources on issues related to net-zero emissions, the reinvigoration of the Controls and IT special interest group and, of course, the Building Performance Awards in February.

To meet zero carbon, we need to do everything: skills, knowledge, training, enthusiasm, collaboration, persistence, creativity and diligence. There must be sustained action in all areas, and everyone has a part to play. It's heartening to see people and groups coming together via organisations such as LETI and the Building Performance Network (BPN), offering inspiration and challenge. We need to keep going, learning from each other, making a difference in whatever way we can.

Operation of buildings shouldn't be forgotten; there's still a huge impact to be made in our existing stock, and focused facilities management (FM) has a key role in the journey to net zero.



Simon Bennett, applications engineer at Adveco

I am looking forward to the progress reports from hydrogen projects currently being carried out. We believe hydrogen is a key future energy solution – more cost-effective to deploy at scale given the existing gas network, and less impactful on a building's existing infrastructure.

Investment by the Department for Business, Energy and Industrial Strategy is encouraging, as are the results of the test projects, so we see a huge opportunity for green gas and hydrogen technologies in the mid- to long-term. From our investigations into the feasibility of hydrogen, we believe a 20% blend is an achievable first step, and 100% provision feasible as we approach 2050.

As a system designer and manufacturer, we need the government to declare on preferred renewable energy sources, whether this be electric, hydrogen/green/natural gas mixes, or a combination of all. Our priority is to develop a new class of higher-temperature air source heat pumps (ASHPs), which address commercial DHW demands and use more environmentally friendly components.

Our other immediate focus is on delivering packaged and bespoke hybrid systems combining high-efficiency gas and electric water heaters and boilers, alongside solar thermal, micro-CHP and ASHPs. Optimising pre-existing and new systems in this way pays dividends, balancing gas and electricity use for a more cost-effective means of delivering sustainability within the building right now, as well as future-proofing later developments.



Tom Randall, head of building optimisation services at Verco

My expectation for 2020 is an acceleration in innovation in building sector processes and contracts to be aligned with building performance, including the path to zero carbon. There has been much coverage of technical innovation – PropTech, CleanTech, Internet of Things, smart buildings and digital twins. For these to

deliver the benefits they promise, however, the building sector supply chain must be realigned. Behaviour change results from capabilities plus incentives. The technology helps with the capabilities – now we also need to develop the incentives.

There is emerging leadership in this area. From a new-build perspective, the Better Buildings Partnership's Design for Performance initiative (see *CIBSE Journal*, November 2018) requires a contractual, collaborative commitment to operation performance and a process that adds rigour to design, construction and early operation. For existing buildings, LandSec has led the way with an FM contract that explicitly requires delivery of operational performance. In addition, this summer, L&G announced the adoption of an FM integrator approach to join up and deliver the wide energy, maintenance and occupant benefits that many speak about, but few existing FM contracts truly reflect.

In the shadow of climate change, there is a growing focus from landlords and developers on how buildings actually perform. Actual or proposed changes to the Global Real Estate Sustainability Benchmark, Breeam, EPCs, Part L and planning are promoting operation transparency. If that is to be achieved, we need this systemic innovation alongside the technical – and I think it's coming.



NO TIME TO LOSE

There was a sense of urgency at the fifth Build2Perform Live, as industry discussed how to respond to the climate emergency and accelerate the move towards zero carbon buildings. **Liza Young and Alex Smith share their highlights**

HISTORIC RETROFITS

At the session on retrofitting and refurbishing historic, listed and rural buildings, Historic Scotland's Moses Jenkins presented a case study of 120-year-old Holm Farm Cottage.

Maintaining moisture movement within the fabric of the traditionally constructed building was a key element in the retrofit, Jenkins said.

Within six months of a previous £18,000 retrofit, the building developed severe mould because the insulation was not permeable to moisture and pathways for air to move around had been sealed up. Jenkins said the old insulation was replaced with vapour-permeable material, sealed vents were opened up, and extract ventilation was incorporated.

'We took account of the occupants of the building and how they lived, and the problems - and slugs - went away,' he said.

Attendees at the fifth CIBSE Build2Perform Live were given a two-day insight into the challenges facing the building services industry if it is to meet ambitious zero carbon targets.

A wide-ranging presentation by Lady Brown set the scene. The deputy chair of the Climate Change Committee (CCC) challenged the construction sector to match other sectors on reducing carbon emissions. She told a full auditorium that UK emissions from construction had only fallen by around 1-2% between 2013 and 2018, while power companies had cut CO₂ by around 55%, and industry and waste firms by 11-12%. Brown also highlighted average temperature projections for 2100 from the UK Climate Predictions report for 2018. In a high-emissions scenario, there is a range of warming from 0.7°C to 4.2°C in winter, and 0.9°C to 5.4°C in summer.

Her presentation, *Fit for the Future in a Changing Climate*, focused on two strands of the work being done by the CCC: mitigation – what has to be done to reduce greenhouse gases – and adaptation, the actions needed to reduce the country's vulnerability to climate change. Lady Brown explained that, while less rainfall in the UK was likely to lead to water shortages, demand could potentially still be met with adaptation measures, such as planting more trees, and building flood resilience and sustainable urban drainage.

For buildings to meet 2050 zero carbon targets, she said there would need to be a focus on efficiency in the next decade, plus the adoption of heat networks, heat pumps and

hybrids. In the 2030s/40s, there would have to be widespread electrification and a potential switch to hydrogen in the gas grid.

The CCC has advised the government to look at hybrid solutions to reduce carbon emissions from the UK's 29 million existing homes. Heat pumps could be used to provide the base load, with gas-fired technologies only employed for heating and hot water during peak demand periods. Lady Brown said this would allow more flexibility, with only an additional 40kW of electricity required for a home to power its heat pump.

There was intense interest in heat pumps across the show, including in the seminar by Lochinvar's Scott Mason (pictured above) and the session on the specification, integration

Baroness Brown of Cambridge





"We have to break up radical targets into smaller radical targets that can be achieved in the short term" – Thomas Lefevre, Etude

and whole-life impact of heat pumps, featuring Star Renewable Energy's Dave Pearson and Elementa Consulting's Louise Hamot.

Professor Will Swan, leader of the Applied Buildings and Energy Research Group at the University of Salford, spoke about research looking at integrating a heat pump and battery with electric vehicles at the university's Energy House, a full-scale replica of a Victorian terrace home (see page 36).

CPA's Peter Caplehorn:
'We need to focus on the compliance of the workforce'



Low carbon communities

There were many examples of engineers striving for zero carbon. Etude's Chris Warboys spoke about the firm's ambitious plan to decarbonise Bermuda's electricity sector.

The Atlantic island's electricity is mainly provided by gas turbines, and the network is run by one private utility company. When asked by the regulator to submit an energy plan, Etude proposed an ambitious scheme to have 65% renewable energy by 2040, including solar PV technology and an onshore wind farm coming online in 2025. 'We had a small budget, so focused on the assumptions and methodology, and were transparent in how we did our calculations,' said Warboys.

Etude engaged with the public through pamphlets, radio shows and the local media, and met critics. After receiving nearly 900 responses to the consultation, the regulator accepted most of its proposals, and set an even higher 85% renewable energy target by 2045.

Another initiative that engaged closely with the public was the Cornwall Energy Island Project, set up by BuroHappold Engineering in partnership with the Eden Project. Ben Smallwood explained how BuroHappold held a workshop in 2015, at which local people explored the future of Cornwall's energy landscape. This was followed by sessions in 2017 and 2019, which aimed to 'enthuse, educate, energise and empower'. 'Energy games' enabled people to consider reduction in demand and an increase in renewable supply.

There was general agreement to reduce demand by about 50% and increase supply to exceed 2030 demand by 30%, leading to a net-export opportunity. Since then, Cornwall has secured a devolution deal with specific mention of low carbon energy, and the council has set ambitious energy targets for 2030. 'Structured events are a powerful way of centralising action,' said Smallwood.

Thomas Lefevre, of Etude, spoke about the zero carbon roadmap for the London Borough of Tower Hamlets, which has a 2030 net-zero target. 'We have to break up radical targets into smaller radical targets that can be achieved in the short term,' he said.

At the session on resilience of schools to climate change, Faithful+Gould's Tim Taylor said the performance of 11 schools was modelled in April – following BB101 overheating methodology – using the 2°C and 4°C global warming scenarios. They found that ➤

BPN CALLS FOR REGULATION OF BUILDING OPERATION

In the Performance Declares! session, the Building Performance Network (BPN) – managed by CIBSE – launched a statement jointly signed by the RIBA, UK Green Building Council, Good Homes Alliance, London Energy Transformation Initiative (LETI) and CIBSE.

The statement highlights that voluntary industry initiatives are not delivering the pace and scale of change required for building performance to improve and for the built environment to contribute to the UK's net-zero emissions target.

It therefore called for:

- Operational building performance to be subject to regulatory requirements. This should start with energy and carbon, and be followed by other aspects, such as air quality and comfort
- The public sector to adopt operational performance requirements
- Government to require building performance disclosure, and to support the necessary infrastructure for this to happen.

The launch was followed, in the evening, by a presentation to the first gathering of Architects Declare – 300 architects who have pledged to act to reduce carbon emissions and improve building performance.

The statement is now open for other individuals and organisations to sign in support. To view the full statement and supporting background, visit www.building-performance.network/advocacy

The BPN is keen to hear from organisations that would be willing to voluntarily disclose the energy consumption of their premises, to help build momentum and demonstrate the industry's commitment to improving building performance.

If you would like to add your name to the supporting signatories and/or discuss disclosing the performance of your premises, contact laura@building-performance.network

Ioanna Mytilinaiou
discussed the
GLA's building
monitoring platform
in the Performance
Declares! session



» 'schools designed today are going to struggle with a warming of two degrees, and even more so with four degrees'.

In another study, using Department for Education building in-use surveys of 70 schools over three years, it was found that they used twice as much energy as predicted, said Joe Jack Williams, of Feilden Clegg Bradley Studios. However, environmental – rather than energy – data was difficult to obtain because the schools didn't want to share it for liability and PR reasons.

Digital trailblazers

The Society of Digital Engineering Awards and Building Simulation Awards were announced at Build2Perform. They showed how technology can be harnessed to create accurate building models quickly, which can be used during a building's lifetime to ensure environmental targets are on track.

The winners (see page 13) are pioneers, and there are fantastic examples of digital models of buildings being used as real-life models – such as Newcastle University's Urban Sciences Building Centre, which multiple winner BuroHappold Engineering helped design.

A more downbeat assessment of the industry's practical use of digital technology was made by Thayla Zomer, a researcher at the Centre of Digital Britain. 'Evidence shows BIM is not yet business as usual,' she said, referring to a NBS 2019 survey that revealed 40% of respondents who said they had adopted BIM weren't actually using standards essential for it.



Dan Cash: 'IoT is in a trough of disillusionment'



There was a decoupling of policy and practice, Zomer added, with an overemphasis on technology by academia and not enough focus on the change in processes required to implement BIM. 'Adoption needed to be motivated by legitimate reasons rather than technology,' she said.

In the same session, Dan Cash, senior lecturer at the University of the West of England, spoke about how the Internet of Things (IoT) is struggling to be implemented in buildings. Expectations for the technology had been over-inflated, he said, and IoT was currently in a 'trough of disillusionment'. He quoted a report by Cisco, which found that 60% of IoT initiatives stall at proof-of-concept stage. Cash said it should be used to optimise building systems, and that automated seasonal commissioning offered an opportunity to improve building performance.

He showed an example of how IoT could be achieved, at a demonstration project by Atamate in Cardiff. Six new, insulated flats had all-electric building services installed, with one featuring occupancy-based heating and ventilation. Sensors communicated with the building's local hub. This connected to the cloud, where algorithms are being developed to optimise and maintain services. Energy demand for the flat with occupancy sensors was $11.7\text{ kWh}\cdot\text{m}^{-2}$ per year and Cash claimed the capital costs were below average.

'We need to get to a process of continually collecting data so buildings can perceive

ZERO INCIDENT, DEFECT AND WASTE

At the session on offsite construction, 'Is zero incident, defect and waste possible?', Dale Perini, of Bryden Wood Technology, spoke about the GlaxoSmithKline (GSK) 'Beta' building prototype – a pharmaceutical facility that can be built to international standards anywhere in the world, using local skilled labour. The Ikea-inspired 'factory in a box' – produced in response to GSK's need to develop factories and packaging facilities in Africa and Asia – fits into a shipping container, and comprises a simple set of instructions and made-to-measure components.

Perini said eight former Gurkhas, unskilled in construction, built a defect-free pharmaceuticals facility from components delivered in shipping containers, packed in reverse order for the re-assembly process, in 12 weeks, resulting in a 60% reduction in programme and 70% reduction in labour compared with a standard build project.

David Bradley, of E+I Engineering Group, said offsite manufacture cuts out time on site, as equipment is tested and commissioned in the factory and does not need to be tested again. To ensure their electrical rooms and skids – which are pre-cabled – can be delivered on lorries, he said the switch gear has been narrowed to ensure no road closures for wide loads are needed. The equipment within the units has also been equally balanced, to allow easier lifting by crane.

There are social benefits too, said Lewis Jones, of Prism. Its manufacturing facility is not a construction site, so workers – who have four-day weeks – spend less time travelling and looking for accommodation. 'This cuts emissions associated with travel, and power to keep things on,' he said.



Heat pumps were of great interest to many at this year's Build2Perform

changes [in the environment] and carry out actions to improve performance,' he said.

Creating a competent workforce

In the session on competence in a post-Hackitt world, Society of Façade Engineering vice-chair Graham Dodd, of Arup – who was on the engineers working panel looking at competency after Grenfell – said it is 'not simply what I'm obliged to do contractually, but what is required of me as a professional engineer to make sure the building works as a system and is safe'.

Construction Products Association's Peter Caplehorn said there had been a slow decreasing of standards, and deregulation,

in the industry, over the past 50 years. Dame Judith Hackitt's review found the regulations and systems supporting them were not fit for purpose, he said. 'We need a culture change, and to focus on the compliance of the workforce.'

To ensure industry delivers on performance, Caplehorn added 'a new form of contract is needed – away from design and build – and a way of procuring that's not about least cost'. Collective responsibility and ownership are also vital. 'We need to run back the confidence that was lost [in the construction industry] and build buildings that are safe, and proven to be safe – and that is a no-brainer,' he said. [CI](#)

Society of Façade
Engineering vice-chair
Graham Dodd



A QUESTION OF INTEGRITY

A panel discussion on integrity between CIBSE Fellows and YEN Members resulted in a positive debate on the ethics of engineering.

Marian Ferguson, founding director at Energylab Consulting, said: 'We need to be better storytellers and focus on what matters to the people using buildings. Engineers need to be true problem-solvers rather than regulatory box-tickers, she added.

Alexandra Logan, senior mechanical engineer at ChapmanBDSP, agreed there needed to be more onus on the human side of engineering. She said collaborating with others is what makes buildings come alive, and that being aware and conscientious is what makes a good engineer. 'The human element within design is so important.'

Tadij Oreszczyn, professor of energy and environment at University College London, said engineers had to have the confidence with issues. The industry was 'not very good at reporting failures or near misses', he said, while noting that many other industries were excellent in this area.

Ideas emerging from the debate were reverse mentoring for Fellows and YEN, stronger mechanisms for CIBSE to ask what Members want, and a media outlet for YEN views.

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A JOURNAL OF DISCOVERY

The *Financial Times* returned to Bracken House after an extensive refurb. **Andy Pearson** finds out how Arup overcame the challenges of retrofitting a listed London building by creating a digital twin to reveal the services' secrets

Bracken House in the City of London is an unusual blend of tradition and modernity. Originally designed by Sir Albert Richardson, the building started life in the late 1950s as a purpose-built home for the *Financial Times* newspaper – the pink sandstone of the building's classical-style façades is said to have been selected in homage to the paper's distinctive pink pages. Back then, Richardson's scheme featured two classical-style wings for offices which bookended the building's industrial heart housing the paper's giant printing presses.

When the *FT* moved out in 1989, the building's new owners, Obayashi Corporation, hired Hopkins Architects to transform the building into a contemporary office environment. Its listing in 1987 prevented the building from being demolished. Hopkins' solution was a scheme that retained the building's classical wings, north and south, but replaced its more utilitarian central element with a corrugated, high-tech steel- and glass-fronted office building (which was subsequently listed in 2013). The scheme included a building services solution designed by Arup for the building's then tenant – an Asian bank.

In 2014, when the bank vacated the premises, Obayashi Corporation turned to John Robertson Architects (JRA) to modernise sympathetically the 26,000m², five-storey building (plus its three levels of basement), bringing it up to contemporary office standards. At the same time, Arup was asked to devise an efficient building services scheme compatible with the building's latest reincarnation three decades after the consultant's initial involvement.

PROJECT TEAM

Client: Obayashi Corporation
Architect: John Robertson Architects (JRA)
MEP engineer: Arup
Structural engineer: Arup
Project manager and cost consultant: Turner and Townsend
Main contractor: McLaren
MEP contractor: Skanska

JRA's architectural enhancements included: replacing sections of the Hopkins-designed central atrium's translucent glass-brick roof to let in more light; the creation of a new roof terrace, including the addition of a running track, to allow the building's occupants to enjoy views of St Paul's while improving their wellbeing; and the addition of two new light-wells at the junctions of Hopkins' high-tech central block with Richardson's classical wings to help improve connection and circulation between the different elements.

Arup's role was to design a shell-and-core/Category A building services solution to complement JRA's enhancements. The consultant's brief was to increase the occupation density from a generous one person per 10m² to one person per 8m² for most of the floors. However, for two of the floors, which had been slated as potential 'financial'





trading floors, the brief called for a design density of one person per 6m².

'Our brief was to put more people in the building than had originally been allowed for and also to enable it to be split into multiple tenancies,' says Steven Berry, associate director, building engineering at Arup, the scheme's building services designer.

Arup's original 1990s building services solution had kept the bank's employees comfortable using a variable air volume (VAV) system. This supplied treated air to a floor plenum where it mixed with recirculated air before reaching the occupied space through circular diffusers, via fan air terminal units. Exhaust air was extracted at high level through outlets in the shallow ceiling void, which connected to an exhaust duct running in the plenum of the floor above.

Hopkins Architects transformed the building into an office in 1989



"This survey gave us some of those 'discovery moments'. We found upstand beams where we were not expecting them"

– Steven Berry

Stripped out building during the refurbishment

To help deal with the increased heating and cooling loads in areas near to the façades, the VAV system was supplemented with fan coil units (FCUs) in the floor plenum. A minimum fresh air system supplied treated air to this perimeter zone. The same FCU/minimum fresh air system was used to maintain comfort in the building's two wings.

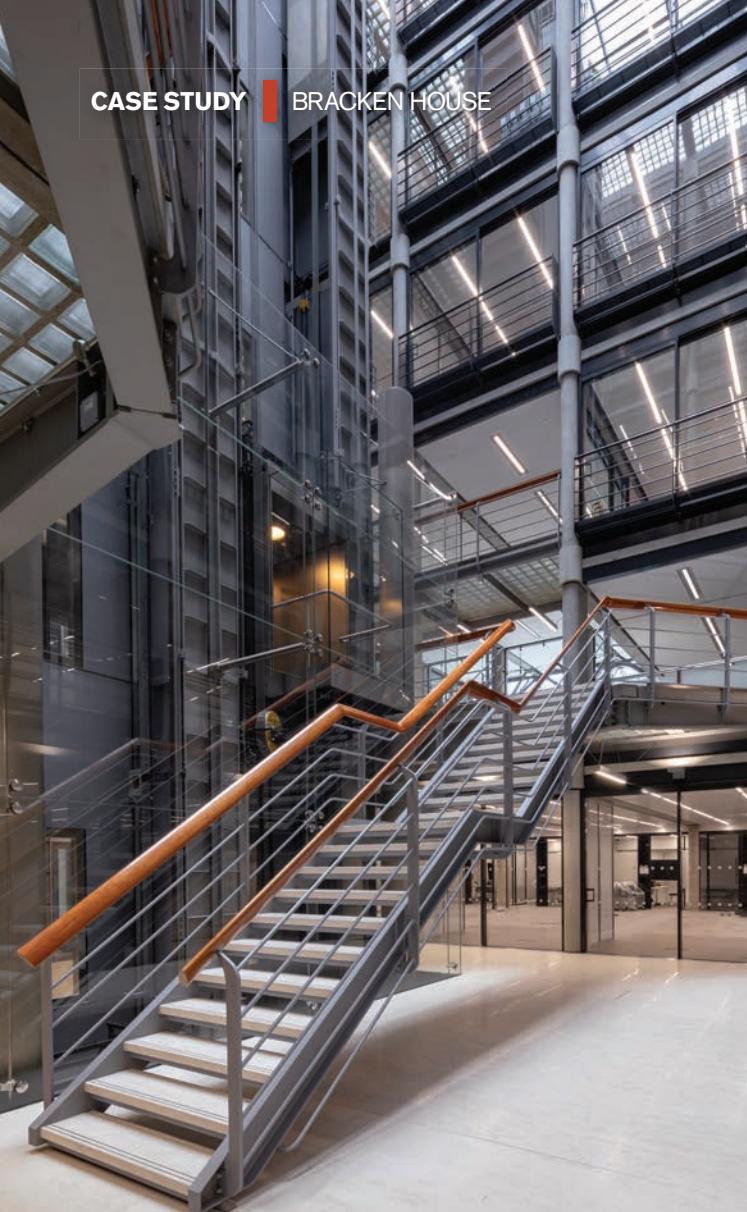
The system was served by heating and cooling plant located in the building's lower basement plantroom in addition to the air handling units, chillers, tanks and pumps. The only major item of plant not to be housed in the basement was the heat rejection plant for the water-cooled chillers that were located in a 'well' on the roof. The primary pipework and ductwork distribution was also in the basement with risers delivering the services vertically to the floors above.

Under the refurbishment, all the existing plant was stripped out. However, the plantroom and distribution risers were retained for use in Arup's new scheme. 'The existing building services were installed in the early 1990s and had reached the end of their economic design life, many items were obsolete and were no longer supported by their manufacturers,' explains Berry.

While Arup's original scheme had been developed in the 2D environment, it was a client requirement that the new scheme was developed in a 3D CAD environment to generate a building information model for use by Obayashi's FM team for asset management and maintenance. The starting point for the digital model was a cloud-point survey, initially undertaken when the tenant was still in place, to enable the design team to start developing the refurbishment solution.'

'The ceilings were still in place and structure covered up and there were even pictures hanging on the walls,' says Berry.

»

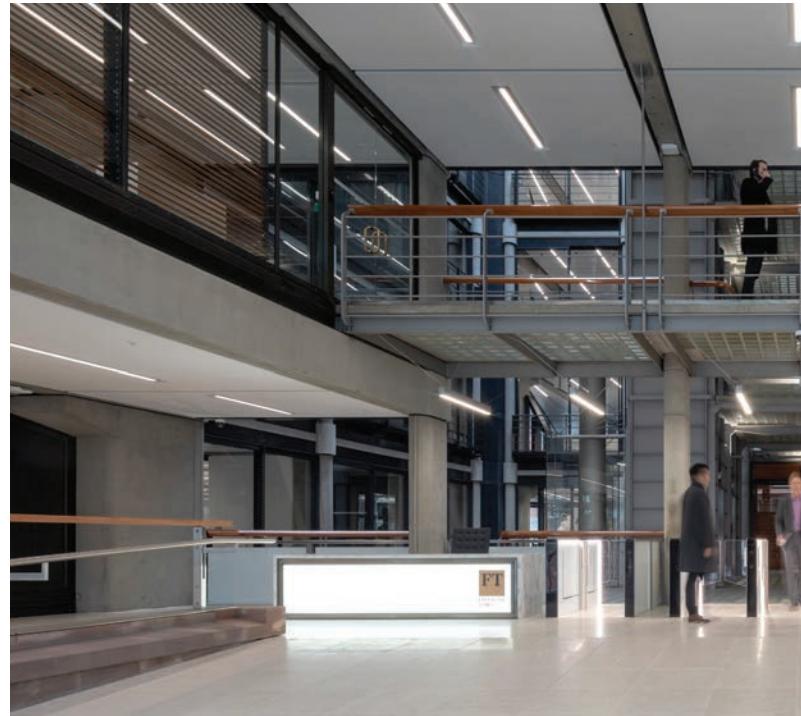


» Although limited as-built drawings existed, these were not always a true reflection of site conditions so extensive surveying was required during the strip-out process. A second, more detailed cloud-point survey was undertaken after the building had been handed over to the main contractor and the raised floor and suspended ceiling removed.

'This survey gave us some of those 'discovery moments'. We found upstand beams where we were not expecting them, which meant we had to rejig the design, moving pipework and ductwork because we actually had less floor void than we initially thought,' Berry says.

The building imposed a number of constraints when it came to selecting a replacement HVAC system for the refurbishment, including the requirement to maintain the current 2.7m floor-to-ceiling height. Other constraints included: a 175mm-deep ceiling void, which is unsuitable for services (except sprinklers and lighting) because it is interrupted by downstand beams; while in the 550mm-deep floor plenum, upstand beams impose a limit on the height of the services that can be distributed within the void and restrict service crossovers to the areas between beams.

A number of HVAC systems were reviewed as replacement options including: underfloor



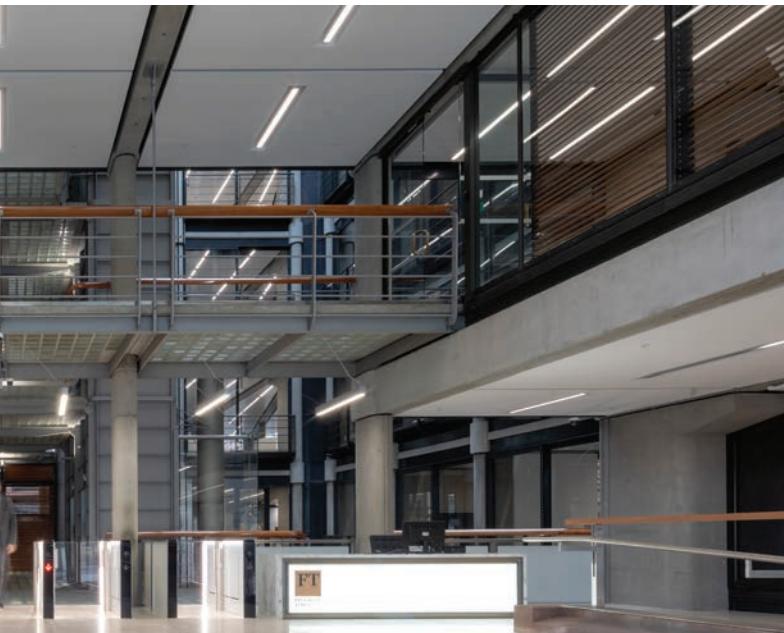
FCUs; underfloor VAV units; an enhanced VAV solution, with an increased number of VAV boxes; and a passive chilled beam system with an underfloor fresh air supply. 'We looked at a number of different ventilation options to evaluate what was feasible,' Berry says.

Each of the four options was assessed based on its cooling performance, flexibility to accommodate changes to office layout, ease of maintainability and its ability to integrate within the building. The chilled beam solution was rejected because it would compromise the 2.7m floor-to-ceiling height. Underfloor FCUs were rejected on the basis that changing the units' filters was considered too disruptive to tenants and because the high density of units required and their associated ductwork would be expensive and require a great deal of coordination.

Of the two VAV options – underfloor and the enhanced underfloor – the more basic solution was least expensive and required the fewest number of services in the floor void, simplifying coordination. This solution, however, lacked the level of zonal control offered by the enhanced VAV option. 'Although the main drawback of the underfloor VAV solution is the lack of zonal control, underfloor supply systems are, to an extent, self-regulating and the level of cooling provided to

There were increased heating loads from IT equipment





"The enhancements included the creation of a new roof terrace, with a running track, to allow the building's occupants to enjoy views of St Paul's while improving their wellbeing"

the floor will naturally adjust according to where the highest loads are concentrated,' Berry says.

In the end, it was decided to go with the underfloor VAV option coupled with underfloor perimeter FCUs for the central building and a ceiling mounted FCU system for the building's two wings – replicating almost exactly Arup's original scheme from three decades earlier. 'Ultimately, in terms of design criteria and cost, we came back to what was installed originally, which we've made better,' explains Berry. He says because the FCUs are located at the building's perimeter it is 'unlikely that maintenance access will be blocked by furniture'.

Under this revamp, the building's floors are designed to be occupied more intensively. 'More people mean the ventilation loads go up and the cooling loads too,' says Berry. In addition, the system had to have sufficient cooling capacity to accommodate the higher heat gains on the potential trading floors.

Arup's scheme included four new, more efficient, water-cooled chillers installed in the basement. These provide a cooling capacity of 835kW per chiller, adding a total of 340kW of additional cooling capacity over the 1990s system while using the same-sized cooling towers. 'We could get chillers that are more efficient and with a bigger cooling output, but the one criteria we could not change was the cooling tower capacity to get rid of the heat, because we could not put any more plant on the building's roof,' says Berry (see panel 'Corridor of uncertainty').

Space was also an issue from a building services perspective with the introduction of the two new lightwells at the junctions between the old and new parts of the building to improve connectivity between the two elements. These internal courtyards, complete with open-tread staircases and landings, also addressed the multitude of

different levels between the central block and the wings.

'To create the courtyards, we had to reposition several risers and the toilets had to be moved,' Berry says. However, advances in technology meant that the designers were able to free up floorspace formerly occupied by the giant IT risers of the previous banking tenant.

The building incorporates a number of different lifts, including scenic lifts in the atrium; goods/firefighting lifts; vehicle and cyclists' lifts; and a roof access lift. The scenic lifts in the atrium, which has significant historical attributes and formed part of the listing, were carefully modernised and upgraded. The goods/firefighting lifts and one of the vehicle lifts were replaced with modern alternatives. The other vehicle lift was replaced to enable cyclists to access the basement cycle store.

In a neat twist, just as the project was nearing completion and Arup's new version of the original underfloor VAV system was being installed three decades after the original, so the FT announced that it would be taking the lease on the refurbished building, returning to its former home three decades after it had originally vacated Bracken House. **CJ**

Occupants enjoy the views of St Paul's



CORRIDOR OF UNCERTAINTY

Unfortunately for Arup, Bracken House is located within a strategic viewing corridor of St Paul's Cathedral. This imposed a maximum height on the building. In the original scheme, the rooftop cooling towers were recessed into the building's roof to keep them below the height limit. Under Arup's new scheme, this onerous height restriction meant the engineer's only option was to site the replacement cooling towers in the same recess.

Size restrictions meant the new cooling towers were almost a like-for-like replacement for the old. Their output means that, although they can supply the base scheme population density and the enhanced occupancy on two floors, redundancy and spare cooling capacity available for a data hall were reduced. 'Although the cooling towers have been replaced, space constraints mean the replacement towers do not provide any significant increase in cooling capacity, which was one of the constraints we had to work within,' explains Berry.

Bringing data to the table

Guide M life tables for maintainable equipment have been updated. Geoff Prudence explains how they align with BESA maintenance schedules and RICS cost guidance

The updated *Guide M Maintenance Engineering and Management* chapter 12 'Life tables for building services and maintainable equipment' was launched by the CIBSE Facilities Management Group at Bouygues' UK head office in London, last month.

Chapter 12 of the guide addresses economic life factors and end of economic life, which are important factors in life-cycle costing of constructed assets, including in-use phases.

CIBSE, in partnership with the Royal Institution of Chartered Surveyors (RICS) and the Building Services Engineering Association (BESA), produced the updated version of Appendix 12.A1, which contains more recent life expectancy data.

The new table acknowledges the development of many new task schedules by the SFG20 library of maintenance specifications since publication of Guide M in 2014. These schedules make clear how often tasks need to be carried out to avoid over or under maintaining assets and explain what skill set should be used to perform the work.

The table includes amendments to align fully with the RICS New Rules of Measurement NRM 1 and NRM 3. (NRM 1 provides guidance on the quantification of building works for the purpose of preparing cost estimates and a cost plan, while NRM 3 gives guidance on the quantification and description of maintenance works for the purpose of preparing initial order of cost estimate).

Otherwise, the content of the new table is as published in CIBSE Guide M. This table is important to the industry as it provides an industry consensus view of common data classifications for all building engineering services, bringing together, as discussed CIBSE Guide M, RICS (NRM 1 and 3) and BESA's SFG20 data standards.

This common data classification may be used by clients, facilities managers and contractors to provide the structured asset information needed for the implementation of building information management (BIM) and effective data exchange during the operational phase of asset life.

Such data can support a number of key applications, including:

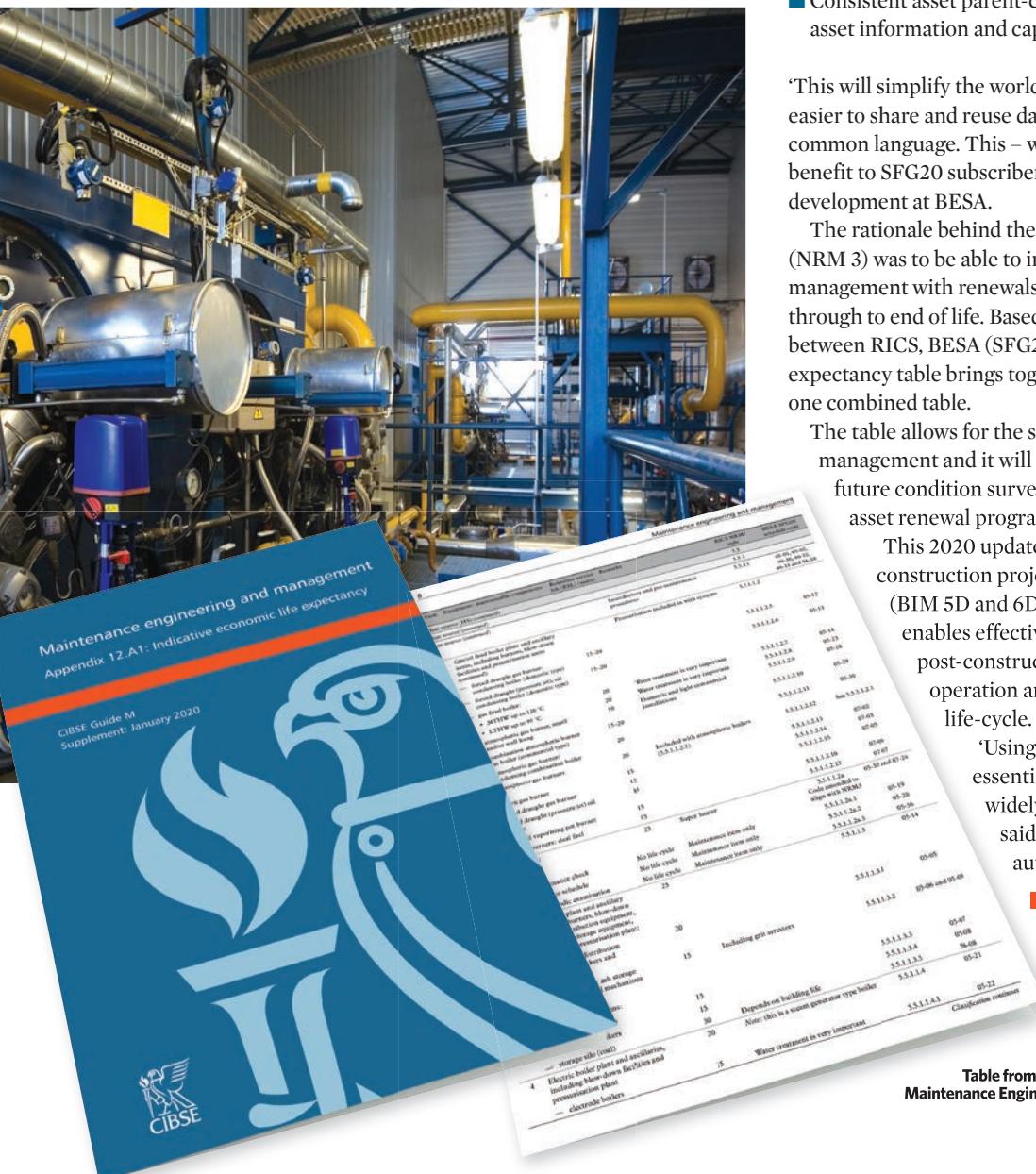
- Project handover to operations and maintenance
- Basis for tendering maintenance and renewal works
- Asset inventory for setting up maintenance registers
- Asset structure for condition surveying
- Asset structure for life-cycle renewal planning
- Setting up computer maintenance management systems, often known as CAFM/asset management systems
- Asset information modelling for BIM projects throughout the asset life-cycle (to provide 5D and 6D to 3D and BIM modelling)
- Facilitates data sharing and exchanging data throughout the asset life-cycle at various stages and levels of detail, for example product data templates.



The revised table should be viewed as the current version for use with CIBSE Guide M. The original (2014) version is still available, and will be the version cited in many existing documents relating to ongoing contracts. Therefore, it will continue to be available to support enquiries relating to those existing arrangements.

The updated life expectancy table fully aligns CIBSE reference service life data, with SFG20 maintenance codes, and to NRM 1 and 3 asset descriptions and coding for building engineering services assets. It also incorporates additional SFG20 maintenance task schedules and SFG20 codes from 2014 to 2018.

"This common data classification may be used by clients, facilities managers and contractors to provide the structured asset information needed for the implementation of building information management"



The benefits to SFG20 subscribers include:

- SFG20 application now includes a new NRM tree structure, which is fully aligned to the NRM 3 and CIBSE Guide M
 - An increase in the number of SFG20 task schedules from 500 to 1,200 (at October 2019), including specialist services – access equipment and lifts; catering; mechanical handling equipment (MHE); security and surveillance systems
 - Supporting industry foundation standards, through NRM/SFG20/CIBSE data, which can be used for future construction projects
 - Standard mapped naming conventions
 - Relational asset structures used through building and asset life phases
 - Consistent asset parent-child structures can be used to manage asset information and capture maintenance data.

'This will simplify the world of building maintenance making it easier to share and reuse data by using mapped structures and a common language. This – with the increase in schedules – is a real benefit to SFG20 subscribers,' said Steve Tomkins, head of business development at BESA.

The rationale behind the RICS New Rules of Measurement (NRM 3) was to be able to integrate the construction cost management with renewals and operation and maintenance, through to end of life. Based on cross-industry collaboration between RICS, BESA (SFG20) and CIBSE, the economic life expectancy table brings together these industry data standards into one combined table.

The table allows for the smooth handover of BIM to facilities management and it will help to structure and standardise how future condition surveying is undertaken and inform forward asset renewal programmes of work.

This 2020 update to the tables is essential to help future construction projects to be more robustly life-cycle costed (BIM 5D and 6D). The common data classification, enables effective handover of asset information post-construction, and this allows for the effective operation and maintenance throughout the asset's life-cycle.

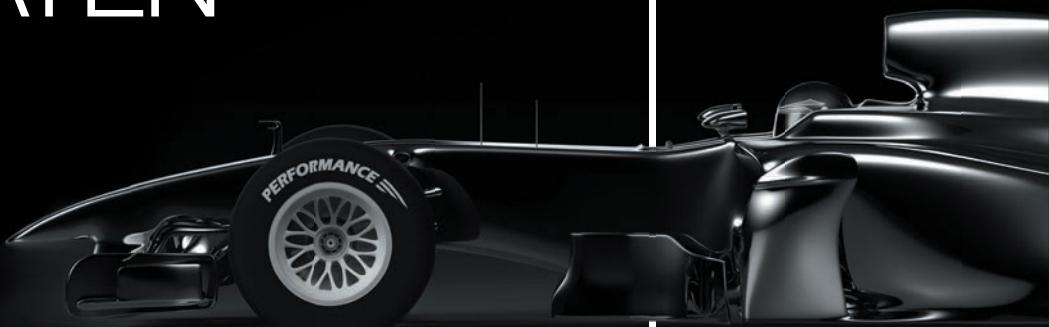
‘Using the common data classification is essential to help life-cycle costing become widely used in a robust and effective way,’ said Andy Green, RICS NRM 3 technical author. 

- The updated tables are available as a free download to CIBSE members and non-members from the CIBSE Knowledge portal.

GEOFF PRUDENCE is the CIBSE Facilities Management Group chair

Table from chapter 12 of Guide M
Maintenance Engineering and Management

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This month: nZEB research; integrating EVs with all-electric homes; retrofitting window film

Heat pumps to replace gas in Sunderland tower retrofit

Ground source heat pumps will replace gas boilers in 364 flats

A energy retrofit project in Sunderland is replacing gas boilers in more than 300 flats with ground source heat pumps.

A large-scale gas-replacement project will result in ground source heat pumps being installed in 364 homes across seven tower blocks in the city, replacing existing gas boiler systems in the properties.

The tower blocks are being retrofitted through the 'Core 364' programme, being delivered by Gentoo Group with the support of energy and regeneration specialist Engie and ground source heat pump firm Kensa Contracting.

A Kensa Shoebox ground source heat pump will be installed in each flat, and connected to a district heating system consisting of ambient shared ground loop arrays.

An underground aquifer will provide the heat source for the tower blocks, accessed via open-loop boreholes drilled to depths of 60m.

The low temperature of the ambient system will mean there are no distribution losses or overheating in the tower blocks' communal areas.

The decentralised heat pumps provide heating independence to the tenants,

who will be able to shop around for the cheapest electricity deal.

The project team estimates that carbon emissions will be cut by 420 tonnes – or nearly 70% – per year, and says that local air quality will benefit from the switch from gas. It predicts that, as the grid further decarbonises, the carbon savings of the system will increase.

Work to replace all existing systems is expected to be completed by late summer 2020.

A Kensa Shoebox ground source heat pump will be fitted in each of the 364 flats



'Pivotal tech' market needs skills boost

Heat pumps will be a pivotal technology for the government's plans for the decarbonisation of heat, but the sector must improve its skills base and get better at selling its benefits to consumers, according to a new report.

Delivering Net Zero: A Roadmap for the Role of Heat Pumps was published late last year by the Heat Pump Association (HPA). It concluded that consumers would have to be 'at the heart of change' and the industry must train 'a cohort of highly skilled low carbon heat installers'.

The HPA said the technology could also play a key role in tackling fuel poverty and improving air quality.

'The report demonstrates the vast carbon savings that heat pumps can achieve immediately,' it said in a statement. 'The question of how we are going to decarbonise the heating of buildings in the future is of huge interest to designers, occupiers and installers. The roadmap presented in the report offers a large part of the answer.'

However, it concluded that emissions from the burning of fossil fuels would not fall unless low carbon heating systems were made more attractive to consumers, either by improving comfort levels or saving them money.

'Installers will play a vital role in raising awareness among potential customers, but there is an urgent need for trained and skilled technicians to be able to design, install and operate heat pump systems properly,' the report added.

Retrofit guide aims to end flooding misery

A new guide to making existing homes flood resilient has been published by RIBA. *Retrofitting for flood resilience: A guide to building and community design*, by Edward Barsley, includes guidance on making electrics, plumbing and gas resilient to flood water.

Measures include using a sump and pump with perimeter sub-floor drainage, to remove excess water, and fitting non-return valves on water and drainage channels where water could backflow.

The book identifies where plumbing and gas are vulnerable to flooding, such as when boilers or radiators are at low level, or drainage pipe outlets are drilled through external walls at low level and not sealed correctly. There are sections on specific products, and the book includes 300 original illustrations by the author, as

well as design strategies at the catchment, community, street and building scale. New building design is also covered.

Barsley said: 'Adaptation should not just be seen as a necessity, given the increase in frequency and severity of flood events, but as an opportunity through which to deliver wider benefits, such as improved biodiversity, and to enhance the quality of placemaking in communities.'



PLUGGING IN NUMBERS

Plugging an electric vehicle into a home energy network could save homeowners £300 a year, according to a new study by the University of Salford in collaboration with Honda and two energy firms. **Phil Lattimore** looks at the challenge of integrating cars with all-electric homes

As the conversation grows around the sustainable built environment, electric vehicles (EVs), low carbon technology and smart grid solutions, a recent research project has focused on the potential benefits of integrating EVs with batteries and renewables in the home.

With 34 million EVs expected to be on UK roads by 2040, the impact of the transition to electric transport is likely to have a significant impact on the electricity sector, both on the demand and supply sides – with batteries in EVs not only demanding more energy but also offering the potential to offer more flexibility to the Grid for energy storage.

The Home as a Virtual Energy Network (Haven) feasibility study – a collaboration between the University of Salford, Honda Motor Europe, Good Energy and Upside Energy – examined how much value vehicle-to-grid (V2G) and vehicle-to-home (V2H) enabled electric vehicles can add in the context of domestic home energy networks.

The study found that EV drivers operating a full energy network could expect to save around £300. This can be done by using storage such as home batteries and smart hot water tanks to maximise self-consumption of solar photovoltaic (PV) power generation and by sharing electricity to and from the grid in an efficient way.

However, it also found that there remained issues with coordination and integration of controls to optimise such systems using multiple assets. It also highlighted the need for hardware costs to fall to encourage investment in these solutions.

Background

Funded by innovation agency Innovate UK, the exploratory study was attempting to determine the potential for V2G in the UK domestic market. The researchers adopted a dual approach to assessing the value of V2G and V2H systems, through modelling and real-world testing.

In-depth modelling was carried out by two Haven study partners – digital energy management solutions firm Upside Energy and renewable electricity supplier Good Energy, which developed modelling approaches and assumptions independently. This enabled the study to remove (or identify) any bias and allow comparison between independent models.

Real-world 'ground truthing' of the models was carried out at the university's Salford Energy House (SEH) testing facility – a Victorian-style two-bedroom terrace house built inside an environmental



INSTALLED TECHNOLOGY

The equipment installed in the Salford Energy House for the Haven project:

- Tesla Powerwall 2 (13.5kWh)
- Honda Power Manager V2G enabled EV charger
- Nissan Leaf (40kWh)
- Mixergy hot water tank (180L)
- Nibe air source heat pump (VMM 320)



"What we were really interested in is what this means for the consumer in terms of savings"

JOULE TERRACE

chamber. It can replicate almost any weather condition, including rain, snow and sunshine, in a controlled way, and vary temperatures between -10°C to 30°C. It was used to subject different configurations of home energy systems to a wide variety of real-world consumption scenarios and a number of EV usage profiles. (See panel 'Installed technology' for a list of the equipment).

Professor Will Swan, director: Energy House Laboratories at University of Salford School of Science, Engineering and Environment, leading the Applied Building and Energy Research Group at the SEH, explains: 'Because we had the Energy House already in place, we were able to build relatively inexpensively a complex, smart domestic energy systems demonstrator, of which V2G was a component.'

Establishing parameters

The Haven study sourced EV usage profiles from a publicly available database (through the My Electric Avenue field trial) to establish typical low, medium, and high usage profiles of users within representative weekday journey parameters.

The different modelling approaches by Good Energy and Upside Energy resulted in the two companies exploring different energy tariff scenarios and combinations when modelling for interaction with grid energy suppliers/purchasers. This included combinations of day-ahead (DA) market electricity prices, use-of-system (UoS) revenues (DUOs and TNUos), dynamic firm frequency response (DFFR) and balancing mechanism (BM) revenues, as well as day-night time of use (ToU) price profiles, covering a range of potential revenue streams potentially available to users of V2G solutions.

'What we were really interested in is what this means for the consumer in terms of savings,' says Swan. 'But we also wanted to stress the system through changing the weather, environment and demand to replicate the genuine experiences real people might face. Even in a complex energy system, everyone wants to be able to turn all their stuff on and off.'

The modelling and set-up at the SEH allowed researchers to explore questions about the impact on the consumer value of using EVs with or without different assets (for example, with or without PV), with different capacity assets (different size PVs and batteries) and with space and water provided by a heat pump. These were assessed for high, medium and low electricity consumption profiles, derived from data from the National Energy Efficiency Data Framework.

The project investigated those revenue streams that offered the

»



- » best value and how much this was dependent on those assets employed, those that gave consumers the most independence from the grid, and the effect of energy consumption on revenues.

Results

The results of the Haven study provided an analysis of the benefits for both energy suppliers and consumers.

According to the report, the Upside Energy modelling suggested that an energy supplier optimising for DA market electricity prices and UoS revenues could increase revenue by around £100 per year by adding a V2G-enabled EV to a home energy network, compared with a charged-when-plugged-in base case.

The total additional revenue available from optimising an energy network consisting of a home battery, smart hot water tank, PV system and V2G-enabled EV was around £500 per year. While the size of these revenues was most sensitive to the specific combination of assets and the size of the home battery the PV array had very little effect on supplier revenues compared with the baseline.

The study also established that a consumer operating on a flat-price profile seeking to maximise self-consumption of PV could generate additional revenue of around £70 per year through adding a V2G-enabled EV – providing other energy storage assets, primarily a home battery, are present to allow energy to be stored when the EV is absent during peak PV generation hours.

Consumers operating the full energy network could expect total revenue of around £300 through increased self-consumption of PV, with these revenues most sensitive to the specific combination of assets and the size of the PV array. The modelling also revealed that small revenue increases were generated with increasing load and when combining into a community where energy can be shared.

Good Energy's modelling approach included revenues available to a consumer by optimising in V2H mode against a day-night ToU price profile, as well as additional revenues from optimisation in V2G mode to capture DFFR and

ENERGY HOUSE 2.0

The University of Salford is currently in the process of building its new Energy House 2.0 laboratory, a £16m project scheduled to be completed by spring 2021.

Energy House 2 will be around seven times the size of the original, allowing it to construct and test small commercial building and modern methods of construction within its environmental chambers on the site. The new site is capable of containing two 100m² detached properties in each chamber.

Energy House 2 will be able to simulate a temperature range of -20°C to 40°C compared with -10°C to 30°C in Energy House 1. It is designed to replicate weather patterns that cover 95% of the world's population.

	EV	EV HB	EV PV	EV HB PV
Min £/year	106.5	80.2	105.6	67.2
Mean £/year	150.8	122.4	147.8	104.3
Max £/year	312.6	225.7	308	212.1

EV – electric vehicle EB – home battery PV – Photovoltaics

Table 1: Minimum, average and maximum benefit for each configuration (vehicle-to-grid)

BM revenues. The results showed a V2H-enabled EV could capture an additional £30-£100 through optimising against the ToU price profile, depending on the asset combination, compared with a base case where a smart charger is used. When including BM and DFFR revenues in V2G mode, total revenues of around £100-£150 could be generated.

Real-world testing

Real-world testing of the solutions and technology configurations in the SEH revealed issues with control, integration and optimisation when individual assets were combined.

Swan explains: 'Each asset is doing what it was specified to do, to optimise for themselves, but in trying to integrate them, we were trying to do something collectively that the assets haven't been individually configured to do. They were not necessarily optimising for the whole system. However, there was a lot of good learning in the study about how we might solve those problems.'

While at an early point in the development of such V2G solutions, Swan expects the market to evolve rapidly. 'In the 20 years I've been involved in this area, I've never seen anything develop so quickly, from controls and systems to storage and renewables,' he says.

The investment case for individual domestic V2G/V2H solutions is currently challenging, with relatively modest revenues from such solutions, but Swan believes V2G at scale could reduce stress on the network and absorb excess electricity when necessary.

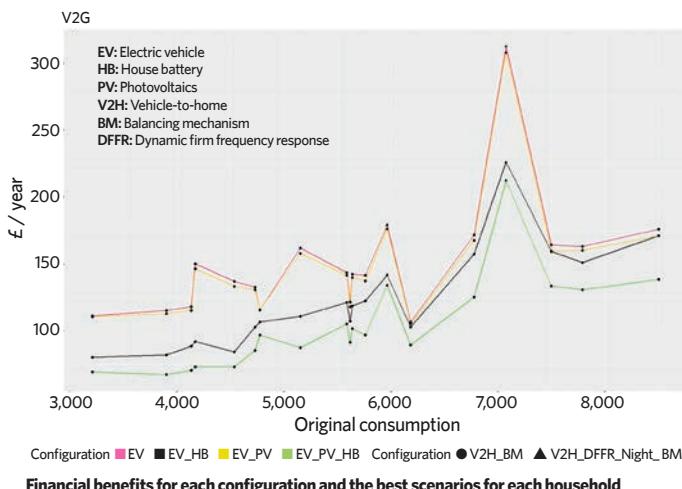
Where V2G at scale may take off first is in businesses or organisations that use fleets of EVs parked overnight, Swan suggests. 'There is more of a business case because you have specific control over a large number of assets. But it's an incredibly fast-moving area, and new business models are emerging all the time.'

Conclusion

The study has offered some useful findings in how V2G solutions can add value in a domestic energy network environment. But, it is still a developing area. 'What you can see is that, although there is revenue to be earned, a quite complex energy service is required,' Swan says. 'You're no longer a passive consumer, you're part of the energy system.'

'While you always have early adopters, it has a little way to go before it becomes a bit further up the adoption curve,' Swan concludes. 'However, I think it will come quicker than many people might think.' CJ

"You're no longer a passive consumer, you're part of the energy system"



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FILM STUDIES

A BIM library for window film will allow the technology to be modelled accurately during design, says **Andrew Cooper**, of Evora Edge

As the climate change emergency escalates, pressure will be on owners to decarbonise their buildings faster and further than before. Building services engineers will also have to improve the resilience of buildings to climate change scenarios, including hotter summers.

We have been asked to model the impacts of climate change scenarios on large building portfolios owned by a major pension fund, and we expect this type of work to increase over the next few years.

All aspects of a building will need to be examined and, as window-film technology gets increasingly sophisticated, it will be harder to overlook the contribution it can make to energy efficiency, as well as occupant comfort and wellbeing.

Role of window film

Window physics is determined by the properties of visible light and thermal radiation, which have similar properties. During transmission, they can be reflected (the direction of the wave changes as it moves away from a medium), refracted (the wave direction changes as it passes through a medium), and/or absorbed (see Figure 1).

Window film changes the properties of a pane of glass by reducing the amount of shortwave radiated solar heat and visible light transmitted into a space. It can also reflect longwave radiated heat back into a space, to reduce wintertime heating loads.

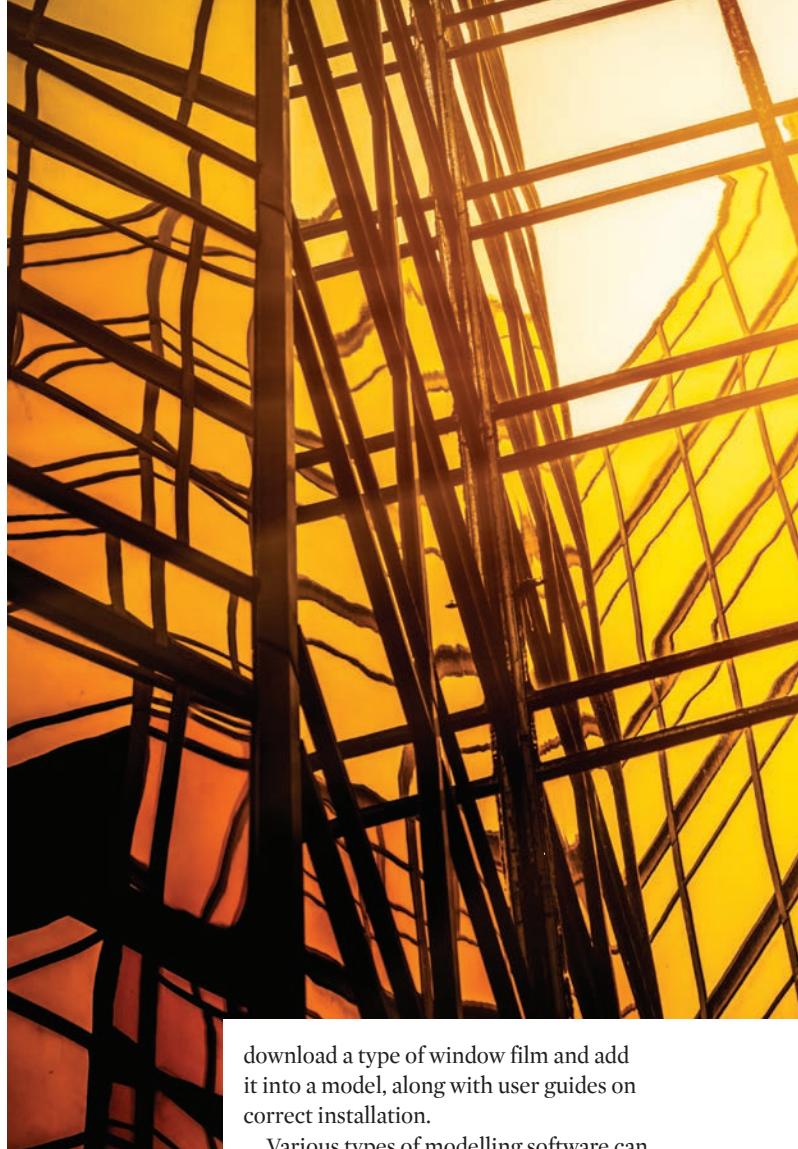
Although it is not a new concept, the technology has evolved through complex manufacturing processes, including the use of precious metals.

The application of film can change the U and g-values of a window, and reduce visible light and glare. It can be specified through a process of layering, with each layer having different values depending on the specific purpose for which it is required (see Figure 2). These layers serve very specific functions and can be just 45µm thick for internal films, or 75µm for external, and up to a maximum of 325µm for safety films.

Depending on the film type, they can be applied to the outer surface of a pane, the inner surface, or to one of the two middle surfaces of a double-glazed unit, if specified by the manufacturer.

BIM library

It has been difficult to model accurately the benefits of window film, and to ensure a consistent approach to data inputs and modelled outputs. We have been carrying out a research project using a commercially available film, with the aim of creating a BIM library that will allow engineers, architects and modellers to



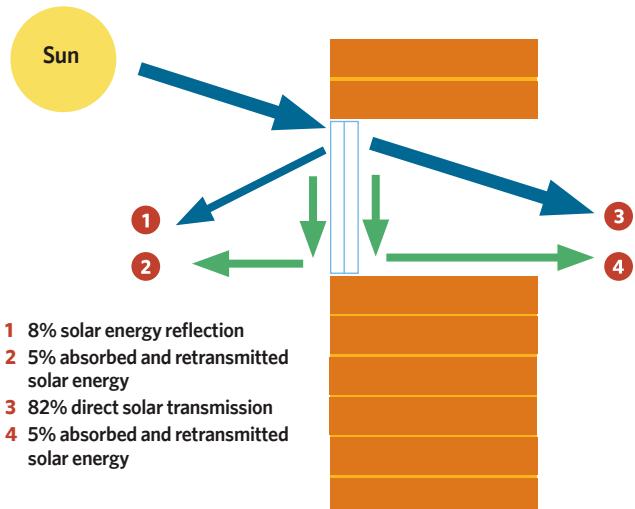
download a type of window film and add it into a model, along with user guides on correct installation.

Various types of modelling software can produce different results, depending on their purpose and default settings. So, to create the BIM library, we had to liaise with the software producers directly, to resolve some of these issues.

Technical challenges

Many energy modellers, even those undertaking dynamic simulation modelling, do not always have an in-depth knowledge

Figure 1: In this example, relating to direct solar irradiance, 82% is directly transmitted to the space, while 8% is reflected and 10% absorbed (5% each side).¹ This equates to a g-value of 0.87 (87% total energy transmission). In practice, the amount of solar energy absorbed would not be transferred 'uniformly' into each side of the space, as environmental and local factors – including the temperature and weather conditions on the outside face – affect this heat transfer





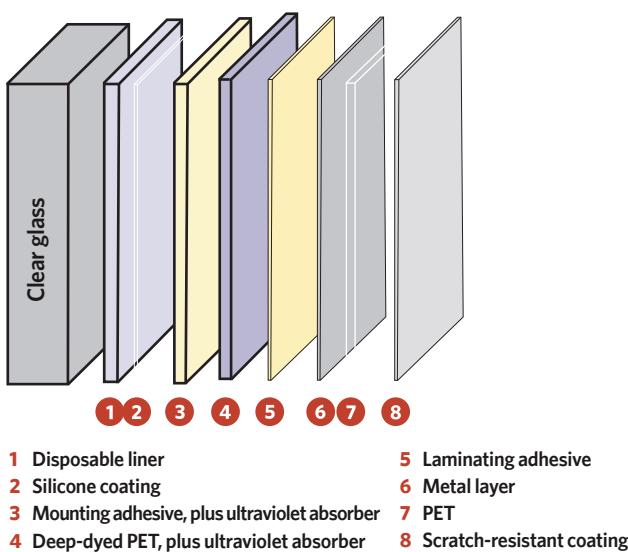
"We have been carrying out a research project with the aim of creating a BIM library that will allow engineers, architects and modellers to download a type of window film and add it into a model"

of calculating window U and g-values. They will, instead, rely on the templates in their modelling tool(s), or seek to calculate the U or g-value based on information they can glean from various manufacturers, with varying results.

This introduces inconsistency and, therefore, risk to the modelling process, which can have a knock-on effect on the selection and sizing of building services or the interpretation of modelling results – for example, when determining human comfort factors.

To overcome these challenges, it is

Figure 2: Modern high-performance window film comprises engineered layers. This example shows a six-ply window film structure²



possible to create mini building information models (BIMs) inside the more complex proprietary modelling systems used by professional energy consultants and engineers. These can be transferred or emailed to other users, and the data imported and exported into other models.

One problem, however, is that these BIMs cannot be transferred between different software systems. For example, it is not possible to open a BIM prepared in EDSL TAS with IES VE or Design Builder, and vice versa. Similarly, it is not possible to transfer the thermal values in a model from Revit or ArchiCAD – often used as design tools – to models used to demonstrate compliance with Building Regulations, Energy Performance Certificates (EPCs), Breeam or Leed credits, or simply design for performance modelling.

To try to get modellers thinking more about the potential of window film, we needed to create a library of mini-BIMs compatible with the software used most often for compliance and energy simulation purposes. This is now the primary driver for new-build assets and refurbishments. For example, a design team would not construct a property that might fail Building Regulations or refurbish a property that might earn a poor EPC rating, so this type of modelling has taken precedence over otherwise static datasets, such as IFC Revit files.

One challenge in creating this BIM library was to ensure the modelled input data resulted in the same technical outputs across different vendor tools.

The calculation tool used by LLumar works to the standards produced by the National Fenestration Rating Council (NFRC). This is also used by the Energyplus software used by Design Builder, and we found a close match between the two.

EDSL TAS, however, works to the standards set by the European Committee for Standardisation (CEN), which has different boundary conditions and provides different results. Within IES there are three glazing performance options – CIBSE, EN-ISO and ASHRAE – and the U values differ between them. CIBSE and ASHRAE are more closely aligned to NFRC calculations, while UK compliance uses the EN-ISO methodology (CEN).

These results primarily impacted on U values, while g-values were less affected.

Our solution was to create, within each BIM, the option to use either the NFRC or the CEN calculations, depending for what purpose the model is being used – for example, Breeam, UK compliance, ESOS, design for performance, and so on. This at least ➤



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- » allows any modeller easily and consistently to test the impact of window film on a building according to the primary purpose of the model.

MG Tower

There is 'real world' evidence of the benefits of window film. A 2011 independent study, by Professor Michele De Carli and his research team at the University of Padua, looked at energy consumption and savings in the MG Tower building in Padua, Italy, before and after the application of a LLumar Helios solar control exterior window film.

The MG Tower is a nine-storey building with more than 1,000m² of glazing, which was reflecting a lot of light and heat into surrounding buildings.

The study was based on a comprehensive three-year assessment of the building, including 450 days of consecutive monitoring of environmental conditions, investigation of the building's energy consumption over the three years, and analysis of the energy savings obtained.

A key method used to assess the impact of the installed solar-control film was the development of sophisticated computer simulations for energy use and lighting conditions, as well as economic benefits, CO₂ emissions reduction, thermal comfort, and visual comfort. These were calibrated based on data collected from the monitoring phase and from measured local weather conditions.

Detailed calibration was vital to ensure simulations properly represented the behaviour of the building before and after film was applied.

In addition to the quantitative analysis techniques used, occupant surveys were undertaken to identify the perceived impact of the film on the building's occupants.

The results showed the building reduced its annual CO₂ emissions by 46 tonnes after the application of the window film, and there was a return on investment within four years, largely because of the reduced need for air conditioning cooling.

The window film reduced indoor temperatures by up to 5°C when cooling plant had been switched off. The reduced need for air conditioning and glare reduction increased occupant satisfaction significantly, and the research team concluded that this improved productivity by €40 per employee per cooling month.³

Modern buildings have numerous windows, many of which cannot be opened. They require complex systems to ensure comfortable temperatures for occupants throughout the seasons. Innovations in window film technology will, therefore, be an important element for engineers who are looking for technologies to reduce the environmental and thermal impact of their buildings. **CJ**

■ The BIM library can be accessed by contacting prossouw@eastman.com

■ **ANDREW COOPER** is director at Evora Edge, the technical engineering division of a global sustainability consultancy.

References:

- 1 Andrew Cooper, Module 14 (Building physics and thermal comfort) of the Energy Institute's Level 2 Energy Management course.
- 2 Source Performance film for glass – taken from a CIBSE CPD presentation by Eastman.
- 3 Case study: Eastman Performance Films commissioned the University of Padua to conduct an independent study of the effects of using LLumar solar control window films on the MG Tower, bit.ly/CJSept19MGT

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Ensuring heat network water quality for effective brazed plate heat exchangers

This module considers how to ensure heat network quality in order to maintain the best lifetime effectiveness of frequently applied brazed heat exchangers

Heat networks are reliant on the effectiveness of their heat exchangers to transfer energy to and from the final load. To maintain effectiveness requires controlled water quality to lower risk of corrosion, fouling, and scaling. This will, in turn, reduce operating and maintenance costs for the entire system. This CPD will explore some of the considerations that will ensure the increasingly common brazed plate heat exchangers have the best opportunity for lifetime effectiveness in what could otherwise be a hostile operating environment.

Heat networks serve nearly half a million consumers across 17,000 heat networks in the UK. Some 90% of the connections¹ are to domestic customers, with the remainder spread across commercial, retail, industrial and institutional users. Networks vary in size and length, from those carrying heat just a few hundred metres between homes and flats, to systems of several kilometres supplying entire communities and industrial areas.² Heat networks currently provide around 2%³ of the overall UK heat demand, but government research suggests that 14–20% of the UK heat demand could be cost-effectively met by heat networks by 2030, and 43% by 2050. It is, however, estimated that around 18% of UK heat will need to come from heat networks by 2050 if the UK is to meet its carbon targets cost effectively. These factors – combined with the growing interest and adoption of ambient temperature loop systems that integrate heat pumps into district schemes – are driving forward the development of new networks.

The water circulating in a district energy system will inevitably be treated in some form, but work recently published by Greaves⁴ illustrated that 15% of the 185 UK heat networks studied had suffered failures as a result of issues around water quality. Heat exchangers transfer the heat from the primary water flowing around the network to the local loads, and many hundreds of thousands of these will be stand-alone brazed plate heat exchangers (BPHEs), which are also employed in heat interface units (HIUs), such as that shown in Figure 1.

BPHEs such as those employed in HIUs, and larger system BPHEs such as shown in

Figure 2, are normally manufactured from pressed stainless steel plates, the plate being embossed with an optimised variant of a 'herringbone' type pattern. These are sandwiched with a copper foil, and pressed and brazed together – typically with copper – to form a compact and effective heat transfer device.

The effectiveness of the heat exchanger is dependent on the thickness and conductivity of the stainless steel plates that divide the two flowing fluids; the surface heat transfer coefficient on both sides of the plates; and any thermal resistance because of 'fouling'. The thin – approximately 0.4mm – stainless steel plates have a very low thermal resistance and, because of the turbulent flow through the heat exchanger, there is very little deposition and accumulation of unwanted materials on the surfaces – therefore, fouling factors are typically low. The surface heat transfers are dependent on the fluid characteristics and the flow, and so are set by the application. (See CIBSE Journal CPD module 118, November 2017, for more details of BPHEs.)

When the BPHE is used in an appropriately controlled environment, there should be no corrosion problems, since neither

»



Figure 1: Example of heat interface unit (Source: Altecnic)

» stainless steel nor copper corrodes easily. However, high chloride levels in an oxidising environment can initiate the corrosion of stainless steel, particularly at higher water temperatures, as the chlorides form a galvanic cell with oxygen and the metals of the BPHE. Chlorides are widely distributed in nature as salts, such as sodium chloride (NaCl), potassium chloride (KCl) and calcium chloride (CaCl_2). The most common form of resulting damage is pitting corrosion, with the chloride attacking areas of the steel where the passive layer is damaged (the passive layer is the protective surface film that is formed when stainless steel is exposed to air).

Pitting corrosion is hard to detect and might only be identified when a unit has started to leak. Another common – and very similar – type of corrosion for stainless steel is crevice corrosion, which can occur at, or immediately adjacent to, a gap or crevice between two joining surfaces. The gap or crevice can be formed between two metals or a metal and non-metallic material, and may occur in welds that fail to penetrate, in flange joints and under deposits on the steel surface where the passive layer has failed to form. Outside the gap or without the gap, both metals may be resistant to corrosion.⁵ Higher temperatures make chlorides more aggressive towards stainless steel. The grade of stainless steel used in the systems should account for the temperature and chloride concentrations – manufacturers will be able to provide advice.

The majority of BPHEs use copper as

the brazing material, which has good resistance to corrosion in the majority of likely water qualities. If the water has a low pH (more acidic), the copper can start to corrode or dissolve in the water. Copper is also very sensitive to ammonia and sulphur. Ammonia has been used in some district energy systems to regulate the pH, so if copper is used as the brazing material, it is recommended that the ammonia level be kept very low. (A normally preferred alternative chemical to regulate pH is, for example, sodium hydroxide.) BPHEs are available that employ a nickel alloy as the brazing material (instead of copper) – resistant to both high sulphur and ammonia contents.

Both copper and stainless steel are susceptible to corrosion in strongly acidic solutions, but copper is the more vulnerable metal in an alkaline environment.

Copper may also be compromised by the presence of dissolved salts, but maintaining electrical conductivity of the water within the recommended range will minimise this source of corrosion. Conductivity measures the ability of a solution to carry an electric current because of the presence of certain ions, and is usually expressed in micro siemens per centimetre ($\mu\text{S}\cdot\text{cm}^{-1}$). Conductivity is also affected by temperature – the warmer the water, the higher the conductivity – and so is normally reported as conductivity at 25°C. The concentration of total dissolved solids in milligrams per litre ($\text{mg}\cdot\text{L}^{-1}$) can also be calculated by multiplying the conductivity result by a factor.

Oxygen content

The presence of oxygen increases the risk of corrosion, so the oxygen content should be kept as low as possible. When adding make-up water, it is important to ensure that either the water has been de-oxygenated or that appropriate additives have been used.

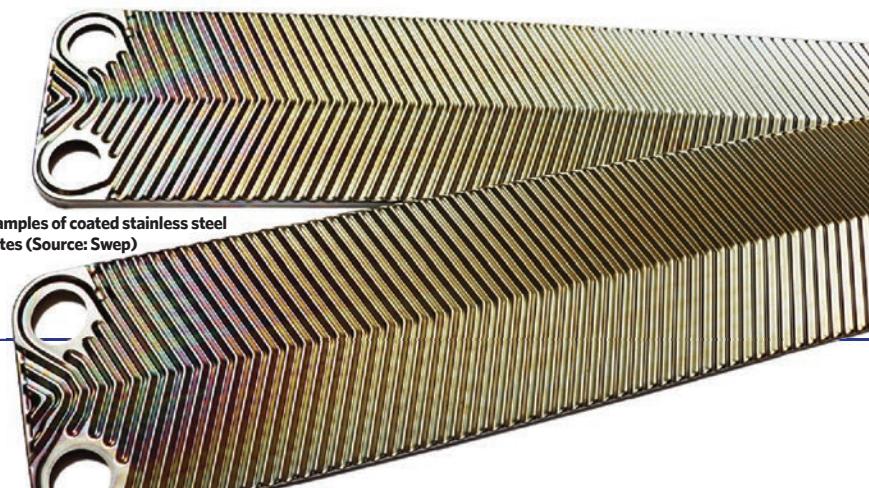
The typical recommendations are that the water circulating in the network should have an oxygen content less than 0.02mg.L⁻¹, be a weakly alkaline environment with a pH preferably between 7.5 and 9, and should contain the lowest possible presence of ammonia and sulphide.

Fouling is the term used to describe the tendency of a fluid to form a film or scale on the heat transfer surface, and is an undesirable phenomenon. Inorganic materials may crystallise as salts, resulting in scaling. Organic deposits include biofilms or microbial organisms. If inorganic or organic material starts to build up inside the BPHE, it will result in lower heat transfer and a higher pressure drop.

Scaling is a type of fouling caused by inorganic salts in the water passing through the BPHE, which may precipitate and form a scale on the heat transfer surface. Most scaling is the result of either calcium carbonate (CaCO_3) or calcium sulphate (CaSO_4) precipitation. It increases the pressure drop and insulates the heat transfer surface, thus preventing efficient heat transfer. Scaling is more likely to occur when the fluid velocity is low (laminar flow) and the liquid is distributed unevenly through the passages on the heat transfer surface.

COATING STAINLESS STEEL FOR ENDURING PERFORMANCE

Ceramic SiO_2 -based surface coatings are being employed to improve corrosion resistance on stainless steel plates in BPHEs to enhance the mechanical and thermal stability. These organic coatings improve the surface behaviour in relation to scaling and fouling. The self-cleaning nature of the coating reduces deposit formation. The protective layer is applied to all inner surfaces of the heat exchanger that come into contact with untreated water.



The solubility of salts in water decreases with increasing temperature, so the salts are, therefore, deposited on the warm surface when the cold water makes contact with it. Scaling is more likely at a high pH, and the risk of scaling generally increases with increasing water temperature. Experience shows that scale is seldom found where wall temperatures are below 65°C. To reduce the risk of scaling, the highest possible water pressure drop across the heat exchanger should be employed. A high pressure drop implies turbulence and higher shear stresses. The shear stresses work as descalers by constantly applying forces to the adhered material that pull the particulate material away from the surface, as shown in Figure 3. For a BPHE with a temperature above 70°C on the hot side and/or very hard water (and a high risk of scaling), the pressure drop should be increased as much as possible on the cold water side.

Particulate fouling

Particulate fouling is caused by suspended solids such as mud, silt, sand or other particles in the water systems. Particulate fouling can influence the performance of the heat exchanger, depending on the particle size. If the particles are large (>1mm) or have a fibrous structure, they may lodge in the inlet of the heat exchanger or clog the channels. The result is an increased pressure drop in the water circuit of the heat exchanger. Clogged channels also mean low water velocities and so reduced heat transfer. Particles may adhere to the heat transfer surface and build up a layer of low thermal conductivity material. Initially, this leads to reduced heat transfer, and subsequently a higher pressure drop in severe cases of fouling. Turbulent flow will keep particles in the fluid in suspension, which will help avoid surface fouling, with the scouring action cleaning the heat transfer surface. As the fluid passes through the channels, it constantly changes its direction and velocity. This ensures turbulent flow even at very low flowrates and pressure drops. The flow depends on the design of the plate pattern but should be evenly distributed across the heat transfer surfaces to maintain uniform velocity. The normal practice is to have the cold water entering the lower port whenever possible, because if it enters through the upper port, it may encourage debris to enter the channels. The distribution pattern in the port areas of well-designed BPHEs ensures a well-distributed flow.

Rough surfaces will encourage fouling by collecting particulate matter. The stainless steel plates provide a smooth surface that minimises fouling, and manufacturers are introducing novel surface coatings to further enhance this (see panel on page 46). Manufacturers must carefully organise brazing points (during manufacture) to reduce the opportunity for pockets of stagnant water.

If bacteria enter the heat networks, their small size (around 1µm) enables them to penetrate throughout the system – bacteria can live with or without oxygen.

Organic deposits/biofilms can reduce the heat transfer in the BPHE, and can also block the flow channels. The deposits can result in microbial corrosion and may require specialist biocide treatment. Appropriate chemical treatment of water can also control suspended particulates.

The channels in a BPHE may clog if particulate matter is not prevented from entering the unit, which then also increases the pressure drop. The piping system must be properly flushed before the BPHE is connected to ensure the removal of material that could cause fouling or clogging. To reduce the risk of a particulate sludge forming inside the BPHE, a filter or appropriately meshed strainer should be installed. Sidestream

Figure 2: A BPHE developed for heat network applications that can typically deliver up to 10MW heat transfer

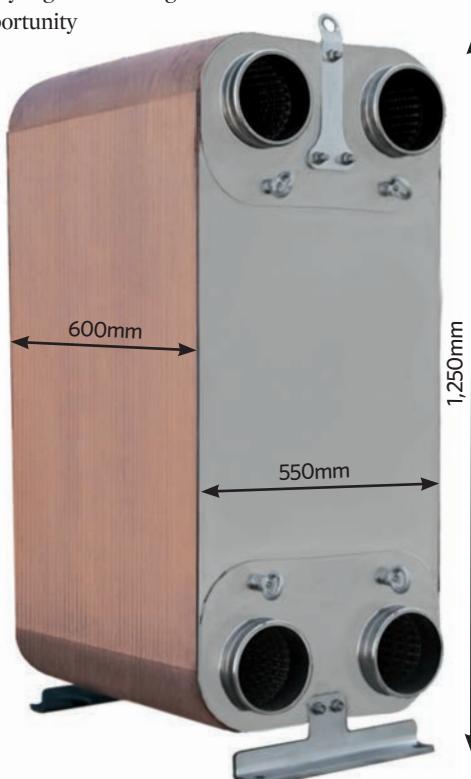
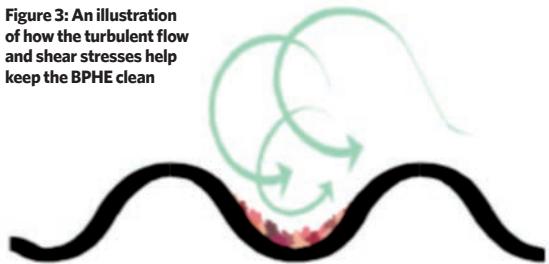


Figure 3: An illustration of how the turbulent flow and shear stresses help keep the BPHE clean



filters are also frequently employed that – as the name suggests – are connected in a bypass arrangement to the main flow, to filter a percentage of the full flow so that the complete system volume is filtered two to three times every 24 hours. These are cost-effective and readily maintainable compared with installing a single large filtration system to handle the full flowrate. Fouling can be caused by corrosion, particularly from other parts of the system. These particles will be carried by the water and may adhere to the heat transfer surface or lodge inside the heat exchanger. For applications with a high concentration of magnetite in the water, such as those with a high leak rate, a filter with a magnetic function is typically recommended. Besides filters, air and dirt separators may be employed to minimise air and particulate matter, reducing maintenance needs and improving performance.

There are some recommended operating practices to ensure the continued effective operation of BPHEs as part a heat network (which have been abstracted from more extensive information in CPI: Heat Networks: Code of Practice for the UK⁶ and the recent CIBSE Journal article by Greaves⁴):

- There should be, as a minimum, continuous monitoring for pH and conductivity, with remote reporting and alerts
- Pressure differences should be monitored across strainers and sidestream filters
- Automatic chemical dosing based on continuous monitoring should control
 - pH levels to a narrow tolerance
 - excessive oxygen levels
 - biofilms, especially when operating with flow or return temperatures below 60°C
- Manual weekly checks should be undertaken to identify any water losses, and there should be a monthly analysis of water chemistry
- Any make-up water should be treated prior to adding to the system
- Water treatment, fill water quality and method and pressurisation should be considered at design stage, based on system volumes and metallurgy.

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■ Turn to page 48 for references.

Module 157

January 2020

- » 1. What is quoted as being the estimate of the proportion of UK heat that will need to come from heat networks by 2050 if the UK is to meet its carbon targets cost effectively?

- A 2%
- B 14%
- C 18%
- D 20%
- E 43%

2. Which of these is not indicated as a characteristic of the stainless steel plates that significantly impacts the effectiveness of a BPHE?

- A Conductivity plates
- B Orientation of plates
- C Surface heat transfer coefficients
- D Thermal resistance due to 'fouling'
- E Thickness of plates

3. What level of oxygen content is recommended as a maximum in the network water?

- A $0.01\text{mg}\cdot\text{L}^{-1}$
- B $0.02\text{mg}\cdot\text{L}^{-1}$
- C $0.25\text{mg}\cdot\text{L}^{-1}$
- D $0.75\text{mg}\cdot\text{L}^{-1}$
- E $0.90\text{mg}\cdot\text{L}^{-1}$

4. When a sidestream filter is employed, how often is it likely that a water volume is filtered equivalent to the whole network volume?

- A Never
- B Once a day
- C Once a week
- D Several times a day
- E The time that it takes for the water to pass once around the network

5. What was used as the basis of the stainless steel surface coating to reduce fouling?

- A CaCl_2
- B CaSO_4
- C CO_2
- D SiO_2
- E SO_2

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Further reading:

A new edition of CIBSE/ADE CP1: Heat Networks: Code of Practice for the UK will be published early in 2020, and will include further detail of water treatment.

There is a very useful guide - *Recommendations - Water Treatment and Corrosion* by the Danish District Heating Association, with an English translation at www.euroheat.org/wp-content/uploads/2017/10/District-Heating-Water-Treatment-and-Corrosion-Prevention-Danish-District-Heating-Association.pdf

For underlying knowledge on water treatment in closed systems, a core reference is BSRIA BG50/2013 *Water Treatment for Closed Heating and Cooling Systems*.

References:

- 1 Market Report: Heat Networks in the UK, ADE, January 2018.
- 2 www.theade.co.uk/resources/what-is-district-heating - accessed 10 December 2019.
- 3 Ford, R, Government support for heat networks - an update, EcoBuild 2018.
- 4 Greaves, J, The scale of the problem - water quality issues in heat networks, CIBSE Journal, July 2019.
- 5 www.corrosionclinic.com/types_of_corrosion/crevice_corrosion.htm - accessed 10 December 2019.
- 6 CP1: Heat Networks: Code of Practice for the UK, CIBSE/ADE 2015.



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Rockwool announces new non-combustible insulated HVAC pipe supports

Stone wool insulation specialist Rockwool has introduced RockLap Pipe Supports – a robust, non-combustible solution designed to minimise thermal bridging from HVAC pipe suspension systems.

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Ideal Commercial Boilers has updated its Eye app featuring hassle-free augmented reality (AR).

The app, available for Apple and Android, brings boilers to life by placing 3D renders of the Ideal Commercial Condensing boiler range over real-life images through the camera in a smartphone or tablet. The app has now been updated to incorporate the latest Apple and Google AR technology. By simply scanning their environment and choosing a product from the library, specifiers and contractors will see the boilers they select displayed automatically scaled to surroundings. If required, boilers can be made smaller or larger or spun through 360°.

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Putting 2019 under the spotlight



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and to overcome the challenge of the British weather, a second court – Court No 1 – was reconfigured and had a retractable roof fitted. The pump solution to support this upgrade included 48 Grundfos Unilift drainage pumps. Meanwhile, the new Royal Papworth Hospital in Cambridge opened its doors with its small army of 32 supporting Grundfos pumps.

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Digital smart metering app for heat networks

SAV and Insite Energy have joined forces to launch Kurve, the market's first digital smart metering app for heat networks. Designed for use by heat network operators and consumers, Kurve has the potential to deliver 62% savings in capital expenditure and 53% savings in operational costs. Heat network operators will gain remote access to data diagnostics from each connected meter, using the system's wired Smart M-Bus infrastructure. Data analysis provides insight into usage patterns and enables heat network operators to optimise network performance.

 Visit www.sav-systems.com



Award win for Mitsubishi heat pump

Mitsubishi Electric's ultra quiet Ecodan air-source heat pump range has been presented with the Renewable Energy Technology of the Year award at the Energy Awards 2019, recognising excellent and intelligent energy use in the industry. More than 500 energy industry professionals gathered at the ceremony in London to celebrate the achievements of the best in the industry across 20 categories, with the entries judged by a panel of 15 industry experts from organisations including Engie, Ofgem and Carbon Trust. The Ecodan provides reliable, renewable heating and hot water production for a wide range of installations.

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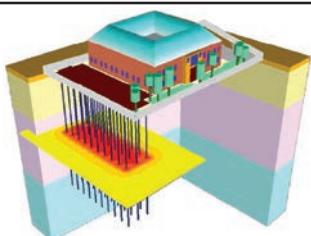
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Domestic hydrogen boilers, like this one by BDR Thermea, could be fitted by retrained installers, says Thom



Peter Thom

Foot off the gas

Government must take the lead if thousands of heating engineers are to be retrained to help meet the UK's net zero carbon targets, says IDHEE director Peter Thom

With the government proposing to ban gas-fired boilers in new homes from 2025, industry is focused on the potential of hydrogen boilers and heat pumps to decarbonise heating in dwellings. If these new technologies are to become mainstream, however, thousands of heating engineers will need to be retrained as low carbon installers.

The Heat Pump Association has said 45,000 heat pump installers will be needed to meet future demand but, currently, there are around 1,700 fitting 20,000 heat pumps a year. By comparison, there are 70,000 gas-boiler installers.

Peter Thom is director at the Institute of Domestic Heating & Environmental Engineers (IDHEE) and was closely involved in the switch to condensing boilers in the 1990s, which involved the upskilling of 70,000 installers. He believes the heating industry is ready to decarbonise, but says government must offer certainty before companies will make the necessary investment.

Can Britain achieve fossil-free heating in new homes by 2025?

It is possible, but it depends on the mix of power stations. It's doable in new-build because you could easily – certainly with the changes to Building Regulations – require the generation of electricity in all homes, and get to net zero quite easily. Rolling that out to the national builders is another question, because you have to get them on board. The political will needs to be there. We need to be on the way to achieve net zero by 2050, but any earlier is probably too big of a challenge.

What will be the prevailing technology – hydrogen or heat pumps?

Hydrogen for the existing housing stock. Why would we abandon the gas network that's connected to 90% of all homes when you can decarbonise it quite easily with the injection of hydrogen gas? Manufacturers have hydrogen boilers that are 92% efficient almost ready off the shelf. If you add flue gas heat recovery and a smart controller, you can achieve almost 100% efficiency.

Heat pumps work in well-insulated properties, but a lot of our homes aren't. They would be great for new-builds, where you have really low heat losses – but, then, do you need much heating? In smaller properties, we could fit electric showers with wastewater heat recovery, point-of-use electric heaters under the sink and panel heaters. In larger properties, we would have a cylinder with solar-thermal or solar PV to heat the hot water, and heat pumps.

Can we train enough installers to fit heat pumps and hydrogen boilers?

We've done it before; we lobbied government for condensing boilers when they represented just 4% of the market. Building Regulations changed in 2005, and we received some funding, working with the industry, government and the BRE, to develop a training programme and accredited course. I trained 400 trainers and it was delivered to 70,000 installers, who got an energy efficiency qualification. It was a smooth transition because we worked together. After that, we had the boiler scrappage scheme to displace G-rated boilers. That's two of the biggest schemes that have helped to save carbon in the UK. But you have training, accreditation, the Microgeneration Certification scheme – barriers that government keeps putting up that are stymying the industry. Small installers are put off by the red tape and bureaucracy.

What is the CIPHE/IDHEE doing to help the industry?

The two bodies have always had a parallel path, lobbying for the same things – raising professionalism, proper qualifications, code of conduct – so we decided to join forces. IDHEE is now a division within Chartered Institute of Plumbing and Heating Engineering (CIPHE), and we have a register for plumbers, heating and environmental engineers, and domestic energy assessors.

What does the government need to do to convince industry it is serious?

It has to demonstrate to us that it is committed. We have been burned by the Green Deal – a lot of companies went out of business as a result. As domestic energy assessors, we had to get qualifications to become Green Deal Assessors and installers, which cost about £10,000. We still have open wounds from that, so the government needs to be specific about what it wants and give us the numbers. We need a proper roadmap with a timeframe. We can then adapt qualifications quite easily.

The Heat Pump Association recently said we will need 45,000 engineers to install heat pumps, but the qualifications are a big investment. Government has to convince the industry – they have to work with us, and we can then convince the masses, like we did with condensing boilers.

The IDHEE was recently amalgamated with the CIPHE, and will continue to promote the installation of safe and efficient systems.

EVENTS

NATIONAL EVENTS AND CONFERENCES

Society of Light and Lighting LightBytes series 2019-20 People, Space, Time, Place

30 January, Manchester

13 February, Leeds

The new series will focus on light and wellness, with presentations divided into four overarching sessions: People, Space, Time, Place. This year's expert speakers will be joined by guest speaker Dr Eleanora Bremilla, 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

Building services one-day overview

14 January, London

Low carbon consultant building operations

15-17 January, London

Low carbon consultant design training

21-22 January, London

Building services explained

27-29 January, London

High-voltage (11kV) distribution and protection

28 January, London

Practical controls for HVAC systems

29 January, London

Fire safety building regulations: Part B

6 February, London

HIGHLIGHTS



Dr Charlotte Adams will look at the heat potential of minewater, in Newcastle on 14 January



Luke Osborne of ECA, will discuss the electro-technical sector, in Birmingham

Society of Light and Lighting & South West – the SLL Lighting Handbook, must-read parts

30 January, Bristol

Paul Ruffles, principal of lighting design consultancy LD&T, SLL past president, and 2018 Lux Lighting Person of the Year, will be guest speaker at this workshop. He will provide an overview of the SLL *Lighting Handbook* to show where his extracts fit into the overall structure of the book, and reveal some of the more peculiar aspects of lighting – why flour mills explode and how atmospheric solvents can eat your luminaires.

Emergency lighting to comply with fire-safety requirements

7 February, London

LCC design training

11 February, Manchester

Electrical services explained

10 February, London

Mechanical services explained

11 February, Birmingham

Designing water efficient hot and cold supplies

12 February, London

Fire safety in purpose-built blocks of flats

14 February, London

Running projects effectively

27 February, London

Fire detection and alarm systems for buildings – BS 5839 Part 1

27 February, London

Energy savings opportunity scheme (ESOS)

28 February, London

Gas safety regulations (designing for compliance)

2 March, London

Introduction to combined heat and power (CHP)

2 March, London

Overview of IET wiring regulations

3 March, London

Fire safety in the design, management and use of buildings: BS9999

4 March, London

Fire risk assessment to PAS 79

6 March, London

Fundamentals of digital engineering

9 March, London

Mentoring skills workshop

9 March, London

Building services explained

10-12 March, Manchester

CIBSE GROUPS, SOCIETIES AND REGIONS

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

CIBSE Membership closing date surgery

8 January, London

An opportunity to speak with a professional interviewer, for tips and advice to complete your Engineering Practice Report.

West Midlands: developments in offsite fabrication and pump systems

8 January, Birmingham

An overview of developments in offsite 'skidding' of mechanical systems, with Lee Davies, of GM Treble.

North East: minewater heat potential

14 January, Newcastle upon Tyne

With speaker Dr Charlotte Adams.

South West and CIBSE YEN IMechE Young Members: heat networks

21 January, Bristol

How will district heating help transform Bristol into a carbon-neutral city by 2030?

West Midlands: energy efficiency and the

changing world of contracting

22 January, Birmingham

Seminar with Luke Osborne, of ECA, covering the emerging and changing world of the electro-technical sector.

Merseyside and North Wales: Harper Adams University Strategic Transformational Energy Project Campus engineering open day

23 January, Newport

SLL and South West – Must-read parts: the SLL Lighting Handbook

30 January, Bristol

With speaker Paul Ruffles, Lux Person of the Year 2018.

West Midlands: design of an accessible and inclusive built environment

5 February, Birmingham

Design of an accessible and inclusive built environment BS8300 – Code of Practice review CPD seminar, with Phil Pearson, of Pearson Consult.

North East – annual dinner

7 February, Newcastle upon Tyne

Annual dinner, with James Bond theme. The charity partner for this event is the Graham Wylie Foundation.

SLL and Scotland: technical seminar on the SLL Lighting Handbook

11 February, Edinburgh

Seminar addressing the fundamentals of lighting, lighting technology, and lighting applications.

North East: district heating and tri-generation

11 February, Newcastle upon Tyne

Technical presentation and networking event.

West Midlands: heat metering selection – getting it right

12 February, Birmingham

CPD seminar with Russell Hillman, of DMS.

UAE dinner and awards

19 February, Dubai

Dinner and Awards celebrating achievements in the industry, hosted by Richard Dean.

West Midlands: driving decarbonisation using digital twins

26 February, Birmingham

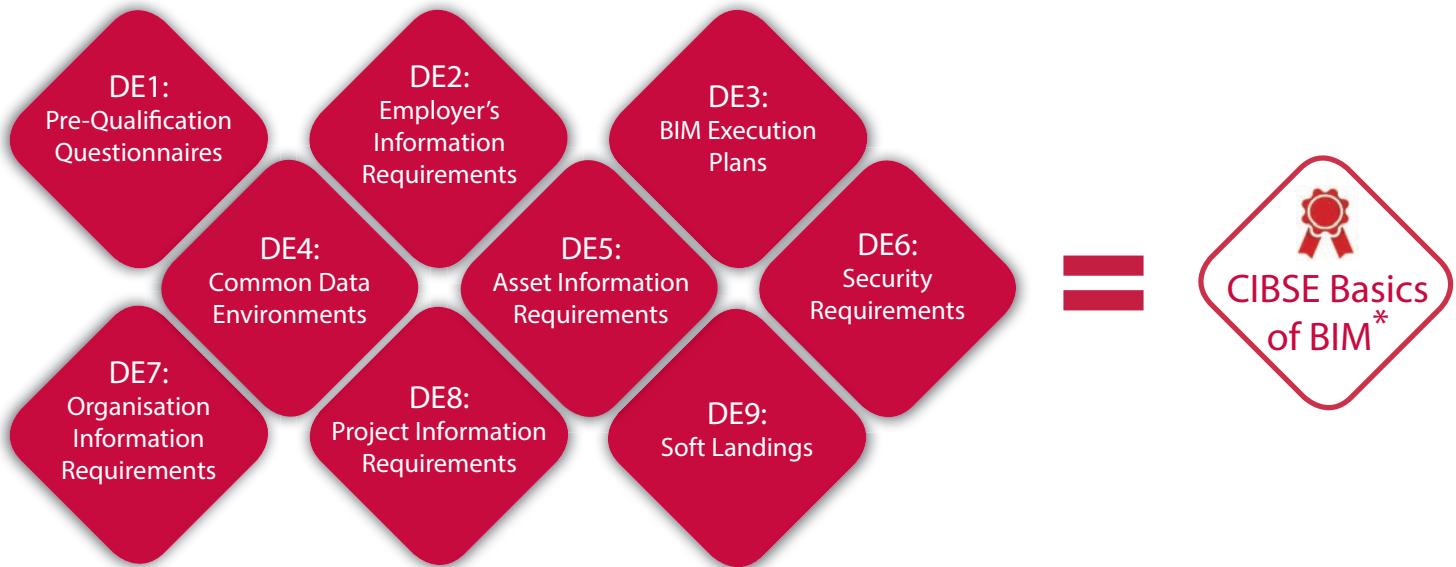
CPD presentation by Eric Roberts, of IES.





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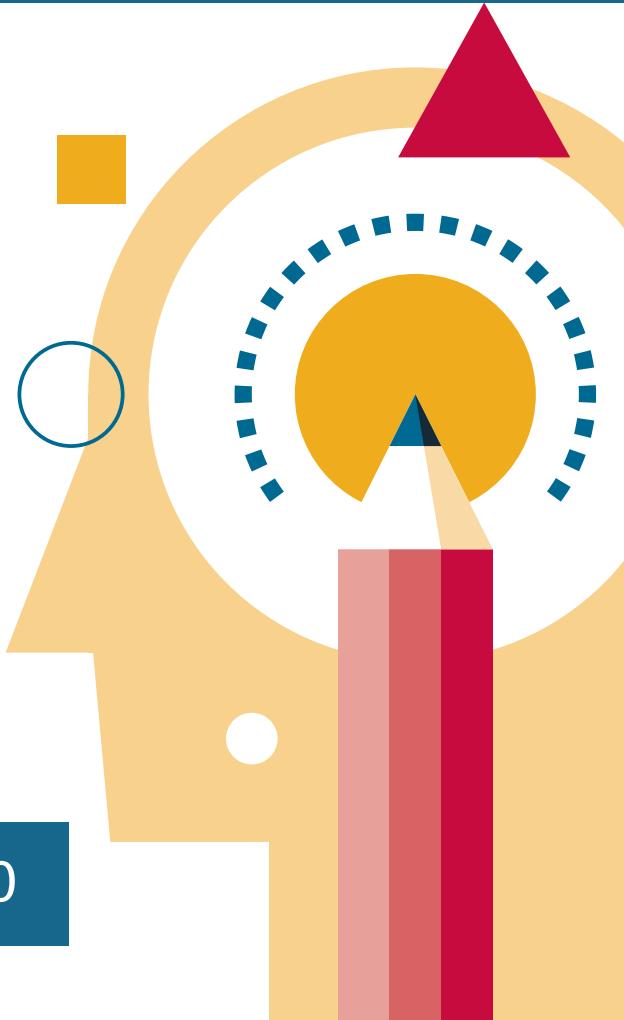


Training Programme 2020

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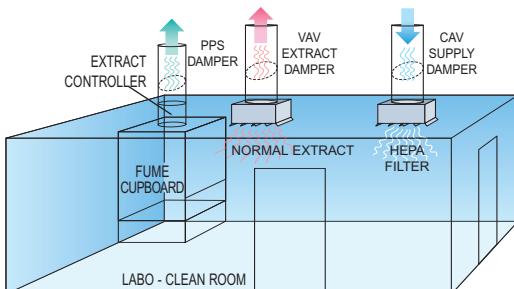


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