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Embodied engineers

The CIBSE Technical Symposium made a welcome return to the lecture halls of London South Bank University. The symposium, which was last held at LSBU in 2018, spent two years as an online only event, but with Covid restrictions now fully lifted, delegates were once again able to meet face to face.

Many in the audience were in familiar surroundings; according to University Provost Professor Taraneh Dean, an astonishing 60% of building services practitioners were educated at LSBU.

Covid 19 maybe on the wane in the UK, but it s still causing major disruption to hospitals and public services and it s important that we do not forget the lessons learned from fighting the disease over the past two years.

There were a number of papers on Covid at the symposium, including a study that monitored CO_2 at public events last summer. UCL associate professor Liora Malki Epshtein explained how sensors were placed in a wide range of venues, including a Liverpool nightclub and Wembley Stadium, to monitor air quality. For the majority of ventilated spaces, the CO_2 concentration was relatively low below 1,000ppm. However, spikes occurred in areas without ventilation where large numbers of people gathered for short periods, such as stadium corridors and stairways, and also in music venues, where a mass of people had surged to the front of the stage.

The topic of embodied carbon was the subject of a keynote speech by IStructE s Will Arnold. He explained how the ratio of carbon emissions apportioned to embodied energy was continuing to rise as buildings operational carbon declined under more stringent energy use regulations.

Arnold said that, by 2030, the embodied energy of an modern building will make up 72% of the total energy emissions and that many low carbon buildings built today would have similar ratios of embodied to operational carbon.

To help calculate the embodied energy in HVAC materials, firms are increasingly sharing products whole life carbon in Environmental Performance Declarations.

These are invaluable but do not cover all components. CIBSE s TM65 seeks to rectify this by providing a calculation that engineers can use to estimate carbon. In a paper presented at the symposium, Hoare Lea s Will Belfield used the methodology to calculate the whole life carbon of cooling and heating systems, and compared a VRF system, an air source heat pump and hybrid VRF.

The results appear in our article on page 64, and demonstrate how engineers can build on one piece of research to help others make optimal decisions about net zero building design.

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CONTRIBUTORS

Hywel Davies
Assessing the implications for daily building activity of new legislation passing through parliament

Lars Fabricius
How using heat pumps to share waste heat and store green energy can help smooth the path to net zero

Julie Godefroy
Questioning the lack of ambition around energy efficiency in the UK's energy security strategy

Tim Dwyer
This month's CPDs look at air-to-water heat pumps and stainless steel in hot-water generation and storage

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IN BRIEF

Coal mine decision due in July

Michael Gove is set to make a decision by 7 July on controversial plans for the UK s first new deep coal mine in decades, the project s developer, West Cumbria Mining, has said. The Planning Inspectorate has submitted its report to the Secretary of State for Levelling Up on the application for the mine, off the coast of Whitehaven in West Cumbria.

The company has said the mine would supply metallurgical coal for steel making rather than be burnt for energy. The inspectorate has been handling the application after it was called in last year.

Ineos offers to build shale gas pilot

Ineos has written to the government offering to develop a fully functioning shale gas extraction test site to demonstrate that the technology can be deployed safely in the UK.

Against the backdrop of spiralling worldwide gas prices following Russia s invasion of Ukraine, founder and chairman of the energy and chemicals giant, Sir Jim Ratcliffe, said exploiting the UK s domestic reserves of shale gas would cut the country s gas costs and ensure its long term energy independence.

Ineos said renewable energy was not yet mature enough to meet the UK s energy needs and that gas would be needed for three decades as the country moves away from burning fossil fuels.

Boiler Upgrade Scheme opens

The government s Boiler Upgrade Scheme went live at the beginning of April. Under the £450m initiative, grants of up to £5,000 will be available to homes and some non domestic buildings switching from gas heating to an electric heat pump or, in limited circumstances, a biomass boiler.

The scheme, which is open to properties located in England and Wales, will accept grant applications from 23 May, and is expected to run for three years.

Gove accuses manufacturers of lack of action over cladding

Minister says sector should be doing more to remediate fire-safety issues

The government will pursue product manufacturers for the remediation costs of residential blocks found to be unsafe in the wake of the Grenfell Tower disaster, Michael Gove has warned.

The Secretary of State for Levelling Up, Housing and Communities outlined the warning in a letter to the Construction Products Association (CPA) chief executive Peter Caplehorn, alongside an announcement that housebuilders have agreed to contribute £2bn to fix 11-storey-plus blocks they have developed over the past 30 years.

Gove stated that he saw little to suggest that manufacturers are 'ready to show leadership and play their part in bringing this unacceptable situation to an end'.

He wrote: 'It is unacceptable that there has been no clear acknowledgement that actions taken by cladding and insulation manufacturers have contributed to the problem, and that manufacturers have, individually and collectively, failed to come forward with a proposal for playing their part in addressing it.'

In response, Caplehorn wrote to Gove stating that CPA members understand the urgency of finding a solution. However, he said that members were 'troubled by the lack of detail in terms of scope and definitions for the work and the lack of support from valuers, insurers and the mortgage sectors'.

Michael Gove

Gove stated that officials have been instructed to do 'whatever it takes' to hold manufacturers to account through powers in the Building Safety Bill, which is going through parliament and is designed to safeguard leaseholders from remediation costs.

He added that a new recovery unit will pursue firms that have 'failed to do the right thing', including through the courts, and that he will 'consider carefully' how to use his other powers to make sure there are 'significant commercial and reputational consequences for those firms that have not stepped up'.

The £2bn contribution from developers is on top of £3bn they will be providing through an expansion of the Building Safety Levy.

Pickles denies deregulating fire safety

Former communities secretary of state Lord Pickles has told the Grenfell Tower inquiry that he was not aware officials in his ministry thought the coalition government's drive to cut red tape applied to Building Regulations designed to curb fire risks.

The peer, who had responsibility for Building Regulations in his role as Secretary of State for Communities and Local Government from 2010-15, told the ongoing inquiry on 7 April that building safety regulations were exempt from the policy promoted by David Cameron's government.

Under the so-called 'one in, one out rule', ministers had to identify an existing piece of legislation to be scrapped for every new one proposed.

Brian Martin, who was responsible for the cladding guidance in a part-time role on secondment from the BRE, told the inquiry on 28 March that there had been a 'lot of pressure' relating to deregulation. He said this pressure had ramped up after the Conservative Party victory at the 2015 General Election, after which regulation was seen as a 'dirty word'.

However, Lord Pickles said it was 'utterly inexplicable' and he was 'genuinely amazed' that officials working on the Building Regulations – and, specifically, the Approved Document B fire safety guidance – thought they were subject to the deregulatory policy.

He said an official at Martin's level should have been 'wholly concerned with technical matters' and not have made 'political assumptions'.

Energy security strategy a 'missed opportunity'

Government paper focuses on energy supply rather than energy efficiency, say critics

A near absence of measures to tackle energy efficiency in the government's energy security strategy has been slammed as a 'missed opportunity'.

The British Energy Security Strategy, which was published on 7 April, contains a pledge of up to £30m of funding to support a competition to encourage UK heat pump manufacturing.

However, the 12-page strategy – which has been drawn up in response to concerns about the UK's energy security in the wake of Russia's invasion of Ukraine – contains no other fresh moves on reducing demand, and is focused almost entirely on steps to boost low carbon power supply. These include a target to roll out eight new nuclear power stations, with a total generation capacity of 24GW, by 2050.

The strategy also increases existing 2030 targets for offshore wind and green hydrogen. The offshore wind target for the end of this decade has been increased from 30GW to 40GW, while the target for hydrogen production has been doubled to 10GW, 'at least' half of which must be 'green'.

Sir John Armitt, chair of the National Infrastructure Commission, said improved energy efficiency offered some of the 'quickest wins' in terms of cutting overall demand. 'The potential benefits are now bigger than ever, and we again call on government to set out a costed, long-term plan for meeting its own targets, and help households make the right choices for their pocket and the planet.'

Housing retrofit specialists Energiesprong UK expressed 'disappointment' that the strategy contains 'nowhere near enough focus on the role of reducing our energy demand and no clear plan for mass retrofit of our homes'.

'This is a mistake – and a missed opportunity. It is not in line with the government's net zero ambitions, nor conducive to supporting the millions of UK families in the throes of devastating fuel poverty,' the company said.

New body to oversee National Grid

The government has said that the remit of a new body it is setting up to oversee the energy system should not yet be extended to the decarbonisation of heat.

Ahead of the publication of its energy security review, the government announced on that it is pressing ahead with the establishment of the Future System Operator (FSO).

The publicly owned body, which will take on oversight of the electricity system from the National Grid, will also be given planning, forecasting and market-strategy functions for gas.

However, in a document outlining responses to a consultation on the FSO's functions, the Department for Business, Energy and Industrial Strategy (BEIS) revealed that it has stopped short of a proposal to give the new body enhanced roles in several areas, including heat and transport. It says the FSO will need to consider the development of hydrogen and heat and transport decarbonisation as part of its system forecasting and strategic network planning role.

The document says BEIS recognises concerns by consultation respondents about the FSO taking on too many responsibilities on 'day one'.

M&S demolition put on hold by Gove

The demolition of Marks & Spencer s flagship Oxford Street store in London has been put on hold after Communities Secretary Michael Gove called in the sheme for further government scrutiny.

The proposed demolition and rebuild scheme for the Art Deco building has been paused by an Article 31 holding direction, which gives the Department for Levelling Up, Housing and Communities (DLUHC) the opportunity to assess the sceme before a final decision on whether Westminster Council can grant planning permission.

The intervention came just a few days after the Mayor of London Sadiq Khan had decided that the controversial scheme could go ahead, despite environmental concerns around the project. Architect and net zero carbon expert Simon Sturgis had warned in a report commissioned by the campaign SAVE Britain s Heritage that the scheme contradicted the mayor s new guidance encouraging retention and reuse of existing materials and structures.

The Greater London Authority (GLA) told Westminster Council on 4 April that it would not intervene in the borough s decision to bulldoze the store and two extension buildings. The council had already resolved to grant permission for the scheme.

The GLA s Whole Life Cycle Carbon Assessments report estimated that the demolition and redevelopment would release 40,000 tonnes of embodied carbon into the atmosphere.

Cost of heating and cooking pollution

The average European and British household is out of pocket by up to €130 (£108) per year because of the health related social costs of outdoor air pollution caused by domestic heating and cooking, a new report has estimated.

Published by the European Public Health Alliance, the report says such costs amounted to €29bn (£24bn) across the EU and the UK in 2018. This translates to €130 per year for an average European household, mostly (94%) relating to direct emissions from fossil fuel and biomass cooking and heating.

The figures for the UK were slightly lower, at €92 (£76) per household per year.

However, in the UK, highly polluting wood stoves which provide only 11% of households final energy consumption resulted in 54% of health related social costs. The equivalent figures for the EU were 14% and 41% respectively.

Heat pumps had the lowest health related social costs of any heating technology at €10 (£8) per household per year.

The report concludes that there should be a greater focus on the air pollution risks caused by cooking and heating in regulations such as the Energy Performance of Buildings Directive.

Low client demand and cost are main barriers to net zero

Only 14% of construction professionals say sustainability targets are set on every project

More than half of construction professionals haven't worked on a single net zero project in the past year, despite government pressure to curb emissions, a new poll has found.

The Sustainable Futures Survey, carried out by construction industry specification and product information platform NBS, canvassed 608 professionals on sustainability issues.

Only 4% of those surveyed had worked exclusively on net zero projects during the past year, while 51% had not worked on a single such project over this timeframe.

The survey also found that only a third of respondents had achieved sustainability targets, while a further third said they 'rarely achieve' them and one in 10 said they 'never' did so.

A lower proportion of professionals reported achieving sustainability targets on projects compared with 2014, when NBS last carried out the Sustainable Futures Survey.

Just more than two-thirds (69%) had worked on projects where sustainability goals had been included at least some of the time, but this dropped to 25% who saw such targets 'most of the time'. Just 14% said there were sustainability targets set on every project on which they worked.

Lack of client demand and the cost of achieving sustainability were identified as the main barriers, cited by 52% and 51% of respondents respectively. The next biggest roadblocks were sustainable products being 'value engineered' (38%) and lack of government policy and regulation (37%). However, nearly all (97%) of the survey respondents said sustainability is important to them, and 81% of executives or leaders ranked it as important.

Comparing these findings with the 2014 survey, NBS said views on sustainability within construction are changing and are increasingly led by personal opinion and values, and less by legislation and others' beliefs.

Octopus Energy buys heat pump manufacturer

Energy company Octopus has announced the acquisition of air source heat pump manufacturer Renewable Energy Devices (RED). The company's factory in Craigavon, Northern Ireland, will be expanded significantly, with 100 new green engineering jobs created by 2024.

Octopus aims to increase monthly production to more than 1,000 heat pumps by the end of this year.

RED also produces controls, software and heating distributing systems designed to optimise heat pump operation. It says its 'smart grid' technology works with the heat pump to make use of spare capacity in the electricity Grid and reduce load at peak points of demand.

Octopus is scoping other locations to build further heat pump manufacturing facilities.

Speed up retrofits to avert climate crisis, says UN

Insulation and electrification of heat are key to mitigating carbon emissions

The upcoming decade is 'critical' for accelerating decarbonisation of the world's buildings, the United Nations Intergovernmental Panel on Climate Change (IPCC) has warned.

The climate science assessors' latest report, published on 4 April, says a 43% cut in worldwide emissions on 2019 levels is required by 2030, to keep global temperatures from rising to 1.5°C above pre-industrial levels.

Based on a swathe of studies, the authors express high confidence that up to 61% of global emissions from buildings could be mitigated by 2050 through measures such as insulation and electrification of heating. This equates to 8.2 gigatonnes of CO_2.

Of this reduction, energy efficiency accounts for more than two-thirds (42%).

The report says the decrease of emissions from buildings has been 'hindered' by 'low' renovation rates and ambition in terms of retrofits, adding that the pace must step up during the rest of this decade.

'The 2020-30 decade is critical for accelerating the learning of know-how, building the technical and institutional capacity, setting the appropriate governance structures, ensuring the flow of finance, and developing the skills needed to fully capture the mitigation potential of buildings.'

The report is the first time that the IPCC has highlighted the potential benefits of removing carbon from the atmosphere, including new technologies such as direct air capture, while stressing the central importance of renewable generation to reducing emissions.

Germany plans to replace third of its gas with Australian green hydrogen

An Australian mining tycoon has unveiled a plan to provide Germany with enough green hydrogen to replace a third of its gas imports from Russia.

Fortescue Future Industries (FFI), owned by billionaire Dr Andrew Forrest, has signed a deal with German energy utility E.ON to deliver up to five million tonnes of green hydrogen per year by 2030. This equates to approximately one-third of the calorific energy that Germany imports from Russia each year.

Green hydrogen is so called because it is produced by using renewable-powered electrolysers to release the element from water.

FFI plans to use Australia's immense wind and solar resources to produce the zero carbon gas, which E.ON will then distribute to its customers in Germany and the Netherlands.

The agreement between E.ON and FFI is a 'major step forward', said Robert Habeck, German minister for economic affairs and climate action. 'The race for large-scale production and transportation of green hydrogen has taken off.'

Australia will use wind and solar to produce green hydrogen

IN BRIEF

Wind and solar supply 10% of global energy

The proportion of electricity generated worldwide by wind and solar power has exceeded 10% for the first time, according to consultancy Ember s annual global electricity review.

In 2021, wind and solar contributed 10.3% of global electricity generation, up from 9.3% in the previous year, the report says. The increase was fuelled by rises of 23% and 14% in solar and wind generation respectively. Combined with nuclear and hydropower, renewables generated 38%, meaning that clean power outstripped coal (36%).

However, wind and solar must sustain compound growth rates of 20% per year to 2030 to keep global heating within 1.5 C above pre industrial levels, says Ember.

EV charging strategy will encourage race to the bottom, says ECA

Electrical contractors have warned that the government s reliance on a market led strategy for rolling out electric vehicle (EV) charge points could jeopardise the quality and safety of installations.

The Department for Transport s EV charging infrastructure strategy gives the private sector a lead role by identifying potential business opportunities and areas of need. Firms will work with local authorities, transport, and energy bodies, it says.

The Electrical Contractors Association (ECA) has warned that a market led strategy could encourage a race to the bottom, and it expressed concern about the pivotal role councils are expected to play in the rollout. It points to a freedom of information request in late 2021, which found that almost two thirds of councils had no real plans to install public charge points.

CPW creates acoustics team

CPW has set up a new acoustics department to provide advice on all aspects of the acoustics, noise and vibration in the built environment. It will be headed by specialist Jon Willmott, who joins the international M&E consultancy after nearly 20 years in the industry. Based in Manchester, he will be joined in the department by acoustics consultant James Large.

IN BRIEF

The President s Prize 2022 the CIBSE Undergraduate Award

The CIBSE Undergraduate Award is now accepting entries, with a prize of £500. It is open to all CIBSE Student members in their final year of BSc, BEng or MEng study, and is designed to encourage students to develop their potential and aim for excellence.

Entrants need to submit a 2,000 word synopsis of their final year project and a completed application form. The judging panel will be looking for evidence of excellent understanding and knowledge of building services engineering, science and design, as well as originality and high quality visual information.

The winner will receive a £500 cheque and trophy, presented at the President s Award dinner later in the year. Two runners up will each receive £100.

For more information and to apply, visit **bit.ly/CJMay22CN2**. The entry deadline is 15 July.

London fire safety consultation includes evacuation lifts

The Greater London Authority (GLA) is consulting on new Fire Safety London Plan Guidance, covering London Plan policies, fire safety, and inclusive design, specifically on evacuation lifts.

The draft guidance sets out how planning applicants should demonstrate that their developments can achieve the highest standards in fire safety.

CIBSE will be submitting a response to the consultation. To contribute, send comments to **technical@cibse.org** by 10 June.

The GLA is running a series of online briefing events for various professional disciplines and the public. Details are available on the CIBSE consultation page at **bit.ly/CJMay22CN1**

CIBSE AGM

The CIBSE AGM will be held on 5 May, as a hybrid event, and will be followed by Kevin Mitchell giving the President s Address. Members will receive a calling notice this month. Further details at **www.cibse.org/agm**

Young Engineers Awards now open for entries

Apprentices, graduates and employers will be recognised at new awards venue

The CIBSE Young Engineers Awards 2022 are open for entries. They recognise the best new talent entering the building services industry, as well as those businesses that go the extra mile to support and nurture them.

The awards encompass Graduate of the Year, Apprentice of the Year and Employer of the Year. As in 2021, the Apprentice award will have two categories – Degree (level 5-7) and Technician (level 3-4) – to reflect the diverse entry routes into a career in building services and celebrate more emerging talent.

Harry Playfair, Technician Apprentice of the Year 2021, said: 'I was overwhelmed and proud to win CIBSE Apprentice of the Year. I have been able to develop new contacts within the industry and meet young, aspiring engineers like myself.' Josie Cheeseman was the Degree Apprentice of the Year in 2021.

The CIBSE ASHRAE Graduate Award challenges finalists to show off their presentation skills on a given topic in front of a panel of industry judges. This year's awards evening is being held at a new venue – RIBA London headquarters – in October.

Any engineer who has graduated in a building services-related field at undergraduate or postgraduate level in the past two years is eligible to enter. Lucy Sherburn, Graduate of the Year 2021, said: 'Hopefully I can use this position to influence change in my industry – in the area in which I work, decarbonising heat, and in making the industry inclusive for all types of people.'

The Employer of the Year Award has categories for small, medium and large firms, and looks for clear, inclusive strategies for recruiting and empowering young people.

- **Entry is free and the closing date is 29 July 2022. See www.cibse.org/yea**
- **The CIBSE Young Engineers Awards 2022 take place on 11 October at RIBA, 66 Portland Place, London, W1B 1AD.**


Lucy Sherburn

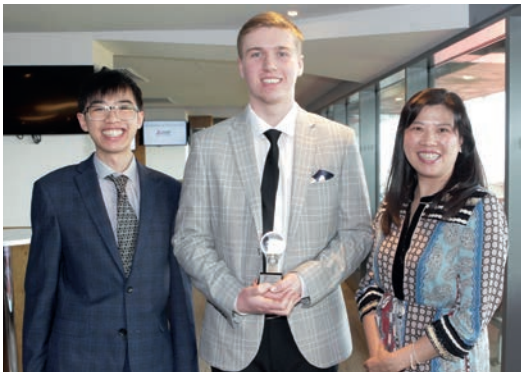

Harry Playfair


Josie Cheeseman

NECO junior M&E engineer wins Alfred Leung Award

Michael Prendergast was presented with the Alfred Leung Award at the CIBSE Merseyside & North Wales Annual Lunch in March. Prendergast is a junior engineer at Liverpool M&E consultancy NECO Services Design.

The annual award recognises the best building services engineering student at the City of Liverpool College. Alfred Leung, a CIBSE Bronze Medal recipient, was a former regional chairman and a popular tutor at the college for many years.


Michael Prendergast (centre) with Alfred's son, Adrian Leung, and widow, Ling Leung

Light exposure at night will be discussed at ROLAN 2022

New SLL event focuses on outdoor lighting

Online conference aims to facilitate collaboration and networking

The Society of Light and Lighting (SLL) and ILLUME/Gdansk University of Technology, Poland, are hosting a two-day conference and live panel discussion, focused on responsible outdoor lighting at night.

ROLAN 2022, taking place online on 12-13 May, will draw on the knowledge, expertise and innovation of those working in the fields of research and practice, to increase understanding, improve communication across the disciplines, and broaden horizons.

The conference aims to facilitate much-needed collaboration and the support necessary to improve lighting practice and enhance research, as well as provide networking opportunities for practitioners, manufacturers and researchers.

The event will feature more than 30 speakers from across the globe, presenting insights on areas such as lighting design, environmental science, biology, astronomy, medical science, and legal considerations.

Their presentations will be split across four dedicated sessions: 'Losing our dark nights'; 'Best lighting practices to reduce light pollution'; 'Light pollution legal aspects'; and 'The impact of light exposure at night on the environment and people'.

Speaker Allan Howard, group technical director of lighting and energy solutions at WSP, said: 'The application of all forms of artificial light at night is an important global topic, not just with respect to dark skies, but also within all environments, through to city centres.'

- For more information about the conference and to register, visit **go.cibse.org/ROLAN22**

Technical Symposium returns

Graeme Maidment and Gareth Jones won the prizes for the best papers at last month's CIBSE Technical Symposium, held at London South Bank University.

Delegates voted for their favourite papers and presentations at the end of the two-day event that saw presentations by 45 of the leading figures across industry and academia.

The award for 'Most effective delivery of material' went to London South Bank University's Graeme Maidment for his presentation *The generation gap! Are 5th generation district energy schemes better or just different?*

Gareth Jones of FairHeat won the award for 'Most significant contribution to the art and science of building services engineers' for his paper *Field trial and design approach for improving hot water delivery time.*

The Technical Symposium returned to a live setting for the first time in two years and attracted over 180 attendees.

- For the full programme, visit **www.cibse.org/symposium**

London South Bank University

Report rounds up an impressive CIBSE year

Read all about CIBSE s 2021 in its recently published Annual Report.

The document reflects on the highlights of the year, re emphasises the Institution s values, reports from our societies and special interest groups, and informs members about the work of the Institution.

Over the year, CIBSE s social media channels achieved 85,748 followers, its website had 3.5 million page views, the Institution consisted of 20,000 members in 96 countries, and there were 200 CIBSE member volunteers on regional committees!

The huge range of events, training, network activities and guidance put together by CIBSE over the year, and represented within the report, is impressive, and it is through the efforts of our volunteers, members and colleagues that these are made possible. Download the report at **bit.ly/CJMay22CN3**

Committees are seeking new recruits

Are you interested in volunteering and getting involved in CIBSE activities? There are a number of roles available, in a variety of areas across the Institution, in the UK and internationally.

Volunteering is a brilliant way to get more involved in CIBSE. It provides great rewards, enhances your CV, and allows you to give something back to the industry.

The Knowledge Management Committee and Knowledge Generation Panel are looking for volunteers. If you d like to influence the strategic development and delivery of CIBSE s future knowledge and updating of existing content, they would love to hear from you.

Applications are welcome from members of all ages, backgrounds and experience, and from different sectors and specialisms involved in the performance of buildings throughout their life cycle.

For further information and to apply, with a CV and short statement, visit: **bit.ly/CJMay22CN4**

Training course looks at Building Safety Act

CIBSE has launched a new *Introduction to the Building Safety Act* training course to help attendees understand the full scope and implications of the building safety reform programme, Building Safety Bill, Fire Safety Act and supporting measures.

The one day course, on 27 May, will also outline the more rigorous regime for the design, construction and operation of higher risk buildings residential buildings more than 18m in height or with seven or more storeys.

For more information and to book your place, visit **www.cibse.org/training**

All change

New legislation governing the construction sector is passing through parliament and will have far-reaching implications for daily building activity. Hywel Davies explores the forthcoming changes

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

It is a time of great change in construction. The huge challenge of adapting our built environment to reduce carbon emissions in response to climate change drives more stringent energy performance standards. The barbarous assault on the sovereign state of Ukraine has seemingly unlocked decisions around the world that could, and should, have been made years ago.

The industry faces significant skills shortages and is turning to modern methods of construction in response. At the same time, it is seeking to embrace digitalisation of the sector and adopt digital information management during the design, construction and operation of assets.

There is also significant legislative reform for many readers of this *Journal*. Some are preparing for the introduction of statutory licensing under state engineering boards in Australia. Others are preparing for the introduction in Ireland of a statutory register for construction, which will require all building works to be undertaken by registered organisations or sole traders. It will be an offence to carry out work unless registered. The Regulation of Providers of Building Works Bill 2021[1] will put the Construction Industry Register, operated by the Construction Industry Federation, on a statutory footing in Ireland, with the aim of embedding compliance in the sector. Statutory registration is

expected to help develop and promote a culture of competence, good practice and compliance with Building Regulations and tackle the shadow economy .

Meanwhile, the Building Safety Bill is likely to reach the UK statute book before this column reaches readers. This will create the Building Safety Regulator, with a statutory duty to support the industry in improving competence and compliance. The bill does not create a statutory register for builders, but it does contain significant new legal duties to raise standards of competence. It also introduces a statutory register of building control professionals in England.

The act provides enabling powers for secondary legislation in regulations. Some are published in draft[2], and clearly indicate the direction of travel. The Competence and Dutyholder Regulations set out very clear legal duties on clients to only appoint those for whom they have taken all reasonable steps to assure are competent.

They also require those who are appointed to decline work that they are not competent to undertake. This applies to all participants in a project, whether designers, contractors or subcontractors. These requirements go well beyond the current competence requirements in the Construction (Design and Management) Regulations, and apply to all work within the scope of the Building Regulations: new buildings and refurbishment alike, residential and non residential. They are not just for higher risk buildings . They cover all building work, of any kind, on any building. Some provisions only apply to higher risk buildings, but the competence requirements, the many changes to the building control system, and the new regulator are for everyone and everything.

One consequence of the act may have escaped attention: it will change enforcement. Construction is used to being fed guidance about how to comply with regulations, but the legal requirement under the Building Act has always been to meet the requirements of the Building Regulations. Dame Judith Hackitt noted the ignorance of what is law and what is guidance.

The new regime is likely to focus far more on the required outcomes, with an expectation that those doing the work, who are competent (otherwise, by definition, they are committing a crime), will work out what meets the legal requirements set out in the Building Regulations and how to demonstrate that they have done so. It is likely to be a culture of evidencing compliance and assuring the regulator that work is compliant, not waiting for the regulator to turn up and find non compliance.

Responsible businesses are already preparing. CIBSE will be providing support and information as the act is brought into operation.[3]

- CIBSE's Introduction to the Building Safety Act training course takes place on 16 May, **cibse.org/training**

References:

1 Legislation requiring providers of building services to register with Construction Industry Register Ireland, Department of Housing, Local Government and Heritage, Ireland **bit.ly/CJMay22HD1**

2 Building Safety Bill: draft regulations, Gov.uk **bit.ly/CJMay22HD2**

3 Building Safety Bill, CIBSE Policy web page **bit.ly/CJMay22HD3**

SCA raises bar on complaints

As every business owner or operator knows, there are never any guarantees that a project will run smoothly, despite the best efforts of those involved, says the SCA s **David Mowatt**

Any business - whether a small family-run business or a large multinational, an established industry name or a newly formed start-up – can receive a complaint from a client. When it happens, there should always be a process in place to resolve the issue swiftly and effectively. This starts with the introduction of a clear procedure for handling complaints in a consistent manner, featuring well-defined processes that can be followed and understood by all parties.

The conduct of Smoke Control Association (SCA) members directly reflects on the position of the association as the voice of the industry. As such, every member is expected to uphold the highest standards, in accordance with the membership criteria. Should the conduct or actions of any member be perceived to have fallen below the agreed standards, a newly published complaints procedure will ensure that grievances are dealt with in a fair and timely fashion.

Every SCA member is expected to:

- Practice competently and maintain knowledge and skills
- Install compliant smoke control products (EN12101 series of standards)
- Act with integrity and respect for others
- Promote sustainability
- Exercise engineering leadership

There may be situations that fall outside the parameters of this list, further highlighting the need for a complaints procedure that promotes careful assessment and balanced judgement.

Since April 2018, existing and new SCA members have had to sign a document confirming that they will adhere to industry best practice and fully appreciate the importance of correct and compliant installations, inspection and maintenance. Members who install smoke control systems are also required to apply for, and receive, SDI 19 Certification installer scheme accreditation.

The SCA prides itself on upholding the highest industry standards, and though complaints against members are rare, the new procedure will ensure allegations are handled and resolved in an objective manner, emphasising the association's commitment to promoting best practice throughout the industry.

- Further information on membership criteria and the SCA complaints procedure can be found at: **www.smokecontrol.org.uk**
- **David Mowatt** is chair of the Smoke Control Association

Reduce demand to secure power for the people

While the UK's energy security strategy puts nuclear and fossil fuels back in the mix, **Julie Godefroy** laments a lack of ambition around energy efficiency

The government has published its long awaited energy strategy, with a focus on security following the invasion of Ukraine. Its aim is clear: If we re going to get prices down we need a flow of energy that is affordable, clean and, above all, secure. We need a power supply that s made in Britain, for Britain.

The focus of the strategy is on power supply, restating the target for a decarbonised electricity system by 2035 (subject to security of supply), but with an ambition to achieve 95% of this by 2030. To a limited extent, it also covers energy efficiency and demand reduction, as well as system resilience and flexibility.

Nuclear

A much reported announcement is the massive increase in electricity generation from nuclear. The new target is up to 24GW by 2050, which is three times the current capacity and would meet up to 25% of projected 2050 electricity demand.

This is supported by a range of measures, including public financing, a new British nuclear regulatory body, and streamlined funding and approval processes.

All of this is subject to value for money assessment, all relevant approvals and future spending reviews a big if given the industry s track record on costs and timescales.

Renewables

The strategy also increases the target for offshore wind to 50GW by 2030 (40GW previously), with faster approval processes. The Climate Change Committee has highlighted the pace and scale of ambition, and the relentless focus needed if this is to be delivered. Solar on non protected land and rooftops may also be encouraged through simplified planning processes. The upcoming Future Homes and Buildings Standard is not mentioned, but is obviously an opportunity.

The strategy does not, however, propose to change the de facto planning moratorium on onshore wind in England, with only a promise to consult on local partnerships with a limited number of supportive communities who may benefit for example, from reduced energy bills. This is disappointing given the potential speed of delivery of onshore wind, the actual level of public support, and the government s own admission that it is one of the cheapest forms of renewable power.

The confirmed funding is expected to improve 500,000 homes, a fraction of the UK s 2.8 million

Fossil fuels

In the week when the Intergovernmental Panel on Climate Change called for urgent action, the strategy includes two major statements on fossil fuels:

First, allowing new drilling in the North Sea. Ministers have said this would not increase the use of fossil fuels, but simply allow UK sourced (and lower embodied carbon) ones. New licensing will take into account the upcoming climate compatibility checkpoint, and there are references to carbon capture and storage (CCS), but no firm commitments. We can probably expect this summer s CCC progress report to include an analysis of whether this is net zero compatible.

Second, an independent review of the moratorium on fracking. This is a bit of Boris Johnson cake ism: fracking is energy intensive and has high risks of fugitive emissions, so if embodied carbon impacts matter when justifying North Sea drilling they also should when considering fracking. Furthermore, if fracking is to go ahead despite much local opposition, the same should apply to onshore wind (which, anyway, receives more support).

Hydrogen

The strategy proposes to produce vastly more hydrogen , doubling the target to 10GW by 2030 subject to affordability and value for money (another big if). At least half would come from green hydrogen it could easily take up a majority of the increased offshore wind production.

Up to half would come from blue hydrogen in other words, continuing our dependency on fossil fuels and, to be low carbon, relying on effective CCS. Unfortunately, the government s proposed low carbon hydrogen standard sets an emissions threshold that does not account for fugitive emissions or provide a net zero compatible long term aim that would really drive innovation.

Energy efficiency and demand reduction

There are some welcome acknowledgements that the first step is to improve energy efficiency , and the majority of our homes are energy inefficient .

DR JULIE GODEFROY
is head of sustainability at CIBSE

However, and as flagged up by the CCC, the proposals are thin, especially compared with the level of ambition and interventionism elsewhere. Most of the strategy s measures had already been announced, such as green heat network funding and zoning, the Boiler Upgrade Scheme, and five year cuts in VAT for insulation and heat pumps.

New announcements are chiefly an upcoming energy advice service Heat Pump Investment Accelerator, aimed at stimulating British manufacturing, and a promise of some upcoming measures. These include energy performance standards, a review of barriers to energy efficiency, and proposals to rebalance electricity and gas prices. While CIBSE has advocated for the latter, it must be alongside a proper retrofit programme or risk further increasing the extent and depth of fuel poverty.

Overall, the total confirmed funding is expected to improve 500,000 homes, which is a fraction of the UK s 28 million. By 2025, around 700,000 homes will be upgraded and, by 2050, all our buildings will be energy efficient with low carbon heating . This is clearly a massive gap, with little information on delivery.

Much is left to the market and private financing. The strategy does not deliver on manifesto commitments for funding, or address policy gaps to tackle all sections of the market, grow supply chains and skills, and support retrofit plans and a whole house approach (rather than individual, one off measures).

The government does not seem intent on addressing that insufficient framework when you consider statements such as our homes are our castles, people want choices regarding how they improve them and the British people are no nonsense pragmatists who can make decisions based on information .

This is disingenuous when the reasons many people do not retrofit their expensive to heat and often cold castles are not preference and choice, but finances and poor access to trusted supply chains. Then there s the estimated one in 10 households reporting food insecurity, whose choice is between heating and eating.

Conclusion

The strategy does not address the current cost of living crisis. This would be acceptable if that was dealt with elsewhere, and the strategy tackled long term issues comprehensively. However, there is much to worry about in its reliance on fossil fuels and potentially expensive and risky solutions (it remains to be seen what no nonsense pragmatist voters will make of that), alongside the huge gaps and lack of ambition on energy efficiency and demand reduction.

OUR PEOPLE ARE OUR GREATEST ASSETS

CIBSE Employer of the Year ChapmanBDSP says support, praise and recognition are key to attracting and retaining the best people. Recently, the practice took staff on a tour of 100 Liverpool Street, a major commercial retrofit, which has become British Land s first net zero building. **Andy Pearson** reports

'We celebrate our achievements, rewarding our team for their great work and fostering an environment of support, praise, and recognition, says ChapmanBDSP s entry to the 2021 CIBSE Young Engineers Awards, where the consultant won CIBSE Employer of the Year.

So what better way to foster a collaborative and celebratory environment than a team visit to one of the consultant s more recent successes, British Land s 100 Liverpool Street, where ChapmanBDSP was responsible for the MEP and environmental design of the developer s first net zero carbon building.

The morale boosting visit was the first outing the consultant s London office staff had been on since the outset of the Covid 19 pandemic, and coincided with the 50th year anniversary of the practice.

In addition to its net zero status, 100 Liverpool Street has also been awarded Breeam Outstanding and Well Gold Certification, making it one of the most sustainable office projects in the UK. ChapmanBDSP s visit took place in the month the scheme received additional recognition with a Civic Trust Award for its contribution to the built environment.

Impressively, the building s net zero carbon status is largely the result of engineering excellence rather than the design team s slavish pursuit of net zero goals from the outset. We set out to achieve the client s brief by ensuring we could deliver sufficient heating, cooling and electrical capacity with an energy efficient design that incorporated the best, energy efficient equipment, says Rudolph Duncan Bosu, ChapmanBDSP s project director.

As a consequence of doing the fundamentals well, combined with an energy efficient and airtight fa ade, when we did run the energy numbers it showed that the scheme could realistically aim for carbon zero, he adds.

100 Liverpool Street is a new building with retained structure. The original seven storey 1980s building, adjacent to London s Liverpool Street Station, was designed by Arup Associates. It had deep floor plates to accommodate businesses with dealer floors at the time of the stock market Big Bang.

Hopkins Architects design set out to rebuild and extend this major development to create more than 48,000m² of modern, flexible, multi tenanted office space with the addition of three new floors of offices, and the creation of an atrium and new retail space.

The atrium is the focal point of the building; it effectively divides the floor plates into north and south zones. The floor plates can be

The ChapmanBDSP team on their away day to 100 Liverpool Street

PROJECT TEAM

Client: British Land
Architect: Hopkins Architect
M&E engineer: ChapmanBDSP
Fire engineer: ChapmanBDSP
Main contractor: Sir Robert McAlpine
Structural engineer: AKT II

The design has created more than 48,000m² of modern, flexible, multi-tenanted office space

The atrium is the focal point of the building

We ve made provision to bring in external services and we ve provided plant space for heat exchangers on both heating and cooling systems should a network become available

further subdivided to allow each level to be occupied by up to four separately metered tenancies. In addition, in a nod to its original inception, Levels 2 and 3 have been designed with additional cooling capacity to allow their use as trading floors.

Hopkins design retains the building s existing foundations and a large proportion of the existing steelwork. It was a decision that helped reduce the embodied carbon in the fabric of the new building, while allowing Network Rail s ground floor retail spaces to continue trading throughout the building s reincarnation.

While the retained structure had both carbon and logistical benefits, the decision to retain elements of the structure had a major impact on ChapmanBDSP s servicing strategy for the refurbishment.

Unfortunately, the floor to ceiling heights of the retained basement were too low to enable the space to accommodate the bulk of the building services plant. We were limited in terms of what we could slot into the basement, which resulted in us having to put most of our plant on the roof, says Duncan Bosu.

This top down servicing strategy did, however, have the additional benefit for British Land in maximising retail and restaurant space on the ground and lower ground floors.

The precise location of plant on the roof was influenced by its future removal and replacement. There are two main plant areas on the building s roof: chilled water and electrical plant is confined to the north plant area, heating plant is to the south.

As part of its design, ChapmanBSDP had to demonstrate that plant could be removed when it was time for it to be upgraded. While you can place the equipment on the roof using tower cranes while the scheme is being built, getting it off for replacement was tricky, because the underground lines and station infrastructure beneath the site limited the areas in which a heavy mobile crane could operate, Duncan Bosu explains.

While the southern plant area was fully crane accessible from the nearby road, only part of the northern plant area could be accessed. This meant that any plant that could not be manoeuvred to the crane accessible area had to be capable of being broken down for removal by the goods lift. We used the BIM model to demonstrate »

» that plant could be manoeuvred around the roof for removal, says Duncan Bosu.

The plant s roof top location enabled the plantrooms to be built off site in modules and craned into position. Similarly, a separate pump room module was also built off site and craned into position.

The chilled water plant was not modularised. The roof houses six air cooled chillers. To save energy, ChapmanBDSP has designed a heat reclaim loop to collect heat from the heat rejection side of the chillers which is then used to preheat the landlord s domestic hot water feed in a dedicated pre heat cylinder.

From the roof, services drop down risers housed in the building s three concrete cores. A common heating and chilled water network serves all demises, including retail, offices and restaurants. We ve modularised both the heating and chilled water systems so that at weekends, when the offices are closed, the retail outlets can still operate, says Duncan Bosu.

An advantage of ChapmanBDSP s top down servicing approach was that ducts and pipes were smaller at the base of the building compared with roof level. This enabled the existing risers that pass through the Network Rail ground floor retail to be reused to service the retail at ground and lower ground.

One of the benefits of this common approach to the provision of heating and cooling is that it will enable the scheme to be decarbonised more easily in the future.

One of the things we looked at was the potential for connection to an energy network, explains Duncan Bosu. We ve made provision to bring in external services and we ve provided plant space for heat exchangers on both heating and cooling systems should a network become available, he adds.

The building services for the office floors are designed on the basis that the building was to be let on a shell and core basis, with tenants undertaking their own fit out. In discussion with British Land, ChapmanBDSP sized the central plant on the basis that most tenants will opt to use a fan coil system.

The design assumes four pipe units are located around the building s perimeter, with two pipe cooling only units serving the remainder of the floor plates. We ve influenced the tenants a little bit by guiding them on the energy rating of the fan coil units to ensure the building sits within certain parameters to achieve the overall EPC for the building, says Duncan Bosu.

Another area of discussion with British Land was on both air quality and quantity. ChapmanBDSP had monitored the site externally. The air quality was not great, so the client made the decision to install carbon filtration on all roof top air handling units, which has helped improve air quality, Duncan Bosu says.

In terms of air quantity: the design was initially developed to comply with the British Council for Offices (BCO) requirement of 12L s^{-1} per person. However, as the design progressed, the air supply rate was increased to 16L s^{-1} per person to further enhance »

The ChapmanBDSP team tour 100 Liverpool Street

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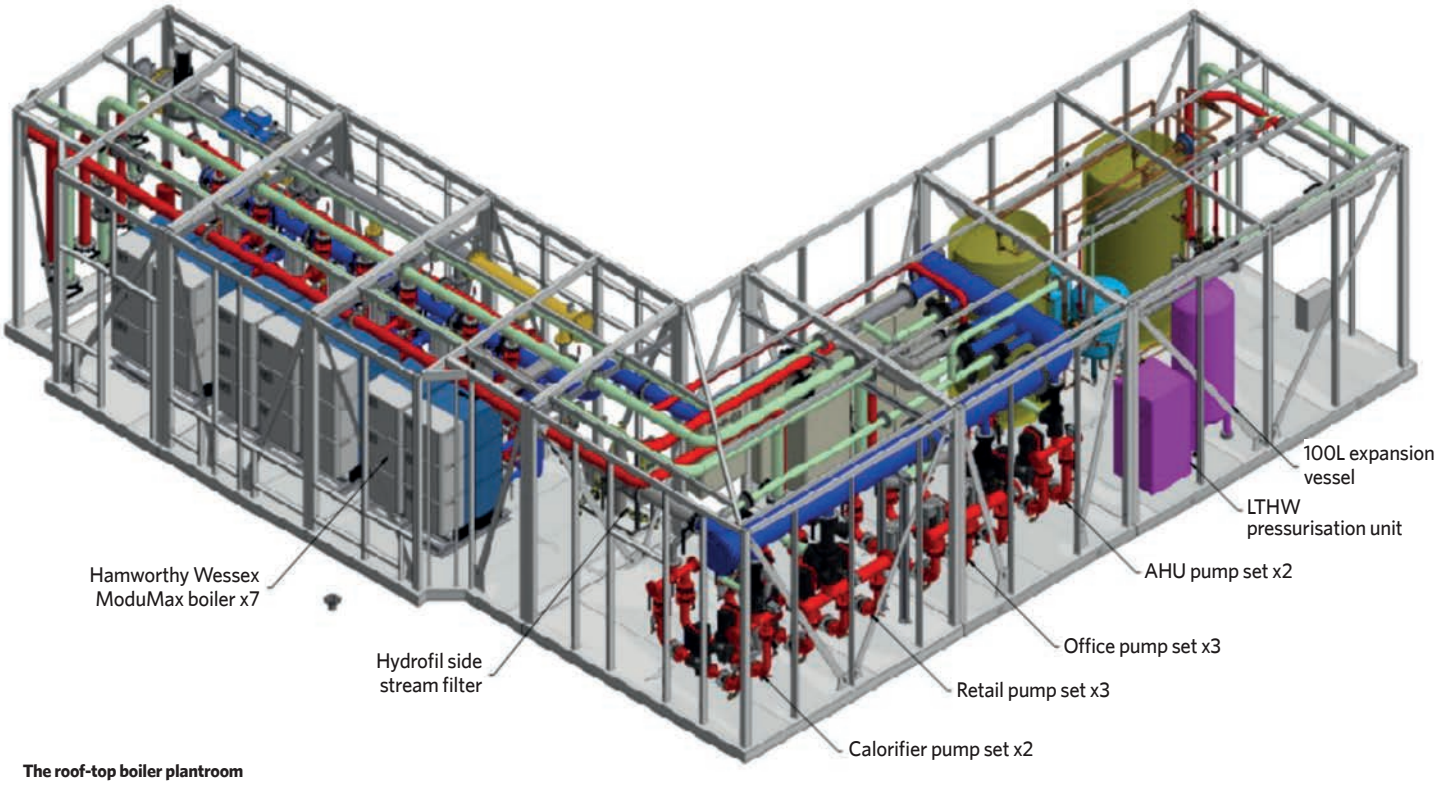

The roof-top boiler plantroom

» the air quality and meet the requirements of the Well Certification. At 2L s^{-1} m^{-2}, it s a higher airflow rate than the Building Regulations and the upper limit of the BCO guidance, says Duncan Bosu. Air supply to each floor plate has the ability to be regulated using variable volume control based on the CO_2 levels from the office space.

The building s eco credentials also include greywater recycling and rainwater storage for toilet flushing. Waste water is collected from the showers and wash hand basins, which is then filtered and stored for use in flushing toilets.

Rainwater storage tanks are in the basement. The tanks primary purpose is for rainwater attenuation. Limitations on plant space meant that there was insufficient room to have a large amount of storage. Instead, the rainwater system controls monitor the weather forecast. If heavy rainfall is predicted, the tanks will be emptied to enable rainwater to be stored to provide attenuation.

The air quality was not great, so the client made the decision to install carbon filtration on all roof top air handling units, which has helped improve air quality

In accordance with its green credentials, the building s electricity is purchased from renewable sources. There is also a small contribution from an area of photovoltaic panels on the building s roof.

British Land has offset the remainder of the residual embodied carbon split equally between a project restoring 30,000 hectares of land on the Tibetan plateau and a teak afforestation project in Mexico to make this building British Land s first net zero carbon development. CJ

CHAPMANBDSP CIBSE EMPLOYER OF THE YEAR

ChapmanBDSP is an independent design consultancy specialising in MEP, environmental, fire, vertical transportation and lighting. It employs around 200 people, of which 157 are building services engineers, 40 of which are graduate and/or junior level engineers.

The initiatives it has put in place to develop young engineers include:

- **CIBSE-approved training and development scheme, weekly CPDs and bi-monthly technical knowledge seminars**
- **An equality, diversity and inclusion (EDI) forum, with all staff completing unconscious bias training.**
- **Pursuing a company diversity strategy that has also made progress, with equal numbers of male and female graduates joining the company over the past three years.**

In 2021, the company's focus was on supporting the mental health of its employees, including running mental health and mindfulness sessions on Microsoft Teams to help employees with their mental health during the Covid-19 pandemic.

A young engineer's endorsement of the company's award entry included the following:

'The company are very supportive and encourage all young engineers to attend industry training events that are organised by professional membership bodies such as the CIBSE and SoPHE YEN.

'The senior engineers are very willing to assist the young engineers wherever possible. Whether this be in the form of helping us with our university studies; assisting us with our design work in the office; or taking us down to site and showing us around.'

As part of its Wellbeing Strategy, the company has invested in 10 Mental Health First Aiders (MHFA), with a representative in each of the design teams. All the MHFA have completed the two-day Mental Health in the Workplace course, which is aimed at empowering businesses to create a positive environment where people can discuss mental health.

The company recognises that its biggest asset is the staff they have working for them and are willing to listen to all employees, which was evident from the results of the recent company-wide investors in people survey on Covid-19 and Wellbeing, in which the company scored in the top 5% for positivity.

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VIVA LAS VEGAS

Las Vegas hosted the first live ASHRAE Winter Conference in two years, and the focus was on how the building services industry would drive the carbon out of buildings. **Tim Dwyer** reports from the hybrid event

Jennifer Cox (left) and Lucy Sherburn

The ASHRAE Winter Conference 2022 celebrated its return to a live setting after a two year hiatus caused by the Covid 19 pandemic. Held in Las Vegas, the event also allowed online participation and, in his welcome address, ASHRAE CEO Jeff Littleton said 2,000 registered delegates were expected on site, with nearly 500 joining virtually.

Littleton also referenced ASHRAE s move to its new Atlanta headquarters, which had undergone a deep retrofit to be transformed from a low performing 1970s building into a net zero ready facility. He then highlighted recent notable publications, including the *ASHRAE Design guide for natural ventilation* and the picture book *Lucy's engineering adventure*, which is aimed at promoting building services careers among the under 10s. This paperback swiftly sold out at the onsite bookstore, and is testament to the enthusiasm and enterprise of ASHRAE s Student Activities Committee.

Littleton concluded his plenary presentation with a call to arms to drive the carbon out of buildings . He said this period will be as pivotal for ASHRAE as the 1970s fuel crisis, as the world comes to grip with the realities of climate change. He pronounced that regulations, goals, and metrics are transitioning from energy to carbon, and ASHRAE must be hyper responsive to these changes . The 140 volunteers of the ASHRAE decarbonisation task force were providing the necessary technical leadership, he added.

Although the conference programme had been rationalised to accommodate Covid 19 constraints and restrictions, there were 52 technical sessions, covering a multiplicity of topics.

Jennifer Cox, of Aecom, and Lucy Sherburn, of FairHeat, travelled to Las Vegas as their prize for being named CIBSE ASHRAE graduates of the year for 2020 and 2021 respectively. Each was formally recognised for their achievements in winning with the presentation of an engraved plaque.

Sherburn presented at a workshop on *Role models: how to inspire future generations*, extolling the promotion of Stem careers in schools, colleges and universities. She said there was a great opportunity to capitalise on young people s increasing desire to work in the low carbon sector, and that the industry should identify role models to influence and support young entrants into the profession.

This session was chaired by Catarina Marques, of London South Bank University (LSBU), and included Steve Gill, of World Refrigeration Day, exploring the concept of cognitive diversity in the workforce as a means of reaching more out of the box , divergent solutions. Graeme Maidment, of LSBU, spoke about the need to engage with school age children, while Ina Colombo, from the International Institute of Refrigeration, opined the lack of opportunities in the UK for professionals from minority backgrounds, and illustrated initiatives to enhance their journey into engineering.

An example of speculative research development was provided by a seminar on *Building-integrated indoor air quality sensors*, which discussed low cost, low power and high reliability sensing systems capable of accurately quantifying indoor air quality (IAQ) metrics.

Zac Siefker, of Purdue University, reported on CO_2 measurement being the metric that is regularly employed to assess IAQ in the occupied space. He presented work that aims to provide alternatives to the current, almost ubiquitous, non dispersive infrared sensor. It included early investigation of chemiresistive sensors that change resistance with CO_2 levels, and resonant mass sensors, which employ an oxide coating on a tiny substrate (driven by an oscillator) that changes resonance with different CO_2 levels.

Siefker was clear that real world implementations are not straightforward. Although his early work has shown good potential for these small, cheap, low power sensors, their response time and other, as yet unanswered, questions on drift and ageing of materials will contribute to their eventual viability and commercial application.

As the world moves towards refrigeration solutions with lower environmental impact, there has been concern that some of the new refrigerant blends, which offer reduced global warming potential (GWP), may present unacceptable risks if exposed to fire. Helen Walter Terrinoni, of the US Air Conditioning, Heating, and Refrigeration Institute, presented an update on some major »

» tests undertaken to identify hazards to fire service personnel when responding to blazes that included new refrigerants designed as replacements for R 410A, which is commonly used in small air conditioning units.

The presentation looked at full scale testing of refrigerants classed as A1, no flame propagation (R 410A with GWP 2088 and R 466A with GWP 733), and A2L lower flammability (R 32 with GWP 675 and R 454B with GWP 466), in what might be considered extreme fire conditions. These included a simulated corridor fire, a domestic sofa fire, and a breakage in a refrigerant line.

Walter Terrinoni noted that hydrogen fluoride gas is formed for any fluorinated refrigerant in fire conditions, irrespective of whether it is A1 or A2L. However, the tests reinforced the understanding that A2L refrigerants are difficult to ignite, have slow flame speed and low heat of combustion, and can be safely applied with proper designs and installations. The full report is at **bit.ly/3rkgczt** and videos on the subject are at **bit.ly/CJMay22TD2** CJ

■ Recorded presentations and papers are available, at cost, via ASHRAE at **bit.ly/CJMay22TD3**

LONDON'S 5TH-GEN NETWORK

LSBU and some of its key research partners contributed to several sessions on heat networks at the ASHRAE Winter Conference, writes Henrique Lagoeiro.

***Smart integrated heating and cooling systems*, chaired by Graeme Maidment, highlighted the opportunities to integrate refrigeration, air conditioning and heat pump systems to achieve significant carbon savings at a low cost to the local community.**

Joel Hamilton, of the UK's Department for Business, Energy and Industrial Strategy, emphasised the importance of collaborating with industry, investing in research and giving economic support to develop a market for heat networks. He reported on a study on waste heat recovery across England, showing how R&D projects can feed into the government's strategic planning.

LSBU's Catarina Marques introduced the potential of smart controls and machine learning to enable a smooth integration of waste heat sources with fifth-generation heating and cooling networks. Akos Revesz, of LSBU, presented London's New River Scheme – a fifth-generation heat network based on the GreenSCIES concept (see 'A sharing society', *CIBSE Journal*, September 2021). This involves an ambient loop connected to decentralised energy hubs that incorporate solar PVs, EV charging points and storage elements, including aquifer thermal energy stores.

The opportunity to roll out the GreenSCIES concept in different UK regions was considered by LSBU's Helen Turnell, while I explored the flexible operation of a heat network using waste heat from the London Underground.

■ **HENRIQUE LAGOEIRO** is a postgraduate researcher at LSBU

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The value of smart

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Cost model

£uel on the fire

The surge in global economic activity post Covid led to the quadrupling of energy prices even before Russia s invasion of Ukraine sent energy markets into meltdown. Aecom s **Vince Colby** and **Rob Mayes** assess the direction of gas and electricity markets as inflation begins to bite

The surge in gas and electricity prices following the Covid 19 pandemic and the war in Ukraine has exposed the fragility of the UK energy market. The National Grid s interdependence with global energy supplies means any disruption to supply, or a sharp increase in demand, has a significant impact on prices.

Even before the war, wholesale prices were increasing sharply. Since the beginning of 2021, wholesale electricity increased from 5p/kWh to 20p/kWh, while wholesale gas leapt from 50p/therm to 250p/therm. Energy supply companies have gone bust after struggling to deal with these sharp and now sustained price increases, and consumers are feeling the effects of these dramatic rises on their energy bills.

Three key elements ensure gas and electricity are available at the flick of a switch or the push of a button: electricity generation, distribution networks and the energy market.

Historically, the UK has generated most of its electricity by burning fossil fuels, but the Grid is powered by using renewable energy sources such as wind and solar as well as nuclear power and imports from other countries (see Figure 1).

Total electricity generated decreased by 3.6% between 2019 and 2020, because of the reduction in demand brought about by the Covid 19 lockdowns. The share of electricity generated from coal fell a further 0.3%, from 2.1% to 1.8%, continuing a long term downwards trend.

At certain times in 2021, the UK provided for its electricity needs without burning any coal. The decline in electricity supplied from fossil fuels was enabled by increased generation from renewables, which raised its share of generation from 36.9% to a record 43.1%.

There have been around 50 to 60 energy suppliers in the UK, but this number has declined rapidly since costs started soaring. Customers of firms that have gone out of business have mostly been picked up by the big six energy suppliers Centrica, EDF Energy, E.ON, nPower, OVO and Scottish Power.

We are seeing a reluctance by the remaining energy suppliers to take on new business. Our clients with new developments ready for occupancy are finding it increasingly difficult to get energy supply deals to permit completions.

Gas and electricity customer prices are determined by a number of factors. Wholesale energy prices account for up to 40% of the average electricity bill, according to Energy UK, with these prices dependent on factors such as the cost of generating electricity, and supply and demand. As suppliers buy in advance, some of the volatility

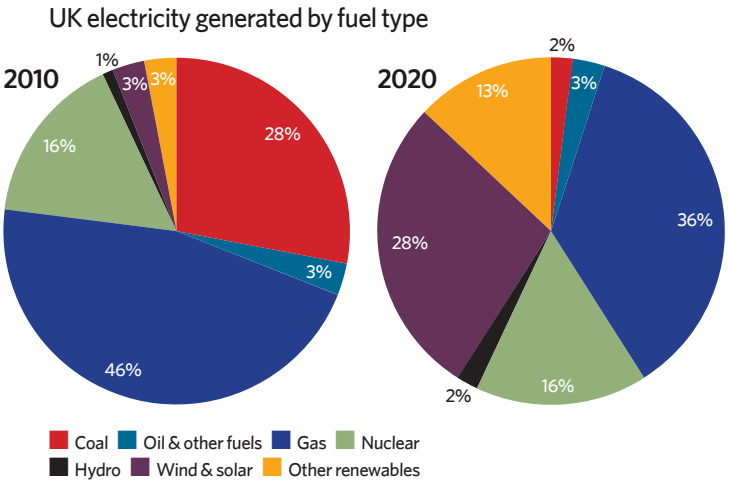

Figure 1: In 10 years, wind and solar became a major energy source on the electricity Grid
Includes generation from pumped storage

can be smoothed out. The price will also be affected by operating costs, such as transport and maintenance, taxes, government policies such as environmental levies and good old fashioned competition.

Where you live also makes a difference, with the charges levied by local distribution networks, and the amount of energy a supplier buys and sells in a region, affecting how much it charges.

What is causing the market upheaval?

There has been a perfect storm in the energy market. The war in Ukraine has meant Europe s gas supplies have become less reliable, and this uncertainty affects the UK because it makes up shortfalls in generation with imported supplies from the continent. China s huge post Covid demand for energy is taking supplies away from Russia and the Middle East, some of which would normally come to Europe.

One of the UK s largest gas storage facilities was closed in 2017, reducing the country s ability to hold buffer or reserve stocks. It has also lost a sizeable portion of its electricity generation capacity. Most of the UK s ageing nuclear power stations have recently been or are due to be decommissioned, with only three scheduled to remain open. Many of the country s coal power stations have also been phased out.

Britain s most important interconnecting power circuit (with France) is operating at reduced capacity following a fire at a substation in Kent last September. It won t be repaired fully until 2023.

Figure 2 represents the wholesale prices that suppliers typically face when buying gas or electricity. The cost of purchasing wholesale energy is the largest component of a customer s bill, and the energy regulator, Ofgem, takes wholesale prices into account when setting the level of the price cap. Ofgem data clearly shows the dramatic trend line in wholesale market prices over the past 12 months, with electricity and gas prices following near identical trajectories.

> Our clients with new developments ready for occupancy are finding it increasingly difficult to get energy supply deals to permit completions

Electricity and gas prices: forward delivery contracts – weekly average (UK)

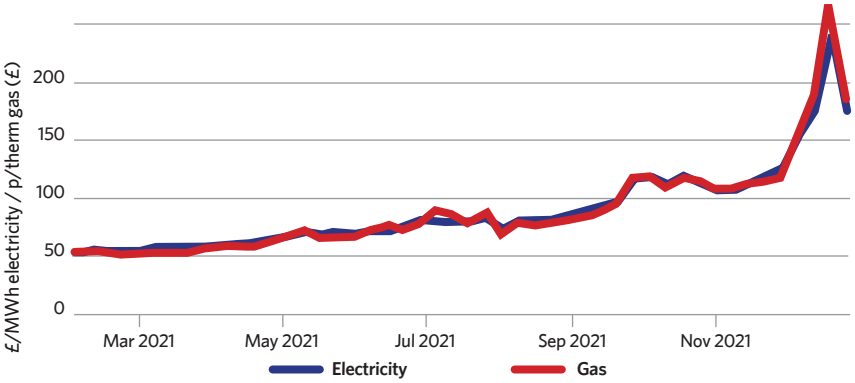

Figure 2: Gas and electricity prices have risen sharply in the past 12 months, despite a recent fall after the initial shock of Russia's invasion of Ukraine

What does this mean for the energy consumer?

- For the domestic market, the acute problem is that the energy price cap, governing most retail energy bills, rose by more than 50% last month, raising the cost of gas and electricity for a UK household with typical consumption from £1,280 to up to £2,000 per year.
- The extra £720 represents roughly 3% of disposable income after housing costs for a household at the middle of the income distribution. Tax revenues will also be hit, because households will have to pay more for energy, which attracts only a 5% VAT rate, so will probably spend less on other goods and services with an average VAT rate at least twice this level.
- The non domestic market doesn t benefit from a price cap and will already be feeling the pain of higher energy prices.
- If the Chancellor wanted to cover the increase by socialising the total cost, taxpayers would face a bill of £20bn per year to lower bills by £720 for the 28.5m domestic households connected to the electricity Grid.
- The only other questions are, who pays and when? The government could decide that those with the highest energy bills relative to income should get greater protection but this scheme would have to be financed by imposing higher energy bills on those who are not eligible for assistance.
- The government could wait and hope gas prices fall and bill increases can be spread over time: pain postponed rather than avoided. But retail energy markets predict that bills are likely to remain high for some time.
- With the European conflict and ongoing energy embargoes and rationing from Central Europe, high energy prices look set to continue for some time.
- The drive to alternative energy strategies and decarbonisation policies will reduce the UK s reliance on fossil fuels and imports, but this comes with a cost and long programme. There appears to be no short term good news CJ

About the authors

VINCE COLBY is a director and **ROB MAYES** a senior project manager in Aecom's specialist utilities team

OVERSIZING MATTERS

With energy prices soaring and carbon reduction a priority, ensuring heating systems are specified to operate as efficiently as possible is essential. In this article, based on their CIBSE Carter Bronze Medal winning paper, **Dr George Bennett** and **Dr Cliff Elwell** explain the impact on energy use and comfort of oversizing boilers and how correct sizing can boost efficiency

Chances are that, if you live in the UK, your home is heated by a gas boiler. Gas boilers are the dominant way to heat British homes, with more than 20 million in operation and more than 1.2 million still being installed every year.

Electrification of heat through the deployment of heat pumps will play a pivotal role in the decarbonisation of heat, as set out in the government s target to install 600,000 such units per year by 2028. But with such a large install base of boilers and continued rate of replacement even in 2028 it is likely that ~600,000+ boilers will be installed improvements to boiler efficiency can, and should, contribute to decarbonisation, and are likely to carry across to hydrogen boilers.

The last major improvement in boiler technology was the move to condensing gas boilers, which resulted in tangible savings of carbon and cost. But the technology hasn t stood still, and continues to be developed. Are there further cost and carbon savings to be gained from the humble boiler? The research we carried out for our CIBSE Carter Bronze Medal winning paper *Effect of boiler oversizing on efficiency: a dynamic simulation study* aimed to answer these questions.

Output

The most common type of boiler in UK homes is the combination (combi) boiler, which provides space heat and on demand hot water. These boilers have proven popular with homebuilders, consumers and installers because of their low cost, simple installation and space saving form factor.

However, such boilers must be able to meet the different requirements of a near instantaneous demand for hot water and space heating. The heating power demand to provide hot water to multiple outlets, such as showers and taps, can be many times the peak space heating demand of homes, and even more on milder days. This difference in sizing requirement for space and water heating presents a challenge to the efficient operation of combi boilers.

Domestic boilers do not typically operate at fixed output and, instead, adjust (modulate) their output to fixed levels, which are selected according to the demand. Unfortunately, the modulation ranges of modern boilers are typically around 5:1 peak to minimum heat delivered (for example, 25kW boiler minimum output would be 5kW).

The conditions of operation for a boiler to achieve its design efficiency is steady state operation with low system water temperature flowing to and from the heat emitters in the building. This will ensure maximum capture of heat and latent heat from combustion products, and avoid the losses associated with starting and stopping.

Should the minimum heat output of a boiler be too high to match the heat demand, the boiler cycles on and off, disrupting steady state low temperature operation and reducing efficiency.

Measuring efficiency

Previous monitoring of boilers in use has shown that efficiency falls short of the

DR GEORGE BENNETT is lead technical energy adviser at the Department for Business, Energy and Industrial Strategy (BEIS)

DR CLIFF ELWELL is an associate professor at UCL Energy Institute

The difference in sizing requirement for space and water heating is a challenge to the efficient operation of a combi boiler

advertised values and expectation, giving the potential for real world improvements. Research has also shown (from the same authors) that on/off cycling is widespread in combi boilers in homes across the UK, where the minimum power output is typically above those required to match winter space heating load.

The research in our paper aimed to investigate whether the limited modulation range of combi boilers, together with the mismatch of space and water heating demands, is a significant contributor to the reduction of in situ efficiency, and whether this can be mitigated.

Our study used dynamic simulation modelling to illustrate the impact of boiler oversizing on cycling, quantify the impact on efficiency, and explore measures to mitigate negative effects. The models mapped a range of operation and oversizing characteristics, coupling an established building model (TRNSYS) with physically accurate representations

> Current legislation and labelling overlook PSR as a determinant of system efficiency, failing to incentivise appropriate sizing

of the heating system in a co simulation environment in Matlab.

In a simulation environment, the efficiency of the whole heating system could be tracked across multiple heating system configurations within the same virtual home, thereby eliminating the uncertainty of field measurement comparison across buildings, with all the uncertainty of construction, occupants, weather, and so on.

The level of oversizing present in most homes is considerable, and it is quantified as the ratio of boiler maximum output to the design heat load of a building, known as plant size ratio (PSR).

By simulating a common combi boiler size of 28kW (with a modulation range of 5:1) in a typical EPC grade C home with a design heat load of 3.3kW, we found that the level of boiler cycling was similar to that found in real boilers. Further simulations showed that the typical oversizing (PSR >3) and associated cycling behaviour brings an efficiency penalty of 6 9%.

Impact

The building fabric model enabled the impact of PSR on internal temperatures to be investigated. When the heating schedule was unchanged from that typically employed (07:00 09:00 and 16:00 23:00), then the increased efficiency at lower PSR was accompanied by lower internal temperatures, impacting thermal comfort.

However, extending the heating periods enabled the more modestly sized boiler to maintain the internal temperature at the required level without sacrificing efficiency. In the dwelling and heating system simulated, the efficiency gain from lower PSR outweighed the increased gas demand from longer operating times, resulting in energy savings.

There is a clear link between raising PSR, increased cycling and an associated decreased efficiency; however, in the UK, boilers are regularly oversized with respect to space heating, especially combination boilers that must cover peak hot water demand.

Current legislation and labelling including Energy related Products and Standard Assessment Procedure overlook PSR as a determinant of system efficiency, failing to incentivise appropriate sizing.

Reducing boiler oversizing by addressing installation practices and certification has the potential to improve efficiency significantly at low cost, decreasing associated carbon emissions and saving customers money.

Smaller, more suitable boilers can achieve their design efficiency in situ, but must be operated for longer periods to achieve the required internal temperatures but this can be done without sacrificing efficiency or energy demand.

The correct sizing of boilers, coupled with more continuous heating schedules, decreases carbon emissions and can be implemented in the short term, before the stock is transferred to lower carbon technologies such as heat pumps. CJ

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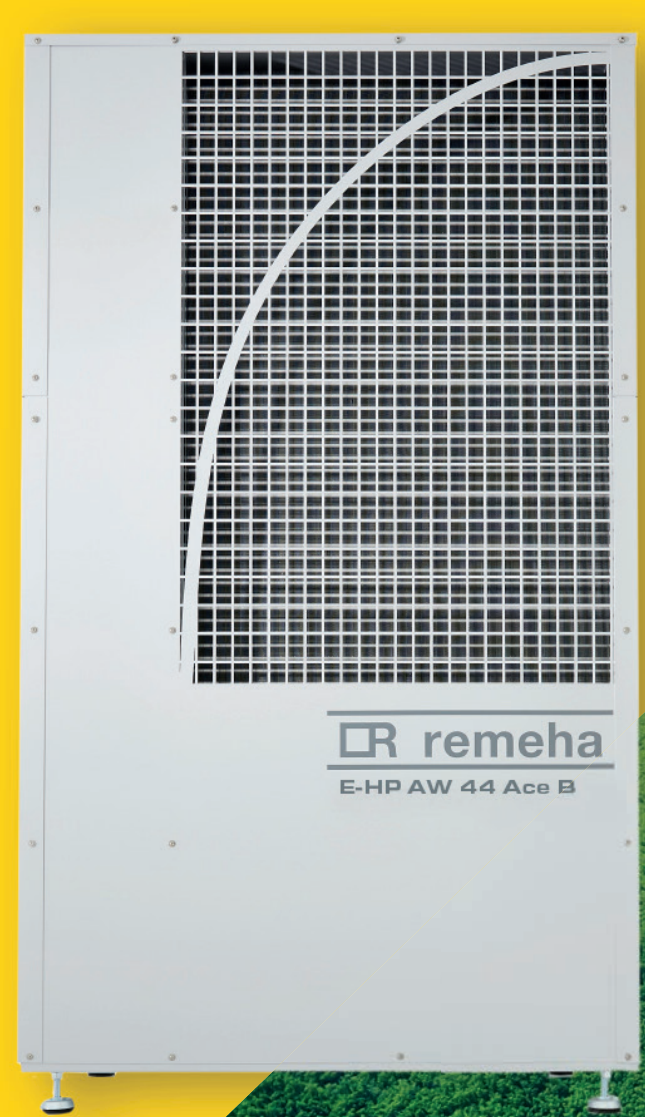

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Heating up

It's clear from the government's new energy strategy, announced in April, that it is banking on heat pump technology to help decarbonise heating in UK homes and commercial buildings. It plans to make 95% of electricity low carbon by 2030, with the target of 600,000 heat pump installations every year by 2028.

However, there is currently a lack of guidance for non-domestic heat pumps, so – following the success of CIBSE's 2021 guidance *AM16 Heat pump installations for multi-unit residential buildings* – BEIS has commissioned CIBSE to produce *AM17 Heat pumps for large non-domestic buildings*, due for publication this summer. CIBSE has been working with Arup and a cross-industry steering group on the title, which you can find out about on page 42.

As examples of what can be achieved with renewable heating at larger scale, E.ON is installing an innovative heat pump and borehole solution at its state-of-the-art Citigen energy centre in the City of London (page 46). Meanwhile, Lars Fabricius, of SAV Systems, discusses how heat networks can be used to share waste heat and store surplus renewable energy (page 36), taking pressure off the Grid and offering the UK a cost-effective route to net zero.

PHIL LATTIMORE, REPORTER

CONTENTS

Collaborating for sustainability

Dramatic energy price hikes, ambitious sustainability targets – just when it seemed that things were on the up, businesses are having to navigate an unprecedented energy minefield. And we, in the heating industry, find ourselves at the heart of both the problem and the solution.

How we heat our buildings must change. We firmly believe that the three 'Hs' – heat pumps, heat networks and hydrogen – all have a vital part to play in the decarbonisation mix, along with energy efficiency. This same diversification of heat sources and focus on maximising efficiency will also achieve the required reduction in heat demand and improvement in energy security.

The challenge, of course, is that there is no single solution, which means that identifying and delivering the most appropriate bespoke approach can be far from straightforward.

So how to resolve this? One solution is to encourage earlier engagement and more robust forward planning across the industry. By pooling our specialist knowledge, we will be better armed to help businesses plot their path to net zero.

Experienced manufacturers will be able to contribute technical expertise to ensure optimal results.

Our united goal must be to maximise heating efficiency and performance at every stage. Taking a more collaborative and proactive approach will help us do just that, ensuring that we deliver the right solutions at the right time to support businesses through these difficult times.

Rob Erwood is sales and specification director at Baxi Commercial Solutions.

For more information, visit: **remeha.co.uk/morechoice**

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HYDROGEN TRIALLED IN COMMERCIAL SETTING

Milford Haven hybrid trial combined hydrogen fuelled boiler with air source heat pump and smart controls

A smart hydrogen hybrid heating system has been demonstrated in a commercial building at the Port of Milford Haven, Pembrokeshire, in what has been hailed as a world first .

The trial combined a hydrogen fuelled boiler with an electric air source heat pump, alongside smart control technology. The aim was to prove the effectiveness of the hybrid technology solution, which could play a role in helping the UK to reach its net zero target.

The trial was part of the UK Research and Innovation funded Milford Haven: Energy Kingdom project, and partners included the Port of Milford Haven, Worcester Bosch, Passiv UK, Wales & West Utilities, Kiwa UK, Offshore Renewable Energy Catapult, and Pembrokeshire County Council.

Hybrid heating systems are designed to switch between using renewable electricity when it s available, and green gases, such as hydrogen, at other times. The trial partners claim that using clean fuel in this way will enable the full decarbonisation of heat, while ensuring cost and carbon emissions reductions are prioritised.

They claim that such hybrid solutions could be a cheaper and less disruptive alternative for the UK s building stock that is not suitable for a standalone heat pump solution, and that these systems could be fitted as a quick and direct replacement to a typical boiler system. They cite research suggesting that almost 50% of UK properties are not suitable for standalone heat pumps.

The hydrogen boiler installed for the project was developed by engineers at Worcester Bosch as part of the Department for Business, Energy and Industrial Strategy funded Hy4Heat project.

Kiwa UK delivered bottled hydrogen to the Worcester Bosch boiler to simulate periods when renewable electricity was unavailable to run the heat pump, or when a temperature boost was required.

The smart controls were designed by Passiv UK and integrated with the system to switch automatically between the air source heat pump and the hydrogen boiler. Every two minutes, the system assesses energy generation mix and renewable electricity availability on the local grid, requesting that the boiler run on hydrogen when renewable power is unavailable. Hydrogen produces zero carbon emissions during combustion.

Tom Veli, project director at Passiv UK, said: Flexibility solutions such as the Passiv UK smart hydrogen hybrid heating control offer the ability to make use of renewable electricity, when cheap and plentiful, to warm up the building fabric, and then fall back on hydrogen as an alternative fuel during periods of peak demand for electricity.

Responding to renewable generation and network requirements in real time enables demand to become more agile, as opposed to static, creating carbon savings, customer savings and commercial opportunities for a smarter, decentralised grid that is powered fully by renewable energy. The Milford Haven: Energy Kingdom project is a great example of this.

Commenting on the trial, Carl Arntzen, CEO at Worcester Bosch, said: Last year, our prototype hydrogen boiler was showcased in a domestic setting in Gateshead, but this is the first ever commercial application of the technology, the first hydrogen hybrid, and the first retrofit of a hydrogen boiler into an existing building.

The Milford Haven: Energy Kingdom project is one of the detailed design projects that is taking place within the scope of the Prospering from the Energy Revolution programme of works funded by UK Research and Innovation, as part of its Industrial Strategy Challenge Fund.

The aim is to design a blueprint for smart local energy systems fuelled by renewable energy and hydrogen and, more specifically, how to create demand and make the distribution and use of green hydrogen financially viable within buildings, industry, power and transport. CJ

Baxi publishes non domestic hydrogen guide

Baxi has released a new educational guide on hydrogen for heating targeted at the non-domestic sector. Its *Commercial guide to hydrogen for heat* is aimed at debunking myths surrounding hydrogen in heating applications, while outlining the potential for hydrogen to become a central pillar of decarbonisation in the UK. The guide looks at the role of hydrogen in the move to net zero, and how the transition from natural gas to hydrogen is likely to happen. To download the free guide, visit **www.baxiheating.co.uk/hydrogen-guide#hydrogen**

Jarrow heat network nears completion

A heat network incorporating battery storage, a PV farm and top-up gas CHP is expected to be completed this summer.

The Viking Energy Network Jarrow is a river source heat pump project, developed by South Tyneside Council, that will export sustainable heating from an energy centre on the south bank of the river Tyne to nine council-owned buildings in Jarrow.

The project, which began in March 2021 and is scheduled to be completed by late summer 2022, is designed to cut the council's annual carbon emissions by 1,035 tonnes, and save the authority around £0.5m in fuel costs annually. The network will harness low-grade heat from the river Tyne and export it to local council buildings, including high-rise flats, two schools and sheltered accommodation schemes.

The system is expected to run close to carbon neutral in the summer.

- Also in the North East, Gateshead Council is developing a geothermal heat network scheme designed to heat the equivalent of around 5,000 homes, using pipework in boreholes sunk 150m into the earth, where mineworks used to be. A 6MW mine water source heat pump will provide low carbon heating for the Gateshead District Energy Scheme extension.

Remeha adds air source heat pumps

Remeha has boosted its portfolio of sustainable commercial heating and water solutions by introducing a range of air source heat pumps (ASHPs) to its product line-up.

The heating and hot water manufacturer's new E-HP AW heat pumps can be seamlessly integrated with other Remeha products and heat sources, to provide sustainable heating and hot water solutions for new-build and retrofit applications.

The air-to-water heat pump range is available in three outputs, with individual heat capacities of 44kW, 88kW and 168kW and cascade options that dovetail with current commercial customer heat demands. The ASHPs are designed to deliver a high supply temperature of up to 65°C and to operate down to ambient temperatures of -20°C.

The 44kW unit is eligible for capital grants under the government's Boiler Upgrade Scheme (BUS) to support the installation of heat pumps in domestic and smaller non-domestic buildings.

- For more information, visit **remeha.co.uk/morechoice**

The sharing economy

Using heat networks to share waste heat and store surplus renewable energy will take pressure off the Grid and offer the UK a cost-effective route to net zero, says SAV Systems' Lars Fabricius

The UK's energy sector has made great progress in reducing carbon emissions with the growth in renewable energy. Wind power, in particular, has been so successful in replacing fossil fuels that Grid integration is now becoming the real challenge.

As a result of a shortfall in transmission capability, it is estimated that the UK exploits only around 50% of its installed wind power capacity. The consequence of this is that, to balance the Grid in 2019, the Balancing Services Use of System payment was more than £1.4bn, which includes constraint payments to wind farms for discarding power.

Using large volumes of wind generated electrical power makes balancing the Grid difficult. To improve the situation, huge investments in grid infrastructure are required, alongside modulating conventional, controllable power plants. This includes demand response initiatives, electricity import and export through transnational interconnectors, and electricity storage, such as hydroelectric and batteries.

This illustrates the inflexibility of this solution, and highlights the need for alternative approaches to storing energy, such as power to heat and power to gas.

By contrast, in Denmark which has probably the highest percentage of wind power per capita in the world there is a growing appreciation that successfully replacing fossil fuels with renewables will require far more than wind turbines and batteries. It will require a complete revolution of the country's economy.

Denmark turned to renewables as a reaction to the oil crisis in the early 1970s, when most Danish homes had oil fired heating. The drivers for change were cost and security of energy supply; now, a target of net zero by 2050 is driving Denmark to embark on a second renewables revolution.

The expensive hard electric approach being pursued by the UK has been eschewed in Denmark in favour of sector (or utility) coupling to provide low carbon heating and cooling to buildings. This is based on installing heat networks in urban areas to share energy between sectors, with heat pumps used to supply heat to

LARS FABRICIUS is managing director at SAV Systems

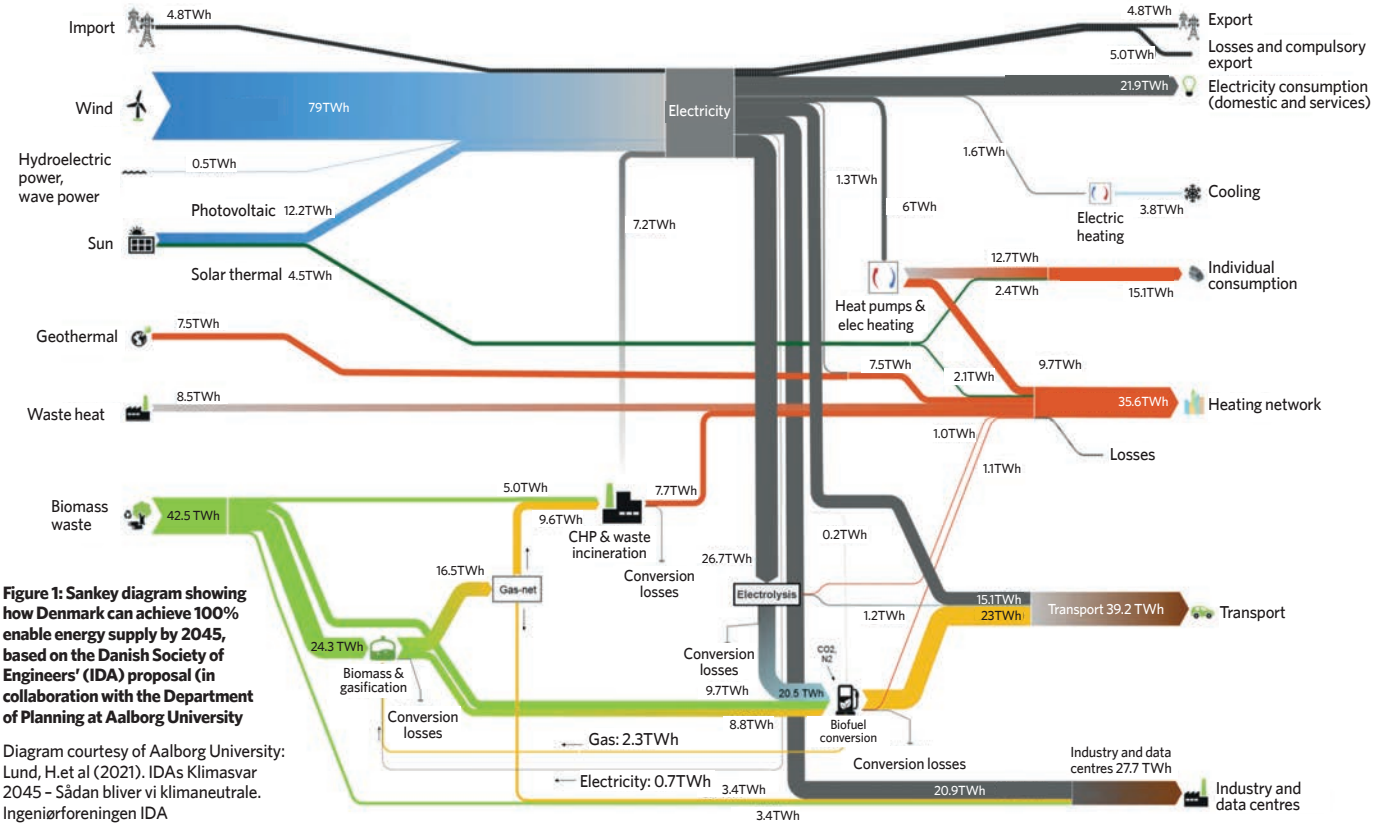


Figure 1: Sankey diagram showing how Denmark can achieve 100% enable energy supply by 2045, based on the Danish Society of Engineers' (IDA) proposal (in collaboration with the Department of Planning at Aalborg University

Diagram courtesy of Aalborg University: Lund, H.et al (2021). IDAs Klimasvar 2045 – Sådan bliver vi klimaneutrale. Ingeniørforeningen IDA

buildings in remote areas where heat networks are not economically viable.

The crucial difference between the two approaches is that hard electrification requires storage using power to power technologies (such as batteries), as opposed to storage by power to heat or power to gas. Power to heat can be activated during periods of abundant wind and/or solar generation, with conversion carried out by large scale heat pumps or electric boilers, and the resultant hot water sent to storage for the short term, or season to season. Surplus renewable power can be used in the electrolysis of water to produce hydrogen gas for applications where there are no ready energy alternatives, such as heavy industry, aviation and transport.

A major benefit of heat networks is that they use waste heat from various sources, including power stations, waste incineration and industrial processes (including hydrogen production), to deliver energy cost effectively. This reduces dependence on non renewable fuels and improves security of supply.

A major benefit of heat networks is that they use waste heat from various sources, including power stations

For Denmark, it is estimated that around 35TWh of heat network heating will be required by 2050, with heat pumps supplying an additional 15TWh (see Figure 1). Some of the heat for district heating will be provided by waste heat from the production of electro fuels, the use of which helps to make the project viable.

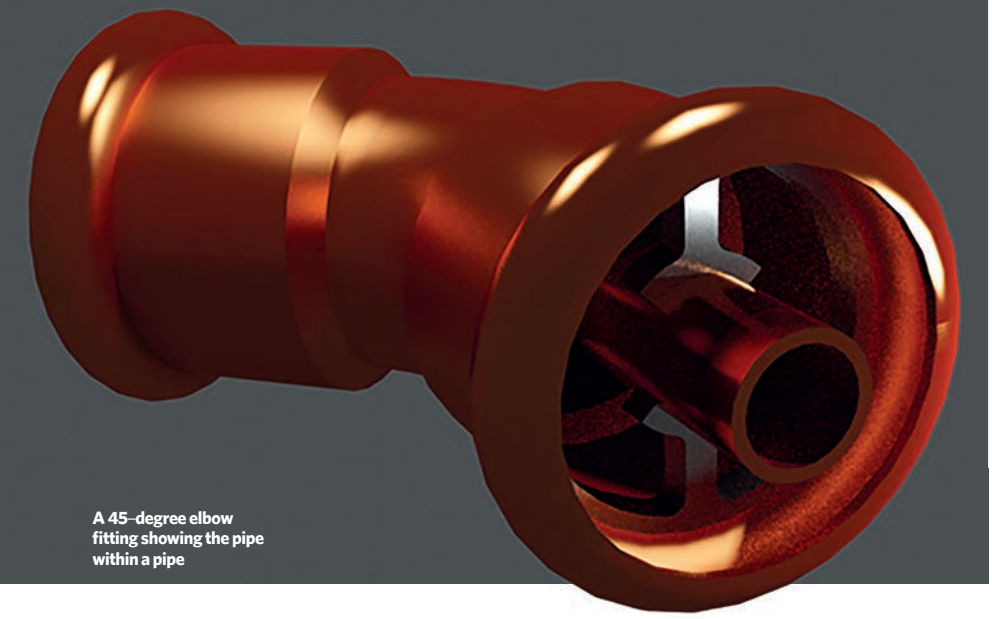
To generate sufficient green electricity to power the country and to produce electro fuels, Denmark is constructing two energy islands in the North Sea, which will be hubs for offshore wind. Initially, one island will supply 2GW of energy, while the other will supply 3GW, but with the potential for both to supply up to 10GW.

According to the UK government, heat networks could contribute 95TWh, or 20% of the total heat demand, which is almost three times that of Denmark. That would offer huge potential economies of scale benefits.

The contrast in both cost and carbon reduction savings from the UK adopting a sector coupled approach could be significant when compared with the hard electric approach that the government appears to be pursuing which is why the UK needs to pause now and consider its options very carefully. CJ

Piping hot

An innovative pipe within a pipe design for domestic hot water systems offers improved energy efficiency and healthy and safe water for end users. **Phil Lattimore** looks at benefits of the CIBSE Award winning Water Kinetics Eco Duo



A 45–degree elbow fitting showing the pipe within a pipe

The provision and selection of heat generation for domestic hot water (DHW) systems is a vital element of any energy-efficient solution. At the CIBSE Building Performance Awards, the winner of the Product or Innovation of the Year – Wellbeing category was the Water Kinetics Eco-Duo, which is designed to ensure energy-efficient, safe DHW supply that doesn't compromise consumer requirements.

Eco-Duo is a copper pipe-within-a-pipe recirculation system that keeps hot water hot and cold water cold. It is designed to control the spread of water-borne pathogens and biofilm, while still being highly energy efficient. The awards judges described the system as 'a novel, innovative product that addresses a real-life challenge robustly'.

Health and safety

Health and safety are key issues when it comes to DHW supply. Hot and cold water needs to be kept at the desired temperatures, and the water has to be kept moving on a regular basis.

DHW systems in commercial and large residential buildings have long incorporated recirculation systems, where water is constantly reheated and pumped around the system to maintain a safe working temperature.

The main safety issues for DHW systems involve the control of pathogens and prevention of scalding.

Traditionally, potable water circulation comprises separate flow and return pipes, with branches off the flow pipe to individual outlets. The flow, return and branches are all subject to temperature loss, relative to the distance from, and return to, the heating source.

Areas of low temperatures occur where there is no circulation in these branches during periods when outlets are not being used or used less frequently. This can result in the undesirable proliferation of pathogens, such as legionella bacteria. Combating these issues requires costly, time-consuming monitoring, treatment, and wasteful flushing regimes.

The control of these pathogens is achieved by compliance with HSE Approved Code of Practice (ACOP) L8. It requires keeping water at a minimum of 60°C and ensuring distributed water is supplied at 50°C (55°C in healthcare buildings) to outlets within one minute; the temperature in the return pipe must be at no less than 50°C. This requires system sanitisation and/or chemical treatment to be deployed frequently.

The most effective way to ensure that legionella bacteria is controlled involves raising water temperature to 70°C. For this to be effective, it must include every outlet and section of pipework subject to heat loss. Raising temperatures, however, increases the risk of serious injury from scalding.

Energy efficiency

Reducing energy usage is an essential consideration for new or retrofitted DHW systems. Heat loss in a conventional system is directly proportional to the difference between the water temperature and the temperature of the air surrounding the pipe; in a conventional system, this will be from both the flow and return pipes.

Water in the system must be constantly reheated and pumped around the system. Reducing heat loss from the surface area of the pipework could, therefore, significantly increase thermal efficiency.

In addition, where storage is necessary to satisfy fluctuating patterns of DHW demand, current legislation (HSE HSG274) requires water be kept at or above 60°C. This in turn requires a constantly high amount of energy.

The pipe within a pipe

To address these issues, the Water Kinetics Eco-Duo circulation system incorporates a coaxially configured return pipe within the flow pipe, reducing surface area and heat loss. Water Kinetics says this approach can halve installation time and costs, pipe

insulation, and wall fixings (as no return pipe is required).

It also estimates that Eco-Duo can maintain a saving of almost 50% in energy costs over a conventional system throughout its lifetime.

Inner-pipe integrity in the Eco-Duo is maintained through the pipe being held by stainless steel coils, and in the fittings by stainless steel separators, which are pre-fitted.

In terms of costs for pipework and fittings, Water Kinetics maintains that there is a slight saving for Eco-Duo compared with standard fittings, taking into account that fewer fittings will be required as there is no return pipe. A larger saving is made on pipe wall fixings and insulation, and in time and cost of the installation.

The system can be programmed to raise the temperature of the water above 70°C for a brief period, at a desired frequency (for example, every 24 hours), thus pasteurising the whole system, right up to the point of use, preventing the proliferation of dangerous pathogens.

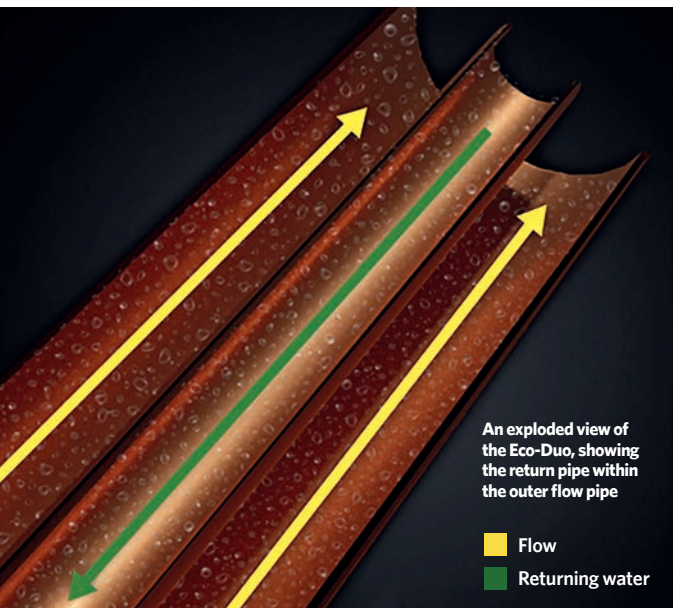
Water Kinetics provides press/flow charts on its website to enable the necessary calculations on pipe sizing to be made. In principle, if a pumped flow system is used, the velocity of the water travelling through the pipework can be increased by increasing the pump speed. Alternatively, if a pumped flow system isn't being used, pipe sizes can be increased by one size.

While one of the challenges with some DHW distribution systems is scaling, there is no additional risk of scaling with Eco-Duo, says the company. It claims the slight disruption to laminar flow of water increases turbulence through the pipework and fittings, and can help to reduce scale.

Water Kinetics says that an Eco-Duo fitting can save 2.27 tonnes of carbon over the 30-year lifetime of a building, which equates to more than 6,800 tonnes per building on average. The company also claims 60% of the materials used in the product are recyclable, with 100% being recyclable at end of life.

The Eco-Duo is designed to deliver a significant contribution to net zero carbon targets, while ensuring water-safety compliance in a cost-effective way. **CJ**

Visit www.water-kinetics.co.uk



An exploded view of the Eco-Duo, showing the return pipe within the outer flow pipe

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How do we decarbonise heat?

Chris Caton

High fabric standards, low carbon technologies and more efficient buildings services will create the net zero buildings of the future, says Groupe Atlantic UK's Chris Caton

To decarbonise heating in new commercial buildings we need to consider the whole building, and not just the equipment generating heat. Of course, this equipment needs to offer high efficiencies, using the least amount of energy, but the distribution of this heat and the thermal efficiency of the structure are fundamental to achieving an efficiently run building.

It s obvious that a more thermally efficient building uses less energy and, therefore, the energy supplied to the building will have emitted less CO_2 in its production and delivery.

The new Part L uplift to Building Regulations for non domestic buildings starts us on a journey to decarbonising heating in the UK, targeting an average decrease of 27% in CO_2. This is a positive first step towards the greater savings needed from the Future Building Standards, which are to be implemented from 2025.

High fabric standards, improved building services and low carbon technologies are the elements identified to achieve the 27% decrease in CO_2.

This, coupled with the government s Heat and Buildings Strategy, and decarbonisation funding worth £3.9bn, announced in October 2021, will help ensure in the shorter term at least that heat pumps and district heating supply the heat. It will also put a focus on the heating distribution system, design and control.

Correctly sizing, at the design stages, low carbon heating such as heat pumps, the system it supplies, and the controls is critical to ensuring comfort and low cost operation and, of course, to minimising CO_2 emissions.

CHRIS CATON is head of commercial product management at Groupe Atlantic UK

Thinking big

New CIBSE guidance on heat pumps in large non domestic buildings will be released this summer. Arup s Joshua Bird looks at what you can expect from AM17

The UK is ramping up its activities to shift towards cleaner ways of heating the country's built environment, and heat pumps are the technology of choice for this transition. Against the backdrop of a long-term energy price crisis, however, the move to all-electric buildings is far from straightforward.

Robust standards and guidance to support the industry are needed if the UK is to deliver high-quality heat pump installations, but there is a lack of up-to-date technical information that addresses heat pumps in larger buildings specifically.

So, after the success of CIBSE's 2021 guidance *AM16 Heat pump installations for multi-unit residential buildings,* the Department for Business, Energy and Industrial Strategy has commissioned the Institution to produce guidance on heat pumps for large buildings. CIBSE is working with a team from Arup and a cross-industry steering group to author *AM17: Heat pumps for large non-domestic buildings*.

Since the release of the Heat and Buildings Strategy[1], and the target of installing 600,000 heat pumps every year by 2028, the UK government has been developing policies to drive forward the delivery of heat decarbonisation and support businesses to prepare for a clean-heat transformation through the 2020s and into the 2030s.

The UK government has consulted on proposals to phase out the installation of new fossil fuel heating systems[2] – those fuelled by oil, liquefied petroleum gas, or coal – in existing businesses and public buildings that are off the gas grid. The government will be publishing a response to this consultation in due course.

Configuring systems

AM17: Heat pumps for large non-domestic buildings provides an overview of the different heat pump technologies currently available on the market, including air and water source heat pumps. It also highlights the advantages of different ground source heat pump (GSHP) collectors – open-loop, vertical and horizontal arrays – and the importance of getting specialist advice.

Selecting a suitable and future-proofed refrigerant is key to the long-term success of new heat pump systems. The trade-offs between performance and environmental impact of different refrigerants are discussed, including a dedicated section on CO_2 heat pumps.

The capability of a heat pump to provide high-temperature process heat, or simultaneous heating and cooling, should be a response to the requirements of the building. One configuration is to use heat pumps in series or 'cascade'

to achieve higher temperatures. AM17 provides information on how such systems might be configured and how the total system efficiency should be calculated (see Figure 1).

Derisking GSHPs

Ground source heat pumps can offer the opportunity for higher year-round efficiencies compared with their air source counterparts. Two crucial risk areas that can drive capital costs are managing geological uncertainty and obtaining environmental permits for open-loop ground source and water source applications.

AM17 supplies guidance on the role of ground investigations and thermal response tests (TRT) in designing such a system. For closed-loop vertical arrays, a trial borehole can provide valuable insight into local drilling conditions – data that can be used to reduce a drilling contractor's geological uncertainty. A TRT can then determine ground temperatures and conductivity, which allows a specialist designer to refine calculations on the number and depth of boreholes required.

The forthcoming guide also contains information from the Environment Agency (EA) on the permitting process for open-loop systems in England, plus tips on how to achieve an environmentally successful heat pump scheme.

Open-loop ground source and water source installations may require groundwater investigation consent, an abstraction licence, a discharge permit, and a flood risk permit – all of which require engagement with the relevant regulator (such as the EA for installations in England).

IMPACTS OF HEAT PUMPS

- **The building electrical supply: the installation of heat pumps may require a new electrical connection to the building. In addition to the kVA capacity required, the district network operator may require information on the starting method of the heat pumps – for example, direct-on-line, soft-start – as this can impact the electrical infrastructure**
- **Plantroom ventilation: due consideration must be given to the toxicity, flammability and risk of asphyxiation presented by refrigerants in enclosed spaces. Further guidance is provided in BS EN 378**
- **Noise from air source heat pumps and outdoor units can be greatest during a 'blowdown' operation, when fans run at maximum speed to dry the evaporator after a defrost cycle**
- **Air source heat pumps and outdoor units can produce both meltwater and pluming during and after defrosting cycles. These should be considered carefully when locating such units, as run-off water is likely to refreeze, presenting a slip hazard**

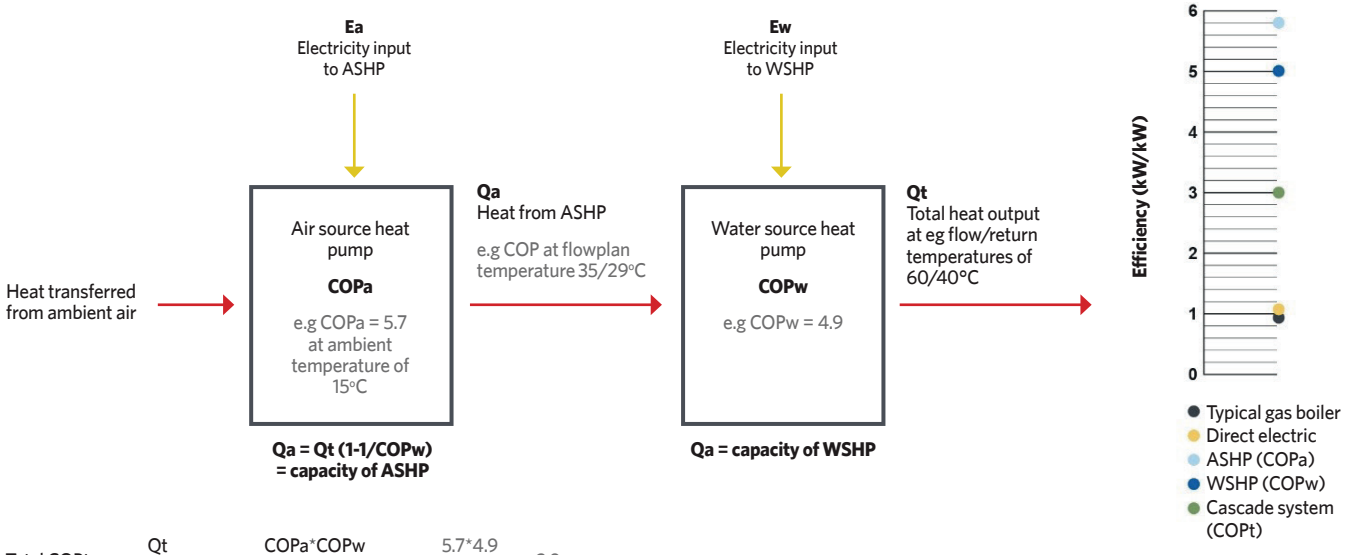
The effect of defrost cycles on the operation of an air source heat pump and the noise it can generate, and the impact this can have on the building it serves, should be considered carefully

Understanding air source heat pumps

Air source heat pumps (ASHPs) will be the most common units installed during the heat pump transition. While there is broad understanding across the industry of the effect of outdoor air temperature on the efficiency and capacity of such units, the effect of defrost cycles on the operation of a heat pump and the noise it can generate should all be considered carefully.

AM17 provides information on how we can use controls and thermal storage to mitigate these issues, including an example calculation of how to size a thermal store to offset the impact of a defrost cycle.

Another aspect of ASHPs covered in AM17 is the distinction between gross and integrated capacity. Manufacturers can provide both the gross capacity of a unit »



$$\text{Total COPt} = \frac{Qt}{Ea + Ew} = \frac{COPa * COPw}{COPw + COPa - 1} = \frac{5.7 * 4.9}{4.9 + 5.7 - 1} = 2.9$$

Figure 1: Calculating the total efficiency of multiple heat pumps in series

Selecting a suitable and future proofed refrigerant is key to the long term success of new heat pump systems

» and the integrated capacity, which includes an allowance for defrost cycles.

The test regime for determining the integrated capacity of a heat pump is set out in EN 14511-3:2018. Selecting a unit based on an integrated capacity means that the system has extra capacity for the unit to supply additional heating to recharge the system after a defrost cycle.

Simultaneous and independent heat pumps (SIHPs) represent some of the most sophisticated units available on the market. These can generate chilled water and low-temperature hot water separately or at the same time. SIHPs are suited to applications with balanced and simultaneous heating and cooling loads.

These units are, however, more costly than alternatives such as reversible heat pumps or heat recovery chillers. Many projects undertake an annual demand simulation to determine the true simultaneous heating and cooling load, and use this information to balance the quantity of SIHPs with other sources of heating and cooling.

The integration or retrofit of heat pumps into our new and existing buildings has the potential to impact most aspects of the design, from MEP systems, space allowances, façade design and plant-replacement strategy.

AM17 also offers guidance on some of the less obvious impacts of installing heat pumps in large buildings (see panel, 'Impacts of heat pumps').

Engineers eagerly awaiting guidance on this important topic will not have long to wait. AM17 will be freely available this summer from CIBSE at **www.cibse.org/knowledge**. CJ

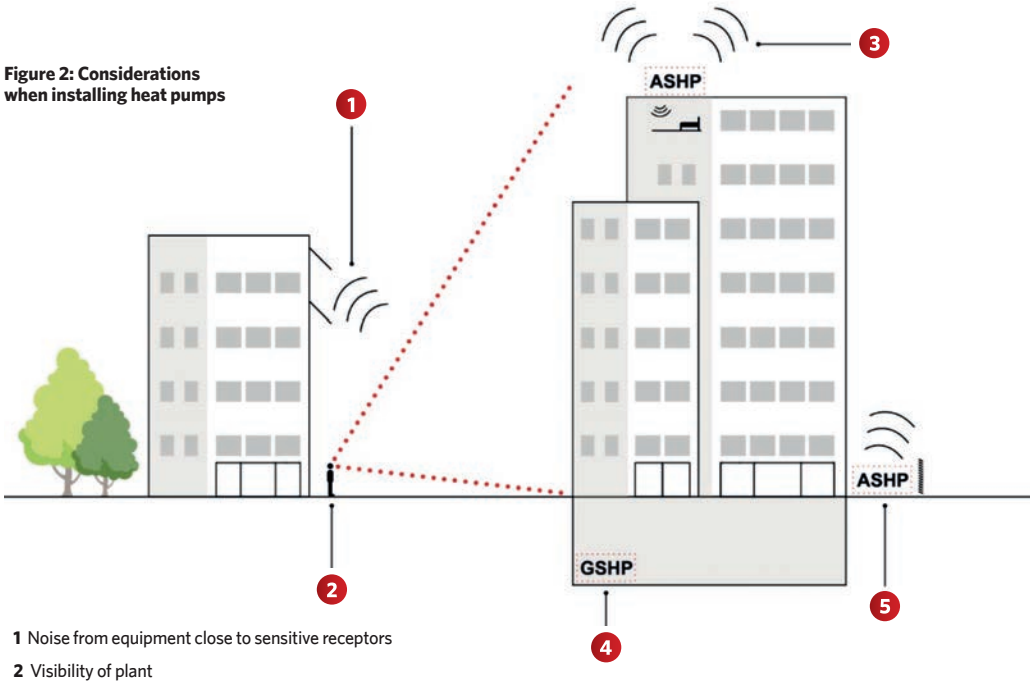
JOSHUA BIRD is a lead building services engineer at Arup

References:

1 Heat and Buildings Strategy, BEIS, Oct 2011, **bit.ly/CJMay22AM17A**

1 *Phasing out the installation of fossil fuel heating systems in businesses and public buildings off the gas grid*, BEIS, Oct 2011, **bit.ly/CJMay22AM17B**

Figure 2: Considerations when installing heat pumps



1 Noise from equipment close to sensitive receptors

2 Visibility of plant

3 Different construction costs of plant areas

4 Impacts of vibration particularly important in hotels/mixed-use developments with residential use

5 Enclosure and acoustic considerations will differ for ground-level plant compared with roof installations

LEARNING FROM PAST INSTALLATIONS

AM17 contains several case studies of existing air and ground source heat pump installations, which offer real-world insights into specific elements of designing and operating large heat pump systems. These include:

- **Using annual building-load analysis to optimise your heat pump sizing**
- **System monitoring**
- **Sizing a cascade heat pump system**
- **Temperature stability using thermal stores**
- **Minimum turndown of heat pumps**

Heat pumps were retrofitted at Arup's 80 Charlotte Street office

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Greening the City

The City of London is adding heat pumps and boreholes to its Farringdon energy centre and hopes to encourage more commercial buildings to plug into its low carbon heat network

The façades of the Port of London Authority building and its neighbour The Central Cold Storage, built to hold animal carcasses for Smithfield meat market opposite, stand as a reminder of London's commercial past. Now behind these venerable walls is a state-of-the-art energy centre that includes an innovative heat pump and borehole solution, which is claimed to cut the carbon emissions associated with heating and cooling by up to 50%.

The energy centre, owned and run by E.ON, is the latest development on a site where power was first generated in 1893. Back then, when electric power was still in its infancy, the Cold Storage building housed one of London's first coal-fired power stations, built to power the market and its refrigerators and purchased by the City of London.

A century after it first started to produce power, the power station now has two combined heat and power (CHP) engines and two absorption chillers, which together form a centralised energy centre capable of providing up to 39GWh of electricity, 40GWh of heat energy and 7GWh of cooling per year for the corporation's buildings in the City.

In 2013, and now known as Citigen, its two 16MW dual-fuel (gas/diesel) CHP engines were replaced by two new, smaller and more efficient 4.3MW gas-reciprocating CHP engines, as part of a £27m investment programme. The energy centre's three, 3MW oil-fired back-up boilers were also converted to run on gas, while a 320m^3, 50m-high thermal store, which can store up to 8MWh of heat, was installed.

'If the heating load on the network is larger than 9MW, the boilers will kick in as top-up,' explains Leke Oluwole, general manager of the Citigen district energy scheme. 'In a normal year, 92% of the heat is reclaimed from the CHP, with an 8% contribution from the boilers.'

Three, 1.1MW low-voltage screw chillers, and a 3MW high-voltage screw chiller, were installed to replace the absorption chillers mentioned above. The low-grade heat rejected by the replacement chillers was discharged to the atmosphere via eight cooling towers.

The final intervention was the addition of a new control room above the energy centre, to enable staff to run it and the 70 other district heating schemes operated by E.ON around the country.

The energy centre's CHP engines generate high-voltage electricity to power the chillers and network pumps, with surplus power sold to the Grid or direct to customers via a private wire network. Heat reclaimed from the CHP engines and their exhausts is used to heat the water in the thermal store, up to a temperature of 105°C. 'The energy centre runs 24/7 to serve the mix of residential and commercial properties on the network,' says Oluwole.

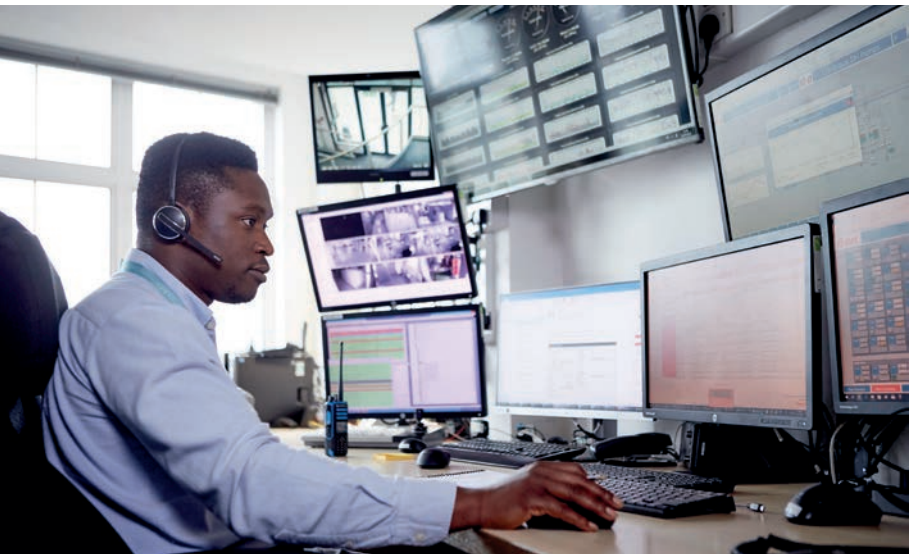
From Smithfield, 11km of insulated pipes weave their way underground, buried beneath public roads and hidden in basements and tunnels. These also deliver heating and cooling to the City of London's buildings, including the Guildhall, Barbican Centre, and the Museum of London.

Heat from the thermal store is carried through 6km of pipes – at a temperature of 95°C flow, 72°C return – to 27 substations, for distribution to buildings served by the plant. Seven of the substations also provide cooling; chilled water leaves the energy centre at a temperature of 6°C and returns at approximately 11°C-12°C, depending on demand.

In June 2021, E.ON announced the start of a £4m project to decarbonise the energy centre and increase its heating and cooling

CHP engines generate high voltage electricity to power the chillers and network pumps, with surplus power sold to the Grid or direct to customers

The Port of London Authority building, which houses the energy station



The control room monitors Citigen and 70 other E.ON heat networks across the UK

capacity, to help meet a growing demand. 'We wanted to expand the network, but to do so sustainably,' explains Oluwole.

Working with consultant Ramboll, E.ON developed a solution that incorporated three new heat pumps, ground borehole thermal storage, and heat-recovery technology into the existing energy centre. 'We did look at other technologies, such as biogas and hydrogen, for this very congested energy centre, 7m below the ground,' says Angelos Chatzidiakos, formerly of Ramboll but now senior solutions developer at E.ON. However, the technologies and infrastructure needed to support these options were not readily available in London.

The heat pumps complement existing CHP, boilers and electric chillers, to provide heat and chilled water as necessary. 'We »

» had embedded carbon within the CHPs, which are still within their payback period, so this solution allows us to make best use of the technologies we already have,' Oluwole says.

Three Carrier AquaForce 61XWHZE heat pumps have been installed. These use a twin-rotor screw compressor and operate on ultra-low global warming potential (GWP) refrigerant R1234ze. In total, the heat pumps provide 4MW of additional heating capacity and an additional 2.8MW of cooling.

Along with heat pumps, three 450mm-diameter boreholes were drilled down into the aquifer, 200m below the street. The borehole installation was key to the commercial viability of the decarbonisation works.

'One of the challenges we face in decarbonisation is achieving a commercial rate of return; the boreholes give us the ability to tap into the Non-Domestic Renewable Heat Incentive to help bring the payback period for this project into an acceptable range for the company,' explains Oluwole. Chatzidiakos agrees: 'The upgrade would still work without the boreholes, but we would lose a lot of financial benefits,' he says.

Space constraints meant the boreholes had to be drilled in the road outside the energy centre. The road is supported by a series of subterranean arched vaults with access to the basement. To reach the aquifer from the road, the boreholes had to be sleeved through the vaulted space to enable the auger to drill down 200m to the aquifer. They also need to be threaded between three rail lines under and next to the site.

Electricity generated by the CHP engines is used to power the heat pumps. Chatzidiakos says the scheme has been designed to enable three sources of heat to be used by the heat pumps: ground boreholes; low-grade from chillers and other plant; and the cooling network (see panel, 'Sources of heat used by heat pumps').

Whatever the source of heat, the heat pumps upgrade the energy harvested to produce hot water at 80°C. That heat can be supplied to the network, saved for future use in the thermal store, or pumped down into the boreholes for longer-term storage.

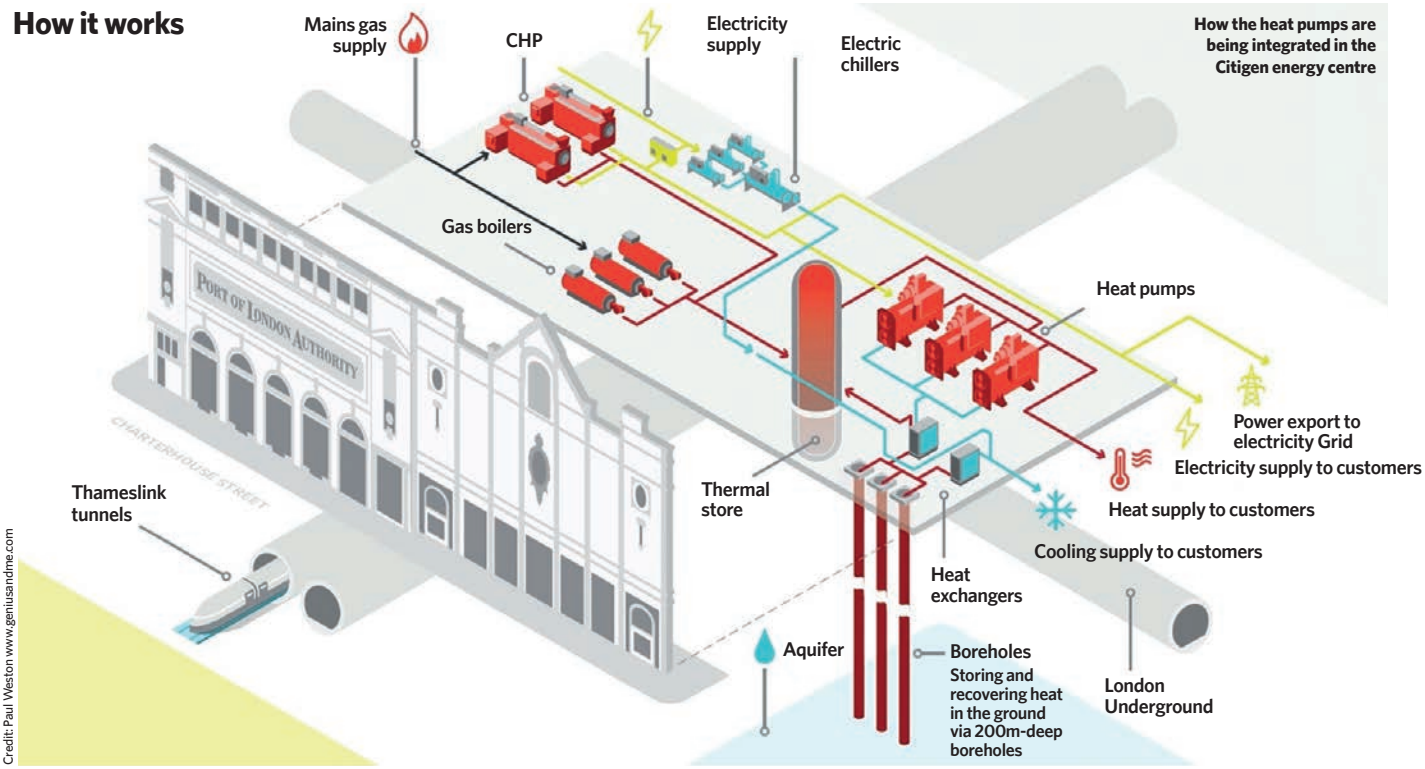
The high flow temperature of the district heating system is because the system serves legacy heating systems in buildings such as the Guildhall. 'This is not a typical heat pump solution because we're supplying older buildings on the network; the Guildhall, for example, requires heat at 85°C, while newer buildings on the network with underfloor heating, for example, only require heat at 45°C,' says Oluwole.

To provide for both, the system is designed for the higher temperature demand of older buildings on the basis »

THREE SOURCES OF HEAT USED BY HEAT PUMPS

- **The ground boreholes will be used as a heat source for most of the year.**
- **The low-grade heat that had previously been wasted by Citigen, such as heat rejected from the chillers, can now be stored in the ground boreholes. This is then upgraded by the heat pumps into useful heat when required, saving cost and carbon. 'The heat in the ground could diminish over time, so, to avoid that, we store the recovered process waste heat in the ground to keep the temperature in balance,' says Chatzidiakos.**
- **The final source of heat is the cooling network itself. 'We designed the heat pump installation in a way that allows them to be used in combined heating and cooling mode,' explains Chatzidiakos. In this mode, the chilled water is not routed to the chillers; instead it is piped direct to the heat pumps. 'Because the chilled water has effectively absorbed heat from buildings, if we take the chilled water return to the heat pump, we can use it as a heat source to provide heat back to the network,' says Chatzidiakos. He adds that this is the lowest carbon mode of operation 'because the chillers do not need to run, but heat is still being removed from the cooling network'.**

How it works



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Heat pumps could run on their own without a CHP

» that temperatures can be lowered at the heat exchanger for newer buildings.

Chatzidiakos says the optimum mode of operation, which is a trade-off between cost and carbon, is to run one CHP and the heat pumps: 'Consuming gas to operate one CHP provides power to run the heat pump, with any surplus sold, while the heat pump can produce heat and chill to the network.'

The system's inherent adaptability helps ensure its commercial viability over time. 'We want to have flexibility on our networks so that if, say, the gas price goes up, we can still run the network and meet our business case,' Chatzidiakos explains. 'At the moment, with the gas price, it still makes commercial sense to run at least one CHP and the heat pumps, rather than run the heat pumps on their own, which we could do.'

In addition to responding to the gas price, the system will be able to vary its mode of operation in combination with the thermal store, to respond to the price of power.

The system is currently being commissioned and the boreholes' performance tested to see just how much energy they can yield and store. The intention is to balance the heat in and out of the aquifer to maintain its temperature at 14°C. 'We can use all of the boreholes as a heat sink or source, or we can extract heat from one and return heat to the ground through another,' explains Oluwole.

> The system will be able to vary its mode of operation in combination with the thermal store, to respond to the price of power

As part of the project, E.ON has co-sponsored a study from the universities of Birmingham and Cambridge to help gain an understanding of the impact of interaction from multiple boreholes.

'There are no rules or regulations to establish the interaction between boreholes, particularly from boreholes on one scheme being drilled close to those on another,' says Oluwole.

'This project should allow Defra [the Department for Environment, Food and Rural Affairs] and the EA [Environment

Agency] to put into place rules to protect the environment and to allow the provision of low carbon heat.'

Oluwole says there is currently a lot of regeneration under way around Citigen, which E.ON hopes to capitalise on. The compact nature of the district heating connection and the space saving it offers businesses is one of Citigen's selling points in the City, where every square metre is at a premium. It frees up attractive roof space that would otherwise house air con units.

'What you can do with a high-temperature network such as Citigen is to cascade it, using heat exchangers, to lower the temperatures – although, over time, we would be looking to lower the system temperatures,' Oluwole adds.

For the future, E.ON is looking at the potential of adding a lower-temperature network to Citigen to serve the area to the south of the current scheme. It has already undertaken a pre-feasibility study with a view to installing a fifth-generation heat network, which will continue its work in helping make London a greener city. CJ

E.ON hopes more City businesses will switch to Citigen for heating and cooling

As the heating and hot water sector moves towards electric systems as part of the drive for improved sustainability, specifiers are increasingly looking at heat pump water heaters as the domestic hot water technology of choice. Kamlesh Vadukul, product manager at Ariston, explains

Pump up the heat

An example of a 200-litre heat pump water heater (Source: Ariston)

Given the current drive and investment in renewables as the UK sets on the path to net zero by 2050, electricity has been identified as a cleaner, greener energy source, and heat pumps emphasised as a key driving technology.

Manufacturers of water heating products have risen to the challenge by developing ranges of electrically powered heat pump-based domestic hot water (DHW) heating products for use in large residential and light-commercial applications.

The benefits of using heat pump water heaters for DHW only

Heat pump water heaters are designed specifically for the production and storage of hot water, and are typically capable of operating at air temperatures as low as -10°C – or lower when a built-in electrical immersion heater is used.

DHW storage requires a minimum of 55°C; however, future building space-heating systems will require temperatures less than 55°C and underfloor heating, for example, may only require 35°C. So, keeping the hot water separate from heating ensures that both systems operate effectively.

Heat pump water heaters are particularly suitable for retrofit applications where additional DHW is required, or where conversion to a full heat pump system is not possible (for example, if upgrading the space-heating system is not practical or financially viable).

Applications

Heat pump water heaters can be sited in areas such as utility rooms, garages, outbuildings and cupboards in a variety of light-commercial applications – including leisure centres, gyms, cafes, coffee shops and retail outlets – as well as in residential apartment blocks.

Combining an air source heat pump unit with an unvented DHW cylinder, such as the 200-litre unit shown above, can deliver hot water at a coefficient of performance (COP) of 3.1 (tested to EN 16147 at an outdoor air temperature of 7°C, relative humidity of 87%, inlet water temperature of 10°C and hot water temperature set at 55°C). The manufacturer's modelling* predicts that this can reduce energy consumption by up to 80% when compared with traditional electric storage water heaters.

This example unit can deliver DHW temperatures of up to 62°C with a full recovery time of less than four hours from the heat pump alone, producing sound power levels as low as 51dBA. Higher temperatures and speedier recovery rates are available if boosted via the direct electric immersion heater.

> Operational costs will depend on the mode of use many early, general heat pump installations suffered from unexpectedly high use of costly direct electric heater top up

The illustrated unit employs R134a refrigerant (global warming potential (GWP) = 1,430) that provides good performance at the higher temperatures required for DHW, and contributes to the A+ energy rating for the unit. Future models are planned for development that employ high-performance refrigerants with lower GWPs.

Design considerations

Although the initial cost of a heat pump water system is higher than traditional technologies, the lower operating costs should offset the investment across the life of the product. As with any hot water heating and storage product, the key design considerations include the volume of hot water required, the water temperature and the heat-up time.

The installation requirement is similar to fitting unvented cylinders, with appropriate space for access (as illustrated in Figure 1). However, ducting is required to deliver and discharge air for the heat pump's evaporator. The intake and outlet for these ducts must be suitably distanced to prevent any air that has already been drawn in and cooled from being drawn back in (which would impact on energy efficiency).

Ducting needs to be insulated appropriately to prevent condensation. The illustrated hot water heater may be used without an exhaust duct, but should be installed in a well-ventilated room with a volume of no less than 30m^3. Such unducted application cannot be used in rooms containing appliances that require air to function.

Integrating heat pump water heaters into existing systems

Units are available with an additional indirect coil, mounted in the hot water store, that can be connected to other heat sources, including solar thermal and gas boilers (see Figure 2). Manufacturers offer control options to provide effective integrated operation of such systems where there are compatible control protocols.

Reducing energy consumption and cost

As an indication of comparative energy costs, manufacturer's calculations, using typical UK electricity prices at the time of writing, indicate that the illustrated 200-litre unit incurs an annual running cost of £161 compared with £575 for a 200-litre cylinder with an electric immersion heater.*

Operational costs will depend on the mode of use – many early, general heat pump installations suffered from unexpectedly high use of costly direct electric heater top-up. Improved control regimes, and more accessible interfaces – such as Wi-Fi-connected apps on mobile phones – provide the user with enhanced control to reduce unnecessary energy consumption through daily/weekly scheduling and holiday programming.

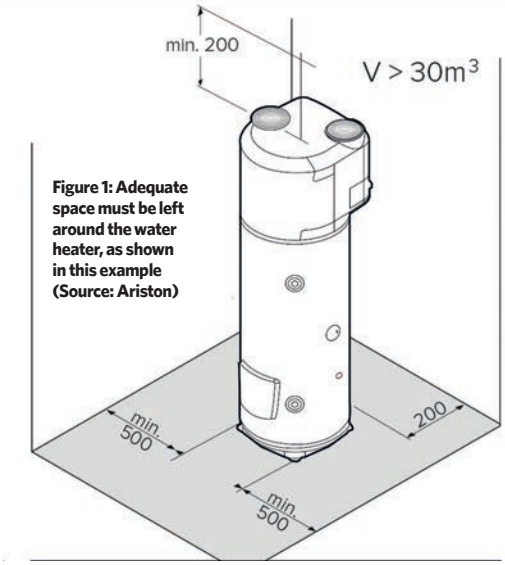

Figure 1: Adequate space must be left around the water heater, as shown in this example (Source: Ariston)

Additionally, integrated 'intelligent' control software, including adaptive optimum-start heating schedules, are available with some units to assist in minimising energy consumption.

Conclusion

Emerging heat pump water heater products are capable of providing high volumes of DHW relatively quickly and efficiently, while offering enhanced levels of controllability and lowering running costs. They will undoubtedly be a useful addition to the technology mix that will contribute towards net zero by 2050. **CJ**

*Running costs are based on EN 16147 test data and operating assumptions, including (but not limited to) one re-heat per day, cold water inlet 10°C and 45°C water temperature rise. Actual in-use running costs will vary.

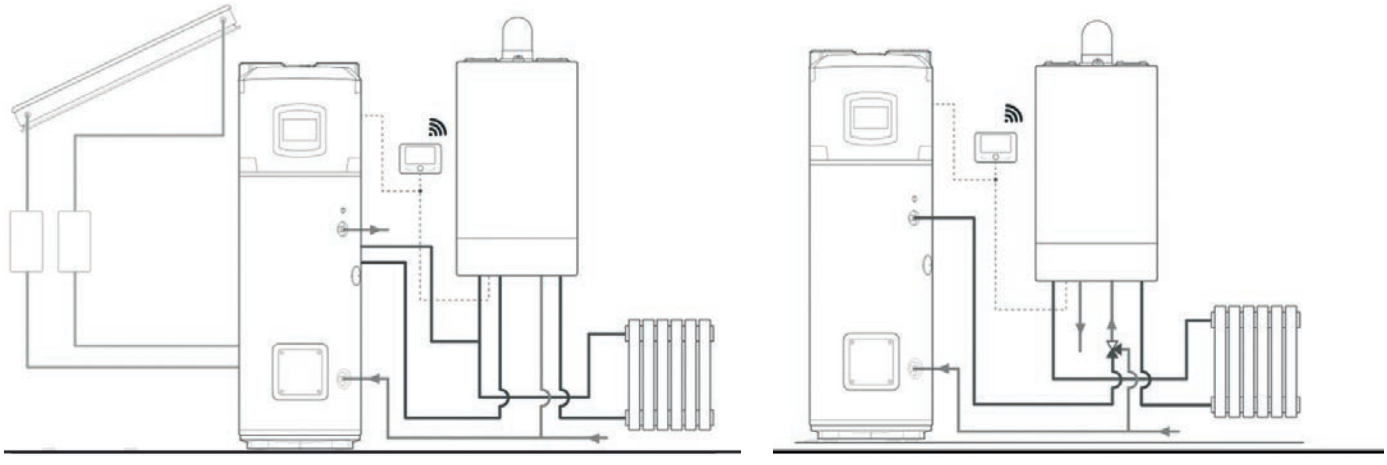

Figure 2: Units with an indirect coil can be connected to other heating products, including solar thermal (left) or gas boilers (right) (Source: Ariston)

Safely towards net zero

Embracing a new safety culture in buildings should not hamper our efforts to deliver carbon neutrality. In fact, it should help, says Lochinvar's Steve Addis

The biggest change to construction practices in half a century is racing towards us with the enactment of the Building Safety Bill later this year. This will introduce such a profound change to manufacturing, planning, procurement, installation, inspection, competence and compliance that many are arguing it will derail our carbon reduction plans.

Delivering a 75% reduction in carbon emissions by 2035 on the road to net zero by 2050 seemed pretty ambitious even before adding the burden of totally revamping the safety culture of an entire industry at the same time.

However, the transformation of building culture in this way should prove exactly what we need to revamp our energy and carbon performance. Poor energy performance is often the most obvious symptom of a building that is not fit for purpose. Making our buildings better will bring benefits all round.

Poor energy performance is often the most obvious symptom of a building not fit for purpose

As well as setting much higher professional competence standards through the new bill, the government has set the tone through its approach to revising our Building Regulations. For example, it has joined up the ventilation and heating targets by running consultations on Parts F and L in tandem. As a result, new homes will have to cut their carbon emissions by 30% and non domestic buildings by 27% to meet the requirements of the revised Part L while, at the same time, tackling poor indoor air quality and overheating.

Expense

Better energy performance must be delivered, but not at the expense of the ventilation rates essential to protect the health and wellbeing of occupants, so making buildings better all round.

These new targets will come into effect next month, with the new regulations regarded as a stepping stone towards the Future Homes and Buildings Standard that aims to make all buildings net zero ready from 2025.

All new residential buildings including care and children s homes, and student accommodation must also be designed to reduce overheating, under changes to Part F and the introduction of Part O.

Changes to ventilation will be introduced to improve indoor air quality and reduce the spread of airborne viruses in new non residential buildings, including the mandating of CO_2 monitors and additional standards for recirculating ventilation systems in all new offices.

The government is proposing three performance metrics against which new non domestic buildings will be measured: primary energy; a CO_2 emission target; and minimum standards for fabric and fixed building services. The introduction of a primary energy metric is designed to make energy efficiency of each building a priority, regardless of the heat source.

There will also be considerable commercial incentives for building owners and managers to do the right thing for their occupants and the planet. For example, more UK developers are adopting the Australian NABERS model because it incentivises whole life performance and, therefore, drives down the life cycle carbon.

We also have Minimum Energy Efficiency Standards (MEES), which could be transformational because they place a regulatory requirement on refurbishment. Since 2018, a minimum Energy Performance Certificate (EPC) rating of E has been in place for new tenancies, but from 1 April 2023, this will be extended to cover existing leases. This will make it unlawful for a landlord to let any commercial property with an EPC rating of less than E. That is just the start, however, as the MEES level is set to rise to B by 2030.

Harmony

This is an example of how regulation can be made to work in harmony with commercial drivers, by setting the legal benchmarks that underpin better performing and, therefore, more financially viable building stock.

The same principle is at work in the government s *Net zero estate playbook*. This sets out advice for public sector organisations and procurers about how they can substantially lower their carbon footprint in line with its policy to deliver a 78% reduction in emissions from government buildings by 2035 as well as deliver value for money for the taxpayer.

The playbook takes a technology neutral approach because it notes that different buildings need different solutions. It urges developers to carry out detailed assessments to ensure they use the right solution for the building in question.

It is a rapidly changing landscape, but the regulatory requirements are moving closer to the commercial drivers, so we are definitely on the right track.

STEVE ADDIS is product manager at Lochinvar
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Meeting seasonal demands with air to water heat pumps

This module considers basic factors that impact the performance of air to water heat pumps, and their potential use with other heat sources to meet building heating demands

There is an inexorable move towards the application of heat pumps, both in the refurbishment of buildings and in new-build projects. This is by no means a universally simple move, particularly where applications might be considered as being outside the effective ranges of widely available heat pumps and, in almost all installations, a bespoke solution will be required.

This CPD will consider the basic factors that impact the performance of air-to-water heat pumps, and provide some examples of combining heat pumps with other heat sources in larger residential and commercial applications that can be successfully applied to legacy systems to meet building heating demands more effectively.

There is practically a limitless source of heat available globally, from the air, water courses, and the ground. The heat pump draws on this massive resource by applying the thermal processes of a 'reverse' heat engine. The classical heat engine, illustrated in Figure 1 (overleaf), uses energy provided in the form of a higher temperature heat source to deliver work, and then exhausts low temperature heat that has not been utilised to deliver work.

To 'reverse' the process of a heat engine, a vapour compression heat pump will apply external work to extract lower grade heat Q_C from a lower temperature source and delivers heat Q_H to a higher temperature output by means of a circulating working fluid, the refrigerant. The work of a compressor will increase the pressure and the temperature of a working fluid by moving (or 'pumping') low temperature heat to a higher temperature output. The performance of heat pumps (to deliver Q_H) is usually characterised by a coefficient of performance (COP) – the number of units of heat delivered per unit work input. A heat pump is subject to the thermodynamic limitations of the heat engine and so the maximum theoretical efficiency (the Carnot efficiency) can be identified from the ratio of absolute temperatures (in K) $T_H/(T_H-T_C)$. In real systems that are subject to inefficiencies, such as friction and radiative heat losses, the achievable COP will likely be under half of this theoretical value. However, the COP_{Carnot} is useful as it can be used to interpret the pro rata impact of varying the relative hot and cold temperatures on the operation of heat pumps. Hence, to operate at a high COP, the heat delivery temperature T_H should be as low as possible and the source temperature T_C as high as possible.

The heat pump cycle may usefully be illustrated using a pressure-enthalpy diagram, as shown in Figure 2 (overleaf). The heat pump system draws in lower temperature heat (for example, from outdoor cool air) at the evaporator (1→2), as the low pressure working fluid (the refrigerant) changes state (evaporates) into a low temperature gas.

The compressor (normally electrically powered) adds work, increasing the pressure and temperature of the refrigerant gas (2→3). The condenser then releases heat to a cooler surrounding fluid (for example, the building's heating medium – typically water) as the superheated gas initially drops in temperature (3→3a) and then condenses (3a→4). Practically, for effective operation of the heat pump, this condenser process typically limits »

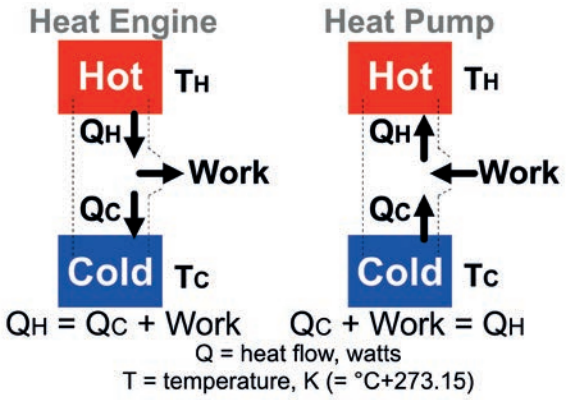

Figure 1: The simplified thermodynamic representation of a heat engine and a heat pump

» the temperature difference in the heating medium flow and return to around 5K.

Finally, the cycle completes as the refrigerant passes through a throttling (or expansion) device (a small orifice) to lower the pressure and temperature of the fluid so creating a cool liquid vapour mix at entry to the evaporator (4→1). (The dotted blue cycle in Figure 2 provides an interpretation of how a real cycle will compare with the theoretical one.) The temperature and pressure of the evaporator and condenser will be determined by temperatures of the heat source and the heating medium that is receiving the heat. As these temperatures diverge, and so the temperature 'lift' increases, the heat pump COP and heat output reduces. If the heat pump is adequately sized, the heat output of the condenser can be controlled by varying the flowrate of refrigerant around the system, either with an on-off, or variable speed compressor.

Typically, the application of air-to-water heat pumps to supply heat for a building will demand the most heat when the outdoor temperatures are low so the temperature lift is highest and COP lowest. The available output from the heat pump will reduce as the outdoor temperature drops. Additionally, as the outdoor air temperature reduces, ice can accumulate on the evaporator if the coil surface temperature drops below 0°C. Water vapour in the air condenses and freezes on the coil surface – this is likely to occur as the outdoor temperature drops below about 6°C and is exacerbated by outdoor air that is more humid. Frosting can reduce the COP by between 15% and 20%[1] and reduce the heating capacity by 40%,[2] not only because of the insulating effect of the ice, but also as a result of the mechanisms needed to remove the ice. As the ice accumulates, heat pump controls will typically sense the change – based on measuring such variables as COP, heat output or air flowrate – to determine when the coil requires de-icing; practically, this is likely to be when the air path through the coil is obscured by approximately 50%. Depending on the manufacturer, de-icing is likely to be provided by one of three different methods. The most common, speediest, and most efficient is to reverse the cycle so that hot gas from the compressor is passed into the evaporator (by way of a reversing valve), so melting the ice. The other two methods are easier and cheaper to implement: the first is to use an electric heater directly on the coil to melt the ice, though this can be costly to operate; and the second is very simple, with the system turning off to let the ice melt – but this is likely to take some time to de-ice the coil. During defrost, the heat pump will not be delivering any heating to the load (and the evaporator fan will be off). Once the unit is free of frost the unit will resume the heating cycle. An effective defrost solution is likely to operate no more than twice an hour and is likely to last in the order of 10 minutes. Some coils have coatings to reduce the potential for icing, and others that employ profiled finned coils – aimed at improving heat transfer – can be more adversely affected by frost accumulation.

Clearly, the output of an air-to-water heat pump will fluctuate significantly not only because of the manufacturer's design but also in relation to outside air temperature (and humidity) and the temperature at which the heat is delivered to the internal load. Methods of determining representative COPs, to more reliably model and compare different systems, are evolving and, most recently, have been drawn together in BS EN 15316-4-2 as discussed in the useful article in the *REHVA Journal* by Johann Zirngibl.[2] BS EN 14511-2 2018[3] provides a set of testing conditions for evaluating the performance of heat pumps at a range of outdoor conditions and delivered temperatures, in an attempt to provide a representative range of operating performance. Manufacturers should be able to provide, at least, the BS EN 14511 values – which relate to 'integrated capacity' that accounts for defrost cycles (as opposed to 'gross' capacity). The methodology of BS EN 14511 can be used to produce a more detailed, hour by hour, model of performance data that is contextualised to the location and application.

Figure 3 provides a simplified summary of the COP of a typical air-to-water heat pump for a London location, related to banded hours of external dry bulb temperature, to meet the heating and domestic hot water (DHW) loads. As suggested by CIBSE AM16,[1] 'where COPs can be provided (by the manufacturer) across a range of ambient temperatures and part-load conditions, this data can be used in combination with the building load profile and local weather data to gain an accurate understanding of heat pump efficiency for a given application in any external ambient condition'.

A buffer vessel is often employed to provide system stability and enable more effective operation of the heat pump (as illustrated in Figure 4). Although smaller than a typical 'thermal store', one of the buffer's primary roles is to provide a store of heated secondary water to reduce the on-off cycling of heat pumps, as it is desirable that compressors cycle no more than three times an hour. The buffer also provides a modest store of heat that during defrost allows the system to continue circulating

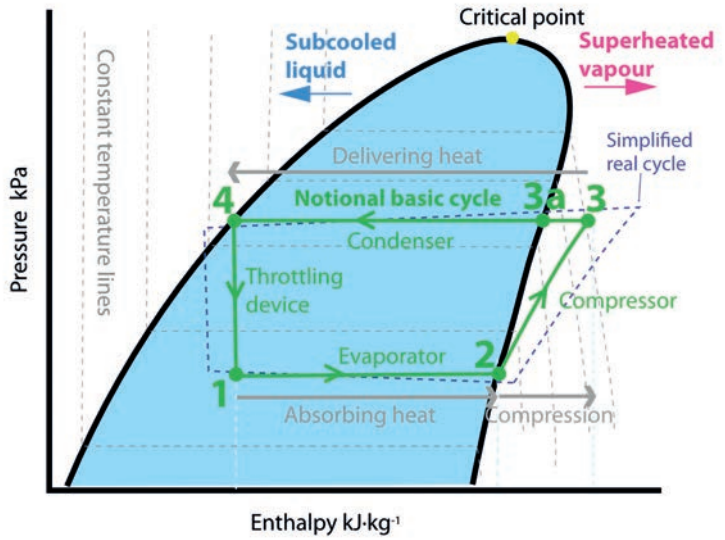

Figure 2: A simplified vapour compression cycle represented on a pressure-enthalpy diagram

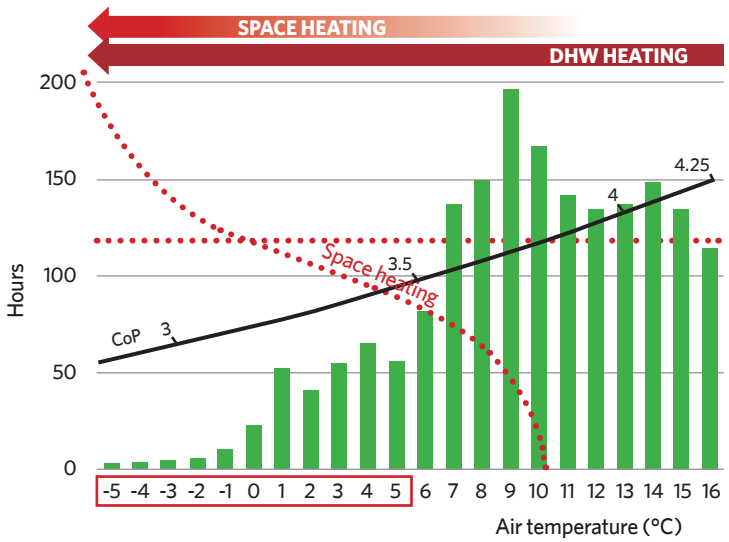

Figure 3: Typical annual air temperature distribution for London versus an example space heating and domestic hot water (DHW) load profile versus heat pump COP (Source: CIBSE AM16: 2021 p17)

heated water. (Thermal stores also may be usefully employed on the load side of systems supplied from heat pumps, as discussed in CIBSE CP1[4] and CIBSE AM16.)

Air-to-water heat pumps may be deliberately undersized, particularly where an existing fossil-fuelled heat source is being retained or there is little or no fabric improvement in a building refurbishment, or where there is little opportunity for increased heating distribution flowrates or greater heat transfer capabilities. It may simply be a design decision that lower capital cost, possibly reduced system embodied carbon, or space constraints makes the case for more than one heat source in what is known as a polyvalent system. An auxiliary heat source could be used for times when loads are uncommonly high or when the COP, and output, of the heat pump reduces at lower outdoor temperatures, or the load increases significantly. In any case, as noted in CIBSE AM16, an air-to-water heat pump that is sized for peak load, at a rarely occurring design heating temperature, will result in a unit that is oversized for the majority of its operational life.

The complementary heat might be provided by, for example, an electrical heating element in a buffer vessel, or an associated gas, oil or electrical boiler, or an alternative renewable source. The heat pump may well have the facility to control operation of the auxiliary heat source so that they work most effectively as a pair. A system with two such sources of heat is known as a bivalent system (as opposed to the monovalent single heat source system). The simplest format is where heat pumps are equipped with a direct electric heating element as backup for unusually cold weather, or possibly as a boost to heat DHW – these are sometimes referred to as monoenergetic systems, as the same heat source, electricity, is used for both. These are particularly suitable for flow temperatures up to heat pump maximum flow temperature and for applications where DHW may be generated by other means.

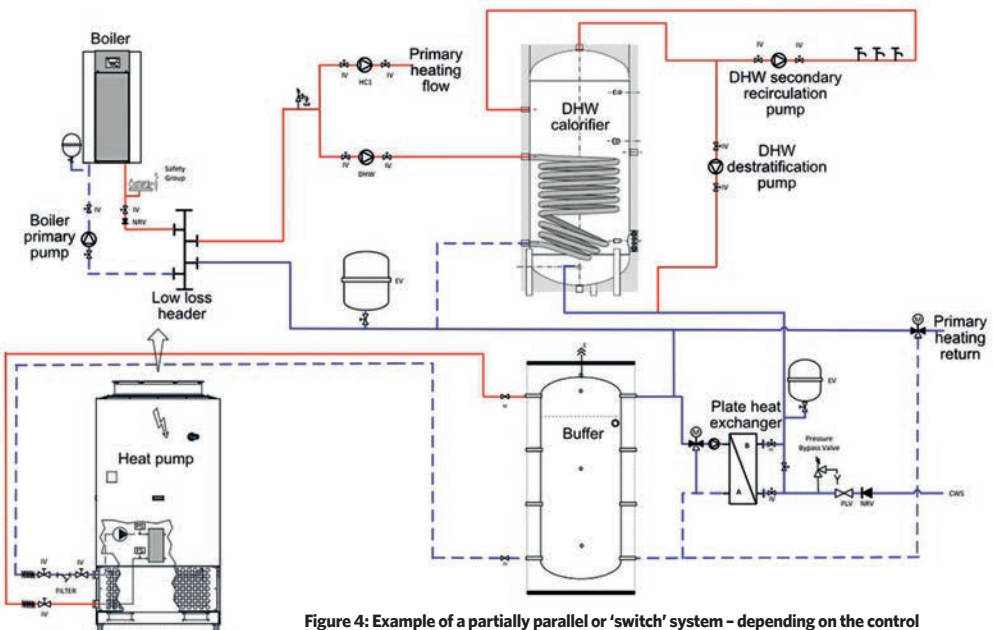

Figure 4: Example of a partially parallel or 'switch' system – depending on the control regime, the boiler can augment the heat pump power output and system flow temperature. This is particularly suitable for application to legacy systems (Source: Elco)

There are a number of bivalent arrangements that may be adopted. The example system in Figure 4 illustrates a second heat source (in this case, a boiler) operating in parallel with the heat pump. The control regime may be set to allow concurrent parallel operation or, potentially, in a 'switch' mode boiler-only operation, and can maintain a higher system flow temperature than would be available from the heat pump alone, or alternatively to deliver a variable flow with a constant temperature matching the heat pump output.

Such a system can be successfully applied for legacy building heating systems with externally compensated flow temperatures with peak design flow temperatures of, for example, 82°C. In winter, when the return temperature is too high to return to the heat pump, the three-way valve on the primary heating return directs all the flow to the boiler header. However, when building heating loads are lower and flow compensation has reduced the flow temperature, the return passes into the heat pump buffer, as the heat pump can make a contribution up to around 60°C. In either case, significant DHW preheating is always available from the heat pump (via the plate heat exchanger).

Since the coldest external temperatures occur for a relatively small number of hours (as shown in Figure 3), heat pumps employing variable speed compressors in such an arrangement as illustrated in Figure 4 are often able to meet the majority of the annual heating load, with the boiler operating for very few hours per year.

Precise assessment of the optimum system arrangement is challenging, particularly in these times of volatile energy supply markets. However, any design must be based on a holistic and individual assessment of the demands of a particular application. This may employ simulation modelling, banded weather data or, potentially, heating degree days, that can then be used to determine the optimum energy – and environmental – solution for a specific application.

Turn to page 60 for references.

Module 196

May 2022

» **1. What is the approximate Carnot COP for a heat pump operating at 50 C and 10 C?**

- ☐ A 2
- ☐ B 4
- ☐ C 6
- ☐ D 8
- ☐ E 10

2. Which point in the illustrated vapour compression cycle will have refrigerant with the greatest superheat?

- ☐ A 1
- ☐ B 2
- ☐ C 3
- ☐ D 3a
- ☐ E 4

3. In the example for London, approximately how many hours per year is the outdoor air temperature at 0 C or below?

- ☐ A 0 to 30 hours
- ☐ B 31 to 60 hours
- ☐ C 61 to 90 hours
- ☐ D 91 to 120 hours
- ☐ E More than 120 hours

4. Which of these is not mentioned as a possible potential driver for a bivalent heating solution?

- ☐ A Load patterns that include exceptionally high loads
- ☐ B Lower capital cost
- ☐ C Heat pump COPs dropping at lower outdoor temperatures
- ☐ D Reduced embodied carbon of system
- ☐ E To allow the heat pump to operate at part load

5. What flow temperature was noted as being readily achievable with the system illustrated in Figure 4?

- ☐ A 30 C
- ☐ B 50 C
- ☐ C 60 C
- ☐ D 65 C
- ☐ E 82 C

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References:

1 CIBSE AM16 *Heat pump installations for multi-unit residential buildings*, CIBSE 2021.
2 BS EN 15316-4-2:2017 *Energy performance of buildings. Method for calculation of system energy requirements and system efficiencies Space heating generation systems, heat pump systems*, BSI 2017.
3 BS EN 14511-2:2018 *Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven – Part 2: Test conditions*, BSI 2018 – currently under review.
4 *CIBSE CP1: Heat networks: Code of Practice for the UK*, CIBSE, 2020.

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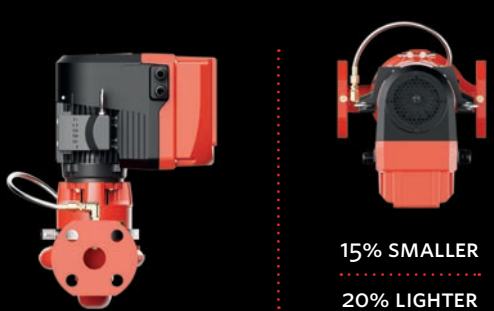

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New EU F-gas regulations spark industry warning

Heat pump roll-out will be slowed by 2027 bans, says trade bodies

Proposed new F-Gas regulations, aimed at accelerating the phase-down of F-Gas refrigerants, risk undermining the EU's own climate goals, according to manufacturers.

The proposed new European Commission regulations are aimed at more stringently controlling the use of F-gases and ozone depleting substances (ODS) in the EU, and the EC claims could help bring about a total reduction in the EU's greenhouse gas (GHG) emissions of 490Mt CO_{2e} by 2050.

The proposed new F-Gas regulation would tighten the quota system for hydrofluorocarbons (HFCs), reducing the potential climate impact of new HFCs coming onto the EU market by 98% between 2015 and 2050.

From 1 January 2027, the proposal is to ban HFCs with GWPs of 150 or more in new split system air conditioners and heat pumps of a rated capacity of up to 12kW.

In the same timeframe, the proposals seek to ban the use of HFCs with a GWP of 750 or more in new split systems with capacities above 12kW.

However, a joint statement from the European Heat Pumps Association, energy and efficiency body EPEE, and contractors' group AREA claims that the EU risks undermining its own goals. The bodies have asked legislators to ensure the F-gas Regulation is compatible with the availability of equipment, lower-GWP refrigerant alternatives and trained engineers to install them.

Women in cooling go global

A new international initiative has been launched by the cooling industry to advance the engagement of women, promote career opportunities, and increase their overall participation in the sector.

The International Network for Women in Cooling (INWIC) was launched in April by a number of international cooling sector associations in conjunction with the UN Environment Programme. Founding partners including ASHRAE and the Institute of Refrigeration.

INWIC aims to address issues including the underrepresentation and visibility of women in refrigeration, air-conditioning, and heat pumps field.

BESA guide focuses on improving IAQ

The Building Engineering Services Association (BESA) has launched Buildings as Safe Havens – a practical guide, the third in its suite of guidance for measuring, monitoring, and improving indoor air quality (IAQ).

The publication is part of a trilogy of guides designed to help building owners and managers turn their buildings into 'safe havens', free from health risks linked to airborne contaminants and viruses.

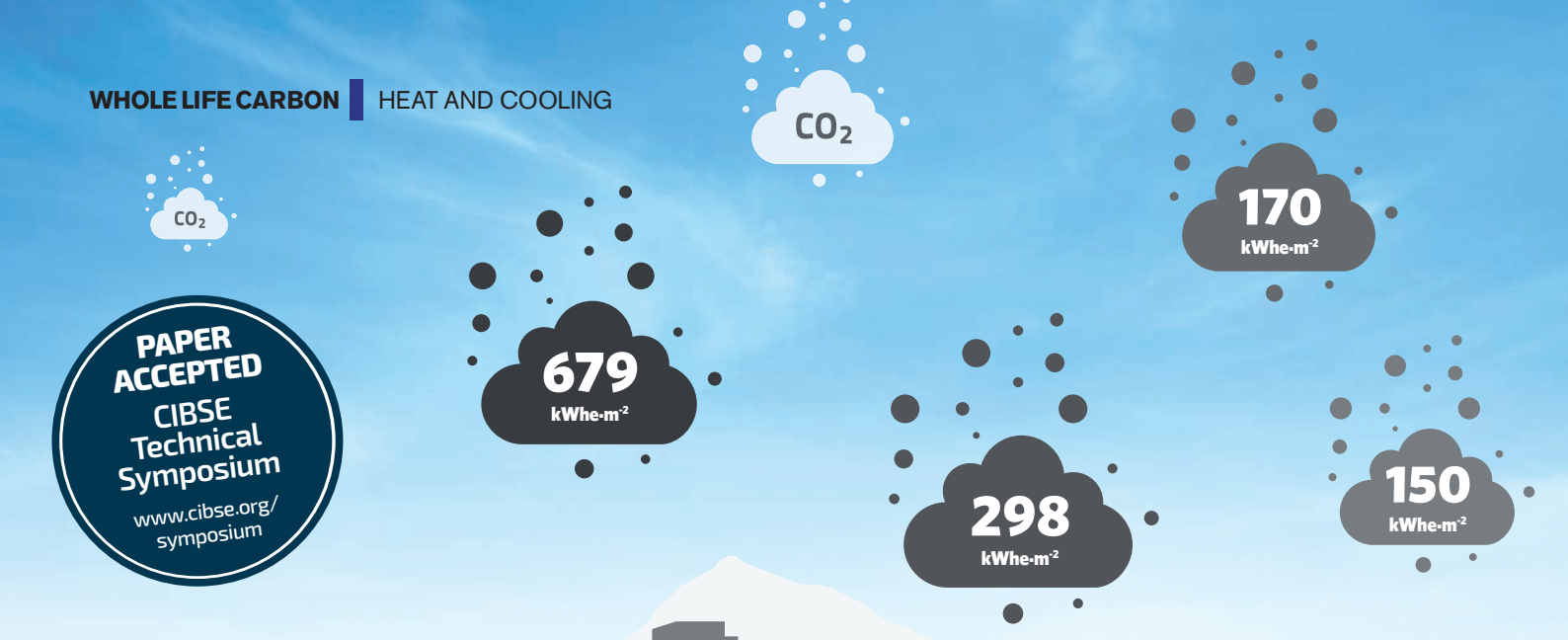
Produced with the support of Mitsubishi Electric, the latest guide offers practical steps that facilities managers and building owners can take to measure IAQ, and provides targeted questions they can put to ventilation experts to establish the right strategy for their building.

For more information and to download the guide, visit **www.theBESA.com/iaq**

Refrigerant guide launched

The Building Engineering Services Association (BESA) and BSRIA have teamed up to produce Refrigerants in Building Services (TG 21/2022), a comprehensive free downloadable guide for the use of refrigerant gases in building services. The guide has been created to help consultants, specifiers, facilities and project managers, installers and end users deal with a period of considerable change for the industry as legislation and tightening environmental and performance targets combine to increase restrictions on how refrigerants are used and what gases will be allowed in the future.

To download the guide, visit **bit.ly/CJMay22AC1**



COUNTING WHOLE LIFE CARBON

To minimise carbon emissions from heating and cooling, the whole life of a system must be taken into account. Hoare Lea s Will Belfield and Mathew Stark compare three common cooling and heating systems to see which has the lowest impact over a 60 year lifetime

Focus on whole life carbon (WLC) has increased significantly in recent years, with the aim of reducing the environmental impact of the built environment and driving towards net zero carbon.

WLC encompasses the emissions from the operation of the building and the embodied carbon of the materials. Operational energy is generally considered to be well understood and, in recent years, there has been a growing focus on the embodied carbon of a building. Initially, a lot of this was targeted at structural elements, such as the concrete or steel frame, as this typically contributes the largest proportion of embodied carbon emissions. In a net zero carbon future, however, the industry will move away from new builds and towards major refurbishments, so the internal fit out of a project becomes a significant proportion of the embodied carbon.

As an item that is replaced regularly during a building s life, and that is directly linked to operational energy consumption and fugitive emissions (refrigerant leaks and irregular releases), building services can have a major impact on the WLC of a development. The recently released Greater London Authority (GLA) WLC benchmarks for a typical office clearly demonstrate this, with the services accounting for 21% of the total.

Recently, CIBSE published TM65, which made the task of estimating embodied carbon in building services much more accessible. In an effort to contribute to this field, this study quantifies the WLC of three options for typical office heating and cooling systems: air source heat pump (ASHP) four pipe fan coil unit (FCU); variable refrigerant flow (VRF); and hybrid variable refrigerant flow (HVRF) (see panel, Systems in the study).

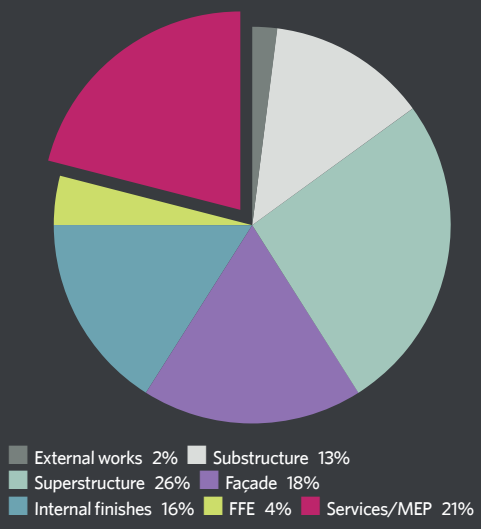


Figure 1: GLA WLC benchmark for typical UK office

The study is based on an eight storey office block comprising two tenancy splits per floor, providing about 12,500m² of commercial office space. For each system, the following items have been included in the scope of

the analysis: central plant (ASHP or external condenser); refrigerant; energy consumption; FCUs; distribution and condensate pipework; pipework suspension, fittings, and insulation; pumps; buffer vessels; branch controllers; and secondary ductwork and grilles.

The operational energy performance of each system has been estimated using IES VE ApacheHVAC software, and the resultant annual energy consumption, in kWh·m^{-2}, is reported for the fans, heating and cooling equipment, and pumps in Figure 2. For reference, a gas boiler baseline scenario has been modelled. The study concluded that the VRF system is the most efficient of the three, at 21.5kWh·m^{-2}, then the HVRF at 23.0kWh·m^{-2} and, finally, the ASHP system, at 28.9kWh·m^{-2}, with all showing a reduction over the gas boiler baseline.

In Figure 3, the energy consumption of each system has been converted to carbon emissions, analysed over a 60 year period, by mapping against the Future Energy Scenarios (FES) Steady Progression carbon trajectory. As with the energy consumption, the ASHP performs the worst, with the equivalent emissions being 58kg CO_2e·m^{-2}, compared with 44kg CO_2e·m^{-2} for the VRF system and 47kg CO_2e·m^{-2} for the HVRF system. However, because of each of the systems benefiting from a decarbonising Grid, a significant reduction for all three cases is seen »

As an item that is replaced regularly, building services can have a major impact on the WLC of a development

SYSTEMS IN THE STUDY

Air source heat pump (ASHP) four-pipe fan coil unit (FCU)
ASHPs are mounted at roof level, and low-temperature hot water (LTHW) and chilled water (CHW) pipework is distributed from the roof to each of the office floorplates via risers in the cores. LTHW and CHW pipework is then distributed at high level on each floorplate to FCUs. There are three ASHPs supplying heating and cooling to the whole building in a duty/duty/assist arrangement. The ASHPs contain a much lower charge of refrigerant compared with the variable refrigerant flow (VRF) and hybrid VRF (HVRF) systems, with water distributing heating and cooling.

Variable refrigerant flow (VRF)
The VRF outdoor units are mounted at roof level. Refrigerant pipework routes from the outdoor units, through the tenant risers provided within the cores, to branch controller boxes located in each tenancy at each floor level. Refrigerant pipework is routed at high level from the branch controller connection to each of the VRF FCUs. All of the pipes are charged with refrigerant. Currently, most available VRF systems use R410a, which has a high global warming potential (GWP). At present, there is no direct replacement, or drop in, for R410a, although these are being developed to try to offset future limitations on supply and the corresponding cost increase.

Hybrid variable refrigerant flow (HVRF)
While the backbone is refrigerant, this system differs from a traditional VRF system in that water is used on the floors to feed FCUs. The VRF outdoor units are mounted at roof level. Refrigerant pipework runs from the outdoor units down the tenant risers, and terminates at a hybrid branch controller (HBC) box located in each tenancy at each floor level. The HBC box acts as a heat exchanger, and hot or cold water runs out of it and onto the floor plate, to feed each of the FCUs. R32 refrigerant is typically used between the external condenser units and the HBC boxes serving the zones.

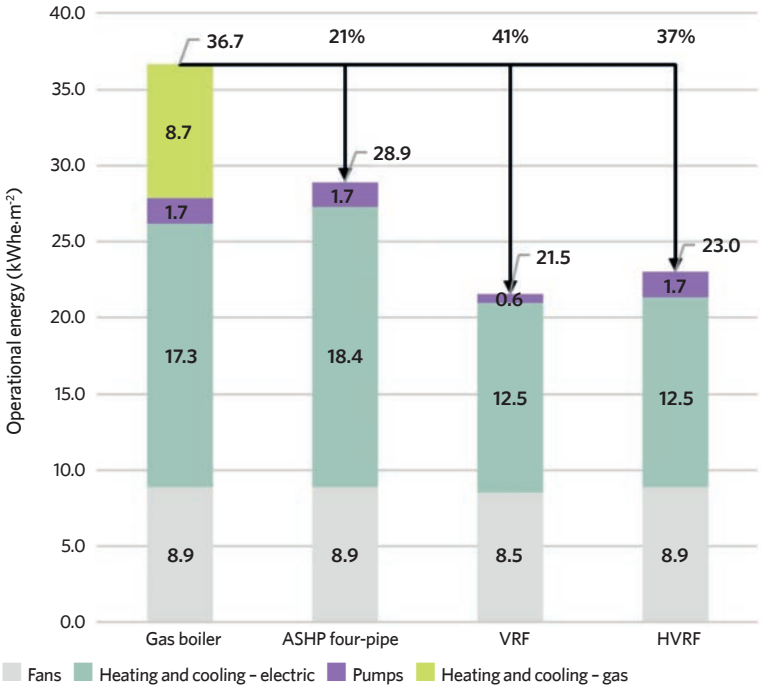


Figure 2: Operational energy consumption (kWhe·m^{-2}). Seasonal efficiencies are: VRF/HVRF – SCOP: 3.4 & SEER: 5.3; ASHP – SCOP: 3.5 & SEER: 5.1; gas boiler and chiller – SCOP: 0.95 & SEER: 5.1. Part-load efficiencies were used in modelling

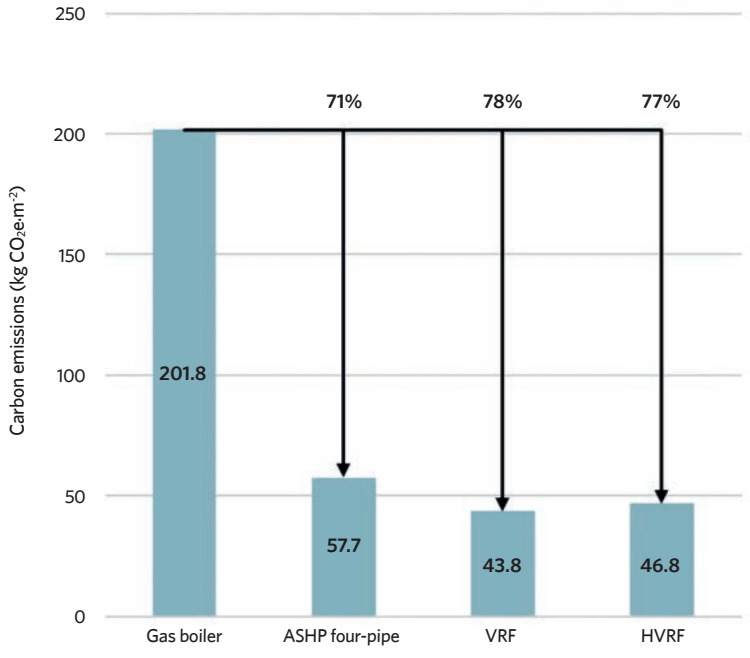


Figure 3: Operational energy anticipated carbon emissions over 60-year period following Future Energy Scenarios Steady Progression

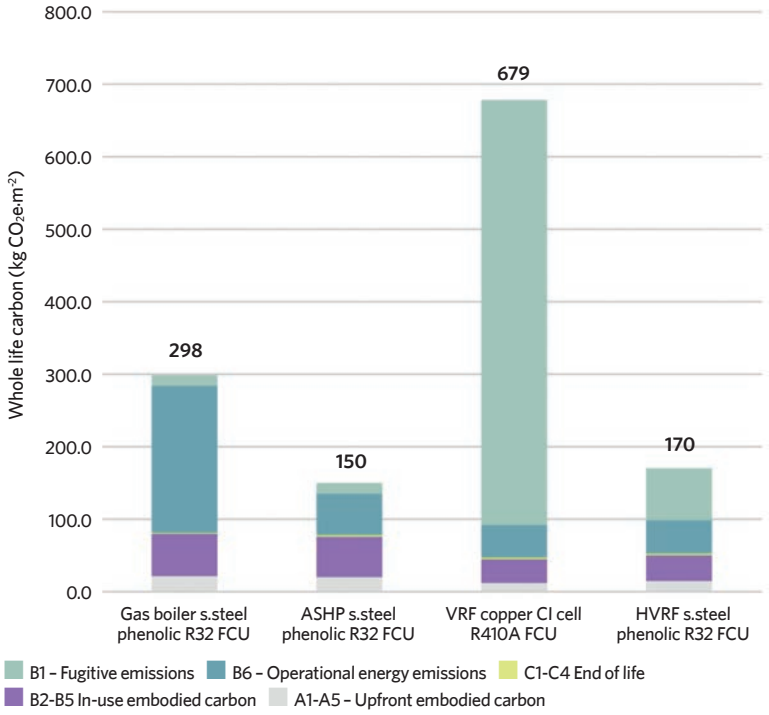


Figure 4: Whole life carbon (WLC) comparison with refrigerant leakage rates as per CIBSE TM65

System	Annual leakage (%)	End of life recovery (%)	Charge (g·m^{-2})
ASHP	2	1	17
VRF	6	3	79
HVRF	6	3	31

Table 1: Refrigerant leakage rates from CIBSE TM65

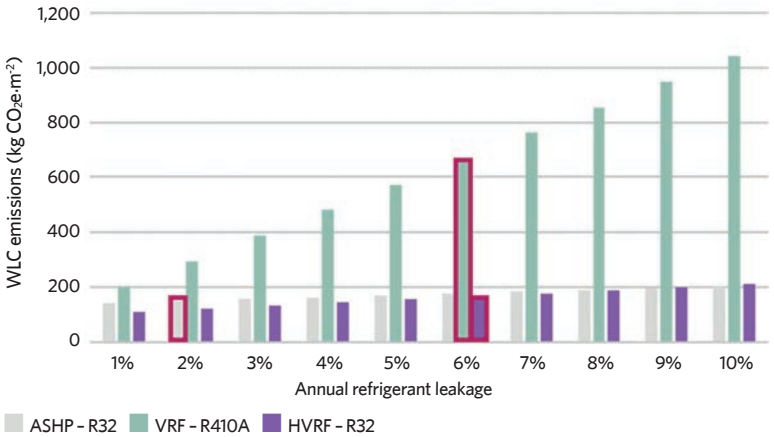


Figure 5: Sensitivity analysis of annual refrigerant leakage rates

Location	ASHP (m^2)	VRF (m^2)	HVRF (m^2)
Roof	109	83	83
On-floor	0	0	48 (2m^2 per tenant)
Riser	32 (2m^2 per tenant)	32 (2m^2 per tenant)	32 (2m^2 per tenant)
Total	141	115	163

Table 2: Plant space requirements

» against the gas boiler baseline, which has a carbon impact of 202kg CO_2e·m^{-2}.

The embodied carbon of the materials/components in each system has been assessed using a combination of Environmental Product Declarations and CIBSE TM65 calculations. The results have been added to the operational energy emissions in Figure 4, representing WLC for each system, with the results split by life cycle modules A C, in line with BS 15978.

The refrigerant leakage (module B1) has been assessed using the leakage rates provided in CIBSE TM65 (see Table 1) and this has a significant impact on the results of the systems, which include refrigerant distribution, particularly VRF. This increases the impact of the VRF to 679kg CO_2e·m^{-2}, making it the worst performing, and more than twice as harmful as the gas boiler equivalent.

When the refrigerant leakage is not accounted for, the operational energy emissions (module B6) for the ASHP, VRF and HVRF systems equate to approximately 50% of the WLC, as opposed to 70% in the case of the gas boiler.

Three main factors contribute to the impact of the refrigerant: the total system charge, the global warming potential (GWP) of the refrigerant, and the leakage rate.

It is the combination of these factors that result in a significant impact on the VRF system when refrigerant is added to calculations. The VRF system has the highest refrigerant charge, it typically uses high GWP refrigerants, and it has a higher leakage rate.

As it is not possible to affect the total charge without changing the system, strategies to reduce the impact must come from influencing the refrigerant GWP and leakage rate. The ASHP and HVRF systems already use refrigerants with a lower GWP, but this is not currently feasible for the VRF system. Such refrigerants are more flammable and, so, not commercially available for use within occupied areas under *BS EN 378 Operational use and safety requirements*. For reference, R32, used with the ASHP and HVRF, has a GWP of 675kg CO_2e·kg^{-1} compared with the R410a s GWP of 2,088kg CO_2e·kg^{-1} in the VRF system.

Figure 5 demonstrates the impact of changing the assumed refrigerant leakage rate with the scenarios as per the CIBSE TM65 recommended rates highlighted. This shows that significant reductions can be realised by reducing the leakage rate of the VRF system, but this has to be reduced to less than 2% for the resultant WLC emissions to be lower than for the gas boiler. It would only be possible for the system to be similar to the ASHP and HVRF if the refrigerant was changed to have a GWP comparable with R32, and limiting the annual leakage rate to below 2%.

In addition to the WLC impact, the study explored other factors that play a part in system selection, including plant space, whole life cost, and thermal comfort.

The plant space required for each system in this case study is show in Table 2. ASHPs require the most space at roof level, largely because of associated pumps and ancillary equipment. VRF and HVRF have the same space requirements in the roof. The riser space required for each system is also comparable, at 2m^2 per tenant and, for the typical building, this totalled 32m^2. In the case of the HVRF, the hybrid branch controller introduces a water based system, which means a Cat 5 water supply a »

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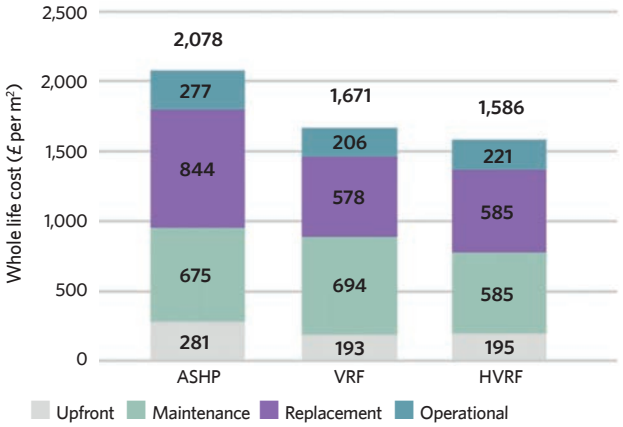

Figure 6: Whole life cost analysis

» fluid representing a serious health hazard that includes the requirement for expansion vessels. This needs dedicated plant space on floors that can be located at high level and results in the HVRF system needing the largest area.

The whole life cost for each system over a 60 year period has been analysed by using a cost (£ per m²) value obtained from similar buildings, and is presented in Figure 6. This shows that the upfront capital cost to install an ASHP system is more expensive than the VRF or HVRF, which are comparable. This remains the case when maintenance, replacement and operational costs are considered, with the HVRF being slightly cheaper than the VRF system. Note, HFCs such as R410a are expected to become more expensive, which will increase maintenance costs.

Historically, water based systems enable closer control of off coil temperatures compared with refrigerant ones, allowing for greater control over room temperatures and thermal comfort. Recent advances have reduced this disparity, however. The closer control is due to water being a more stable heat transfer medium than refrigerant, giving the ASHP four pipe FCU systems an advantage over VRF when we consider occupant comfort.

HVRF aims to solve this problem by providing the function of a four pipe fan coil system and the efficiency of modern VRF in one system, by switching to a water based distribution system on office floors, which results in high sensible cooling and efficient heating. Load capacity control is achieved through inverter driven pumps and flow control valves, which can be built into the hybrid branch controller.

Key conclusions

The global warming impact of refrigerant fugitive emissions can represent a significant proportion of a development s WLC emissions. A standard VRF installation, employing R410a refrigerant, can generate more than twice the emissions of a gas boiler system over a 60 year period. To reduce emissions, industry must focus on minimising the volume of refrigerants, specifying refrigerant with a low GWP; and reducing leakage rate through inspections and maintenance.

The ASHP has the lowest WLC emissions of the three systems, despite performing slightly worse operationally. Plant space, whole life cost and thermal comfort are also important factors when considering system selection. CJ

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TESCO CHECKS OUT HEAT RECOVERY

Retail giant explores waste heat recovery and aims to integrate HVAC systems with refrigeration

Tesco has carried out a decarbonisation study designed to help determine the best future strategy for its estate

Supermarket giant Tesco is exploring how it can use waste heat recovery systems in its stores to reduce energy consumption and its carbon footprint, by increasing use of waste heat from refrigeration/cooling.

Speaking on a Building Engineering Services Association (BESA) webinar in March, Tescos Phil Holzer, the groups refrigeration engineering manager, property UK and group energy and engineering, said that the UKs largest supermarket group would be working to align its HVAC and refrigeration programmes to improve the integration of heat recovery into its stores energy reduction strategy.

Holzer also said that since 2021, Tesco had been fitting heat recovery to its refrigeration plant..

Hosting the webinar *Heat recovery towards net zero: Every little helps at Tesco*, BESAs head of technical, Graeme Fox, said the sector needs to approach projects with a far more collaborative attitude going forward if tomorrows buildings are to be truly carbon neutral .

He pointed out that megawatts of usable heat were currently being rejected from cooling applications every year and much of this could, with a little bit of joined up thinking, be recovered and used to supply heat for heat networks or social housing built near to those non domestic buildings .

Fox called for building services design consultants to work more collaboratively with refrigeration consultants rather than work in silos, to harness more rejected heat and enable us to become carbon neutral.

Holzer outlined Tescos approach to reaching net zero carbon targets in operations by 2035. Although primarily focused around refrigeration, the decarbonisation of our heating systems and the switch to electric heating means we need to consider its integration with our heating and ventilation systems, he explained.

In terms of heating decarbonisation, electrification of heating for Tesco is focused on heat pumps and waste heat recovery from refrigeration. Although Tesco has been using heat recovery in some parts of the business for the past four or five years, Holzer said it had recently carried out a study designed to help determine the best future strategy for its estate.

This study involved building a detailed data model in a heavily modified total equivalent warming impact (TEWI) format. The model uses real world site data including expected heating demand and refrigeration waste heat available in different modes to reflect different load profiles, plus other energy consumption and emissions.

Holzer explained in detail the modelling processes and results they found. The initial research indicated that a lot more study was needed around store heating demand, which Holzer said was likely to be more complex than just store size and location, taking into account building construction, whether we re using cold air retrieval, the ventilation arrangement we ve got .

To explore this further, Tesco has initiated a knowledge transfer partnership with UCL to look at these issues in more detail.

One of the biggest challenges is around the HVAC and refrigeration controls integration, Holzer explained, to ensure the demand for heat recovery is operating more effectively and efficiently.

Ensuring heat pump refrigerant has a low global warming potential was also an issue for Tescos ongoing decarbonisation strategy, Holzer said.

Another challenge is the alignment of HVAC and refrigeration replacement programmes across the estate, which need to go hand in hand but some of which are currently bound by existing policies for service life and write down periods.

To try to help this alignment, we have, since last year, been fitting heat recovery as standard to our refrigeration plant, whether its used or not, effectively making ready for a future boiler replacement and decarbonisation project, Holzer said. CJ

Mitsubishi Electric launches branch controller for hybrid VRF

Heat recovery VRF solution uses water between controller and indoor air conditioning units

Mitsubishi Electric has launched a new City Multi Vertical Hybrid Branch Controller (HBC), a floor-standing system designed for office buildings, schools and other commercial premises that is designed to offer flexibility of design for low-global warming potential (GWP)-refrigerant air conditioning systems.

The two-pipe heat recovery variable refrigerant flow (VRF) solution uses low-GWP R32 refrigerant between the outdoor condensing unit and an indoor vertical HBC. From here, the intelligent system uses water between the HBC and the individual indoor air conditioning units.

The use of R32 is designed to support the F-gas reduction targets, and the use of water between the indoor elements removes the need for leak detection in occupied spaces, in compliance with BS EN378 legislation.

The Vertical HBC is available as a six-port main unit, with new compact eight- or 16-port sub-HBC options. Mitsubishi Electric claims these make the system a much more viable solution for a wider range of applications. Valves, pumps and the heat exchanger are all contained within the Vertical HBC, allowing for phased, modular installation, ensuring that the Vertical HBC is suitable for Cat A to Cat B applications and easing maintenance regimes, the manufacturer says.

The vertical branch controller

According to Mitsubishi Electric, an overall system can be expanded using additional horizontal sub-HBCs, allowing up to 50 indoor units to be supplied by one outdoor condenser.

'There's an ongoing focus on energy efficiency in commercial buildings and increasingly stringent regulations around carbon emissions, as well as the use of refrigerants in occupied spaces,' says Jobin Varghese, product manager for HVRF at Mitsubishi Electric. 'The City Multi Vertical HBC can help future-proof buildings to meet energy standards both now and in years to come.'

● For more information, visit: **bit.ly/CJMay22AC2**

Blinds cannot be used in the dynamic thermal modelling method of compliance

DESIGNING OUT OVERHEATING

Approved Document O was published in December, and is aimed at reducing overheating risk in new residential buildings. Inkling s **Susie Diamond** says the new regulations have significant implications for the design of such buildings, including homes, student accommodation and care homes

The new Building Regulations on overheating, Approved Document (AD) O, are a good idea. The Climate Change Committee (CCC) recommended that the government introduce legislation to tackle overheating risk in new homes because of concern over the rising number of heat related deaths.[1]

Many new homes do not pose a significant overheating risk, but features such as large glazing areas and windows with limited openings (or barriers that discourage their use, such as noise), lack of cross ventilation, and locations in warmer parts of the country and within urban heat islands can, together, produce significant summer discomfort. Our warming climate increases the urgency with which we need to address this.

Part O presents two methods for compliance: a simplified method, intended to be quicker and easier to use, but that is more prescriptive, and another, more flexible route that requires dynamic thermal modelling.

The simplified method

The focus within the simplified method is on glazing areas, free areas (the openings created when windows are open), availability of cross ventilation, and location (within England). Mechanical cooling is, ostensibly, discouraged, with a clear preference stated for passive design measures, although there is no firm requirement that restricts it.

What to watch for

The simplified method is not as simple as it first appears; it requires a lot of measuring and detailed calculation. The thresholds are challenging to meet and small adjustments can alter the result significantly. This is particularly the case for units in higher risk locations, such as large areas of London, or in moderate risk locations for units with predominantly west facing glazing.

Evaluating the free area requirements is also not as easy as it seems. Appendix D provides guidance, offering look up tables of values based on window opening dimensions and angle, or a link to download the ClassCool spreadsheet, which was developed for schools and provides »

» a bespoke calculation, but assumes top hung windows where the AD assumes side hung, which adds to the confusion. Also note that it is the equivalent area values that must be used from ClassCool, not the free area values, as might easily be assumed.

It will be important to complete a Part O assessment pre planning, while window dimensions can still be readily altered, but the calculation requires more detail opening mechanisms and free areas, frame dimensions, and so on than is generally known at this design stage.

In high risk locations, glazing limits are generally the same or lower (except, oddly, in west facing homes with cross ventilation), and you have to apply shading. In moderate risk locations, you don t have to provide shading, but it would add flexibility if this option were factored in.

The dynamic thermal modelling route

This essentially follows CIBSE TM59[2], but with some important changes:

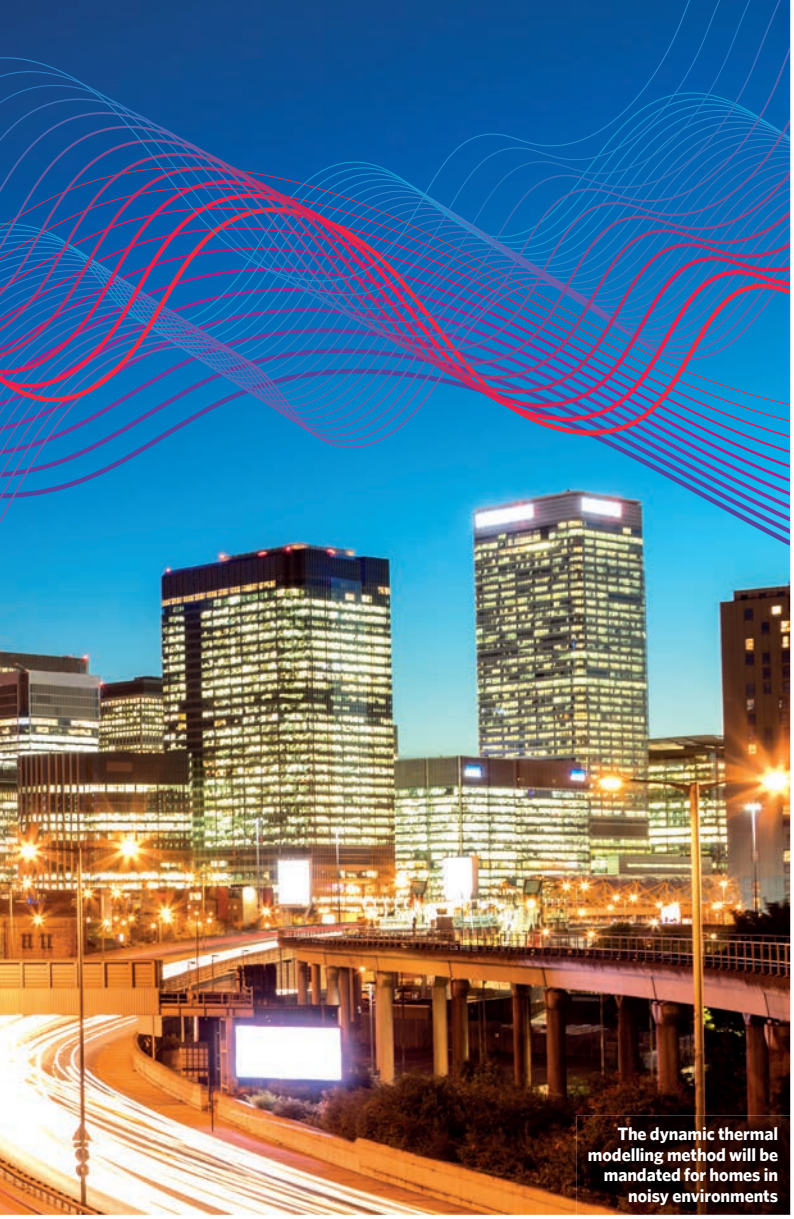
- Internal blinds are not to be included in the model: this will make it more challenging to gain compliance an odd move, as most occupiers will put up some form of blinds or curtains in most windows for privacy, as well as shading/glare control.
- The rate at which windows are assumed to open is explicitly set, starting at 22 C and with maximum opening not reached until inside temperatures exceed 26 C. This is slower than many modellers have previously assumed and, again, will make compliance slightly more challenging.
- Bedroom windows (if they are secure) are required to be left fully open all night if bedroom temperatures exceed 23 C at 11pm, and closed all night if not. This is not a feature that most modelling tools can support, but there are scripts and workarounds to make this possible, and the software companies have promised updates soon. It s not clear what impact this change will have on results, but our initial tests at Inkling suggest this might lower the overheating risk predicted compared with results using the TM59 protocol, which would close windows below internal temperatures of 22 C.
- There is no advice given on how to select a sample set of units to include in a modelling assessment. The Department for Levelling Up, Housing and Communities says this is up to building control.

There is no rationale given for deviating from TM59, as it was published by CIBSE, and it could lead to confusion, with the modelling methodology split between two documents.

This route requires dynamic thermal modelling software and an experienced modeller, so will incur higher assessment costs than the simplified route, but may, in some cases, allow more cost effective design options.

Which of the two compliance routes you follow is up to you, unless your project features any of the following, in which case you must use the dynamic thermal modelling route:

- A communal heating or hot water system with significant amounts of horizontal distribution routes
- A mechanical cooling system



The dynamic thermal modelling method will be mandated for homes in noisy environments

It will be important to complete a Part O assessment pre planning but the calculation requires more detail than is generally known at this design stage

- External noise levels at night that are too high to rely on openable windows.

Noise

The acoustic limits set for bedrooms during sleeping hours seem appropriate, but estimates suggest that (very approximately) at least a third of existing UK homes would not meet them, particularly those in cities or near busy roads.

There is no practical guidance given on how measurements should be taken, including minimum time periods and sampling rates; this could have significant implications for the reliability of assessments. Also, there is no distinction made between different noise sources: birdsong, road traffic, high winds, and so on.

There are significant implications for a site if the noise levels are evaluated to be above the thresholds set. First, the dynamic thermal modelling method will be mandated. Second, there is the impact of not being able to rely on opening windows for passive cooling.

The AD states a preference for passive approaches, but once natural ventilation solutions are ruled out, mechanical ventilation will be needed. This triggers a change in criteria within TM59 from those for homes predominantly mechanically ventilated , which no longer uses adaptive thermal comfort and, instead, requires rooms not to exceed a fixed threshold of 26 C for more than 3% of occupied hours.

There are London weather files that do not meet this requirement (on external air temperature) and, therefore, some locations will almost certainly be bumped into mechanical cooling once noise levels are deemed too high.

This will be acceptable to some developers, and well designed and specified systems can be energy efficient. But others, including social landlords, might not welcome the additional maintenance and potential for fuel poverty that mechanical cooling can infer.

It also doesn t feel in the spirit of this new regulation that increased levels of mechanical cooling in homes could be a direct consequence.

In cooler/windier locations it may be possible to meet the acoustic limits by reducing window free areas or using acoustically attenuated vents, and still comply with TM59. This is because purging heat can be achieved effectively with smaller openings, or windows open for shorter periods when it is cooler or windier outside. However, to model windows as openable in the daytime and closed at night in response to noise issues would not currently be permissible within the guidance.

Part O requires higher guarding heights (1,100mm) than those required in Part K, which will mostly mean raised sill heights. In addition, a maximum reach for window handles of 650mm will limit the width of opening panes. This could have a significant impact on glazing design in homes.

Conclusion

Homes built to meet this regulation should be at lower risk of overheating than other recent builds, and the focus on limiting glazing areas and providing generous window openings is the right one. However, that focus is impeded by the complexity and confusion in the detail.

We need to see more clarification, especially around: the acoustic limits and how they should be assessed and acted on; efficient evaluation of window glazing areas and free areas; when mechanical cooling is permissible; and suitable sample unit selection advice.

The Future Homes Hub is working on guidance, including worked examples that should help clarify the assessment process and give good advice on meeting the thresholds for each compliance route in a range of circumstances. It plans to publish by the time this requirement comes into force in June. CJ

SUSIE DIAMOND is a founding partner at Inkling

References:

1 'Overheating buildings will cause thousands of deaths', *CIBSE Journal*, August 2021, **bit.ly/CJMay22SD1**
2 *TM59 Design methodology for the assessment of overheating risk in homes*, **www.cibse.org/knowledge**

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Exploring the benefits of stainless steel in hot water generation and storage

This module considers the factors driving the increase in the application of stainless steel in heating and hot-water plant

Many materials are used in manufacturing of products for generating and storing hot water for heating and domestic hot water (DHW) systems in buildings. This article provides a commentary on the factors that are driving the rise in the selection of stainless steel for the core working elements of heating and hot water plant installed in UK buildings.

The principal factors that decide the suitability of a material for a product are its performance and the total life cycle environmental impact and cost. For gas fired boilers used for heating, as well as dedicated hot water heaters that, in this article, will be referred to collectively as hot water generators, materials have been selected for the heat exchanger with the aim of maximising effective and reliable heat transfer from the gas flame and resulting combustion gases to the water. In common with hot water stores, a key challenge for hot water generators is to maintain long term performance while limiting the risk of corrosion caused by the water and its impurities.

CIBSE Guide G[1] defines corrosion as the reaction of a metal with its environment resulting in damage which impairs the function of a component or system. Depending on the material, oxygen is one of the most important factors when considering corrosion. In closed systems, such as heating circuits, oxygen levels may typically be controlled by limiting fresh make up water or using deaeration devices. DHW systems, however, will necessarily have continually replenished and so oxygenated water. Wet corrosion is the most significant form of corrosion, and occurs by an electrochemical oxidisation reaction that requires the presence of oxygen. For example, steel reacts with the water and oxygen to form hydrated iron(III) oxide rust that, unless prevented, will eventually cause structural failure. The attributes of the water the water quality that is being heated in a water heater, whether for a closed heating system or a DHW system, will directly impact the potential amount of corrosion affecting the materials used in the fabrication of the heater (as well as in the wider distribution system). Water quality will depend on the geographic location of a building, as well as whether the water is supplied from a mains pipe or sourced from a local aquifer.

The hardness of water relates to minerals suspended in the water, such as calcium and magnesium bicarbonates, measured in parts per million (ppm), and is normally related to the geology of the region. Hard water derives from groundwater passing across limestone, chalk and gypsum deposits and is typically designated as a water hardness in excess of 280ppm. Soft water , where hardness is 100ppm or less, is prevalent in areas that are formed of hard igneous rock, such as granite. The pH of water tends to be lower, below pH 6.5, and so acidic, in soft water areas, and hard water is considered as most often having a pH above 8.5, so alkaline, that is also referred to as basic water. Across the UK, groundwater drawn in Scotland, the south west and north west of England, west Wales and most of Northern Ireland is typically soft water.

In hard water areas, the excess minerals in the alkaline water may accumulate as the water is heated and then solidify as scale, which will reduce the performance of heat exchangers and impede the flow of water, as well as interfere with the operation of »

» valves. Such scale can significantly derate the performance of hot water generators, and preventative methods such as water softening may be required.

Acidic water can promote corrosion by developing pitted surfaces. In closed circuit heating systems, corrosion inhibitors are routinely used to limit corrosion, especially if some oxygenation of the system water occurs. Some inhibitors contain anti scaling components, but in hard water areas, the use of water softening may be considered.

A balance of factors, which will be specific to the application and the local water quality, will determine the material that provides the most effective solution taking into account the system requirements during the operational lifetime of the product. The evolution of hot water generators and revolution in hot water stores has seen a variety of metals including copper, cast iron, aluminium, steel and stainless steel that continue to be used today.

Copper, with high thermal conductivity, high ductility and malleability, was an early choice for hot water heaters and in recent years, predominantly for indirect hot water coils and storage vessels such as hot water storage cylinders (calorifiers). Copper will typically develop copper oxide films that will coat its surface and, although protective to corrosion from normal water use, are not true passive layers (like the much thinner layers that form on stainless steel and aluminium). General corrosion of copper only occurs in low pH water (acidic) that should never flow from mains water in the UK.[2] Increasingly, applications of pressurised, unvented hot water systems and larger hot water stores have reduced the application of malleable copper for cylinders.

Cast iron was traditionally the material used in boiler heat transfer surfaces owing to its robust nature and resistance to the impacts of highly sulphurous flue gases produced from burning coal and oil. Cast iron heat exchangers are thick and weighty; however, cast iron is not suitable for condensing applications because of the risk of corrosion from acidic flue gases that means it struggles to meet the modern environmental, spatial and operational requirements of many applications.

Aluminium has been commonly used over the past 50 years for heat exchangers in hot water generators. It is alloyed with other metals that can be cast to produce complex, high thermal conductivity waterways in a heat exchanger block that is lightweight with excellent heat transfer properties.

Aluminium is often employed because of its lower cost, low mass and high efficiency, and the low density of aluminium will typically mean that heat exchangers have a

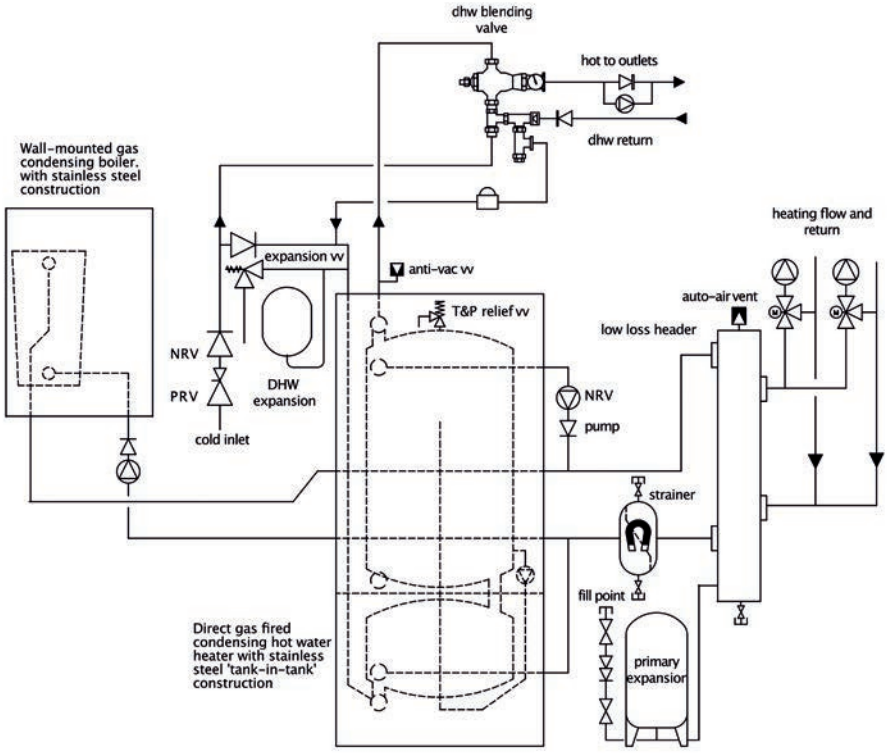


Figure 1: A pipework schematic of an example system utilising a condensing hot-water heater and a condensing boiler, both with stainless steel cylinders and heat exchangers configured to independently supply heating and hot water (Based on schematic provided by ACV)

AUSTENITIC STAINLESS STEEL

Steel – an alloy of iron and carbon – when heated to a liquid molten state, and then cooled and solidified, forms crystals. The gradual formation of crystals can mean that any one type of steel is actually made up of several crystal types as the metal passes through multiple temperature stages,[4] and it is not uncommon for steels to contain a mix of structures. Austenite is created in steel at 912°C, at which point it transitions to a 'face-centred cubic' crystal structure that can absorb up to 2% carbon. The non-magnetic austenitic crystal structure is maintained at ambient temperatures through the inclusion of additives when melting steel alloy. Stainless steel is a generic name for more than 150 carbon steel alloys that have a minimum of 10.5% chromium, each alloy having its own particular properties and applications. Chromium makes stainless steel corrosion resistant by oxidising quickly, forming a thin oxide layer on the metal surface that protects the underlying metal from corrosion. With this thin passive film completely covering the metal surface, the metal is passivised and corrosion is greatly reduced. Common austenitic alloys contain 15–20% chromium together with 6–11% nickel that gives it strength and ductility. 300 series grade stainless steels contain approximately 18% chromium and 10% nickel. Most commonly used grades of stainless steel employed in hot-water generators are 304, 316 and 316L, which have a high level of corrosion resistance, and the ability to shape and form the metal into tanks and detailed heat exchangers. 'L' designates a lower proportion of carbon (not exceeding 0.03%) in its composition, which reduces the risk of carbon precipitation, making it a more appropriate material choice for welding. By adding 2% of molybdenum to type 304L creates type 316L, which has increased resistance to pitting and crevice corrosion in chloride-rich environments, and is typically used in heat exchangers for condensing boilers. The higher alloy-grade stainless steels will be more costly.

Stainless steels perform best under fully aerated or oxidising conditions to maintain their protective film, and so are ideally suited for DHW generators and thermal stores. Any conditions that cause the protective films to break down can result in corrosion rates comparable to those of mild steel. Austenitic stainless steels, at high pressure and temperature, exposed to chloride ions can suffer rapid pitting and initiate intergranular attack and stress corrosion cracking, as discussed on the web resource Corrosionpedia.[5] An example source of such chlorides is inappropriately selected encasing thermal insulation that has become wet.

Some of the earlier applications of stainless steel heat exchangers suffered from corrosion failures at welded points. With the appropriate selection of materials and good welding procedures this can be minimised, as discussed in a useful web article[6] by Kasay Mwiks.

similar embodied energy to steel. To prevent corrosion, water should be maintained at pH 6.5 8.5 (where needed, this can typically be maintained with commonly applied water treatment regimes).

With the increased application of unvented indirect hot water cylinders, larger thermal stores, and direct gas fired, condensing hot water heaters, steel has become a popular choice for hot water heaters, as well as in boiler applications. Steel provides a robust container for hot water but requires a water side glass lining to prevent the water corroding the surface of the steel, as well as where appropriate a fire side glass lining to protect against low pH, high acidity condensate from the flue gases. Although such glass lined tanks are relatively sturdy, it is practically impossible to apply, and maintain, the glass surface coating in a perfect state, so a passive anode rod is typically installed inside the cylinder to provide galvanic cathodic protection against corrosion. The anode, created from a metal such as magnesium having a more negative electrochemical potential than the steel is sacrificially consumed in the process of losing electrons, as the water serves as an electrolyte and the cylinder s steel shell as the cathode.

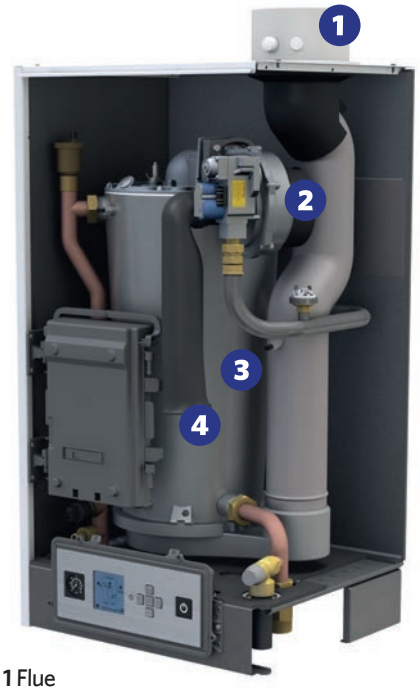
A functioning sacrificial anode will typically last from three to five years but requires regular physical checking and replacing as needed as the rate of deterioration will depend on the actual water quality and flow rate. In hard water areas, sacrificial anodes can function because of high water electrical conductivity caused by ions in the water. Soft water, with fewer electrolyte ions, has lower electrical conductivity, reducing the current from the anode to the cathode, so inhibiting protection. A sacrificial anode applied in these circumstances will provide little or no protection and will appear to remain in excellent condition. However, the steel is potentially at risk and either requires a powered anode or should be substituted with a different cylinder material. The alternative is a non sacrificial electrically powered anode (alternatively known as an impressed current anode) that produces a very low current in the water and provides the same protective effect on the steel shell but without significantly corroding the anode. The electrical anode is often made of titanium, which could potentially last the lifetime of the hot water cylinder. In extreme soft water areas, this system may not have sufficient protective effect, as water conductivity can be low. Electrical anode protection can be capitally expensive because of the device costs and the additional electrical connections required for installation. However, over the product lifetime, it can prove more cost effective than maintaining and replacing sacrificial anodes though to function, it requires a continuous, uninterrupted, power supply. Both methods of cathodic protection will incur a recurring maintenance activity and associated cost to the life cycle of the appliance.

Austenitic stainless steel (see boxout Austenitic stainless steel) does not require cathodic protection in order to prevent corrosion on its surface. As with aluminium, appropriately selected stainless steel is able to withstand the corrosive attack of flue gas condensate and so provides an appropriate material for the cylinder and heat transfer surfaces of condensing gas fired hot water generators.

There tends to be regional preferences for employing stainless steel in soft water areas where glass lined appliances have proven to have a short service life, with

1 Modulating air/gas premix burner with fan
2 Combustion chamber
3 Stainless steel heat exchanger
4 Stainless steel 'tank-in-tank' hot water production tank
5 Indirect water pre-heater

Figure 2: Cutaway of combined gas-fired condensing boiler and water heater with stainless steel heat exchanger. This is applied in the system shown in Figure 1 as a dedicated hot-water heater (Source: ACV)



1 Flue
2 Modulating air/gas premix burner
3 Stainless steel heat exchanger in insulated casing
4 Air intake

Figure 3: High-efficiency wall-mounted gas condensing boiler with up to 75kW output. Stainless steel construction with self cleaning flue ways. This is applied in the system shown in Figure 1 to provide heating

stainless steel recommended up to a more challenging pH 9.5. The ability to withstand harsh operating conditions while providing reliable and consistent performance without the use of galvanic protection can be deduced by manufacturers providing long warranties against corrosion for stainless steel hot water products. Stainless steel hot water generators (such as that shown in Figure 2) and hot water stores are lighter in weight than the equivalent products constructed of the more fragile glass lined steel and so will require less costly handling and installation. Hot water generators and stores that employ stainless steel will typically have a higher capital cost compared with alternatives. The gap in pricing between stainless steel and the equivalent glass lined steel products can vary widely as the prices of raw materials fluctuate, but the difference may be diminishing because of increases in overall production costs.[3]

Stainless steel has relatively low embodied carbon compared with other commonly used materials, and selecting products that are manufactured with high grade, corrosion resistant stainless steel will contribute to their longevity, and so reduce whole life carbon impact. Increasingly, building services product specifications are nominating stainless steel hot water products, as it is perceived to be a safer material because of its resistance to corrosion and its long life span.

Turn to page 80 for references.

Module 195

May 2022

1. What is created when steel reacts with water and oxygen?

- ☐ A Hydrated iron(I) oxide
- ☐ B Hydrated iron(II) oxide
- ☐ C Hydrated iron(III) oxide
- ☐ D Hydrated iron(IIII) oxide
- ☐ E Hydrated iron(IIII) oxide

2. Which of these is most likely to be basic water?

- ☐ A 100ppm hardness
- ☐ B pH 6
- ☐ C pH 7
- ☐ D pH 9
- ☐ E Water drawn from area of granite

3. Which of these statements is most likely true?

- ☐ A An electrically powered anode requires replacement every three to five years
- ☐ B Cathodic protection requires no maintenance
- ☐ C Glass linings reduce the electrochemical corroding reactions
- ☐ D Sacrificial anodes are typically titanium
- ☐ E Soft water has high electrical conductivity

4. What is the approximate minimum amount of chromium required for a steel alloy to be stainless steel?

- ☐ A 6%
- ☐ B 10.5%
- ☐ C 15%
- ☐ D 18%
- ☐ E 20%

5. Which of these is not included in the illustrated combined gas fired condensing boiler and water heater?

- ☐ A Combustion chamber
- ☐ B Impressed current anode
- ☐ C Indirect water pre heater
- ☐ D Modulating air/gas premix burner with fan
- ☐ E Stainless steel tank in tank

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References:

1 CIBSE Guide G *Public health and plumbing engineering*, CIBSE 2014 (rev 2017).
2 *Good Practice Guide No. 120: Avoidance of Corrosion in Plumbing Systems*' NPL 2011.
3 Private communication of opinion from ACV.
4 **www.accu.co.uk/p/112-what-is-the-difference-between-ferritic-austenitic-martensitic-stainless-steels-accu** – accessed 11 April 2022.
5 **www.corrosionpedia.com/definition/1505/chloride-stress-corrosion-cracking-cscc** – accessed 11 April 2022.
6 Mwiks, K, *An Overview of Welded Joint Corrosion: Causes and Prevention Practices.*

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CIBSE.ORG/YEA

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OPEN FOR ENTRIES

The CIBSE Young Engineers Awards are back for 2022, and will take place at RIBA on Tuesday, 11 October.

The awards recognise and celebrate the young engineers making a difference, and the employers who support their growth and development.

This year, we are delighted to share that we will celebrate **27 years** of showcasing determined graduates, **15 years** of identifying the best employers, and **3 years** of exhibiting hard-working apprentices in the industry.

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29 July 2022

Awards categories:

> CIBSE Graduate of the Year

> CIBSE Employer of the Year

> CIBSE Apprentice of the Year

Products of the month

Carrier launches ultra low GWP chiller range for industrial applications

New range is designed to minimise energy consumption while maximising performance

Back in March, the heating and cooling specialist Carrier introduced the AquaForce Vision 30KAV, a new line of compact, high-performance process cooling chillers equipped with ultra-low global warming potential refrigerant R-1234ze. Energy-efficient solutions support Carrier's goal to reduce its customers' carbon footprint by more than one gigaton before 2030.

The 30KAV chiller is optimised for all applications requiring reliable cooling of up to -12°C, including food manufacturing, pharmaceuticals and metal industries. It is designed to minimise energy consumption while maximising performance and ease of installation and maintenance. Available in four sizes, with capacities ranging from 280kW to 1,300kW, the chiller has an ultra-low physical and carbon footprint thanks to its compact design, onboard variable speed drive and Novation micro-channel heat exchangers.

For mission-critical applications such as process cooling and food manufacturing, the 30KAV includes an ultra-fast capacity recovery option, enabling immediate chiller restart following power restoration, with 100% capacity recovery within one minute, which minimises the risk of product damage from shutdown.

All models in the range can also be equipped with a total heat-recovery option that allows more heat to be recovered during the winter, further increasing efficiency and reducing running costs. This option increases heat recovery by 25% at nominal load with 35°C outside air temperature, and by 100% or more with low outside air temperature, compared with the traditional serial-only approach.

The 30KAV has been designed to be quick and easy to install and maintain. Its compact dimensions give ready access in areas where space is tight, while its electrical system ensures compatibility with earthing requirements in different segments.

'The 30KAV has been designed and optimised for use in a wide range of process cooling applications,' says William Doll, European marketing manager for chillers and heat exchangers at Carrier.

'It delivers high seasonal energy efficiency, a low environmental footprint, excellent reliability, safe operation, and a very low total cost of ownership over its lifetime.'

Visit www.carrier.com/commercial/en/eu/products/air conditioning/air cooled chillers/30kavize

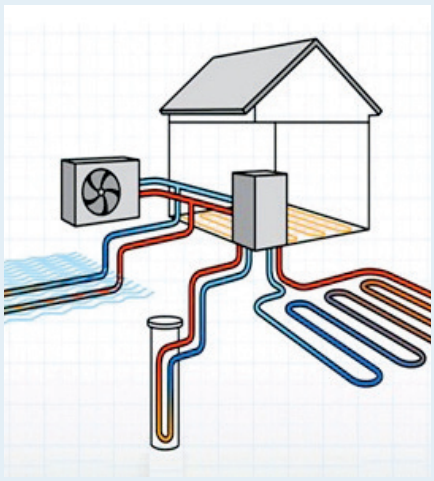
Rinnai adds heat pumps to expanding H3 product list

New carbon calculation service allows customers to identify most effective heating system

Rinnai has expanded its range of low carbon, hydrogen-compatible heating and hot water products to include heat pumps, as well as introducing a carbon calculation service that allows customers to identify the heating system that suits their needs. The Monobloc line of heat pumps is available in an assortment of variants, ranging from 4kW to 110kW.

Rinnai's heat pumps are suitable for both domestic and large-scale commercial hot water applications. They use a cascaded system that enables multiple heat pumps to work in conjunction with one another, which means greater operational performance for large applications. The HPI models omit minimum acoustics via an installed ultra-low sound capability, making them suitable for any area with prohibitive sound legislation.

Rinnai's HPI range operates within compliance of all stringent sound standards, ensuring low-sound functionality. All Rinnai



heat pumps use R32 refrigerants, renowned for reducing electricity consumption by up to 10% and for holding a lower global warming potential (GWP). R32 has a GWP one-third lower than other refrigerants.

Rinnai's HPI heat pump range has an ERP rating of A+++ and can switch between settings of heating, hot water and cooling.

Rinnai's HPI heat pumps, hybrid formations, electrical formats and hydrogen gas-mix powered water heaters are part of the H3 range of products. All new models are designed to embolden decarbonisation, energy efficiency and reduce customer costs.

Rinnai's carbon calculation service considers design from a holistic perspective, taking into account capital expenditure, operational expenditure and carbon savings. The service will compare a customer's current heating system to Rinnai's product list of low-carbon, high-performance heating systems, allowing the customer to see the benefits for themselves. More information can be found on Rinnai's website, on the 'Carbon Calculation service' page.

Rinnai is an international manufacturer of hot-water heaters and heating systems, and designs and produces more than two million units a year. It has an established reputation for high performance, robust cost-efficiency and extended product life-cycles.

For more information on the Rinnai product range or on the carbon calculation service visit www.rinnaiuk.com.

Viega receives seal of approval from Wates Group

Plumbing solutions provider Viega has been awarded Wates Approved Innovation Partner status for its Megapress press-connection technology, and is now a part of the Wates Innovation Network.

Viega's Megapress technology underwent a rigorous approval process that included pitching the solution to a panel of Wates Green Judges. Scott James, managing director at Viega, said: 'We are delighted to be a part of the Wates Innovation Network and are pleased to cement a strong working relationship with Wates.'

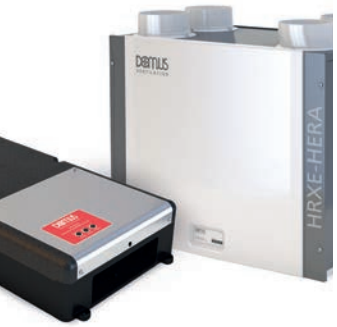
Visit www.wates.co.uk/articles/innovation partners/viega megapress

Aquavent the trusted protection from hydraulic shock

The Aquatech Pressmain Aquavent Automatic Surge Protection Valve successfully removes the cause of hydraulic shock by breaking the vacuum.

Aquavent eliminates the water hammer on boosted water systems, and prevents burst pipes and flood damage. It is built to last, thoroughly tested, WRAS-approved and easy to fit.

For more information, contact sales@aqpm.co.uk or visit www.aquatechpressmain.co.uk



Domus Ventilation exhibits at Specifi events across UK and Ireland in 2022

This year, ventilation solutions provider Domus will be delivering exhibitions at five Specifi Mechanical Services events, which provide a more relaxed alternative to traditional engineering exhibitions. After three successful shows in Bristol, Manchester and Birmingham, Domus will continue to showcase its range at Specifi events across the country.

For more information on Specifi events, or to register for free attendance, go to www.specifi.co.uk.
For more information on Domus Ventilation, go to www.domusventilation.co.uk

Condair welcomes new sales manager

Humidity control specialist Condair has appointed Darren Bryant as its new area sales manager for the south-east of England. Having worked at Condair for 12 years, Bryant is moving on from his previous role of service sales manager.

He said: 'I am very happy to have taken on the area sales manager position. I'm looking forward to getting to know our customers in these regions, and helping them improve their productivity and working environments through enhanced humidity control.'

www.condair.co.uk

Domus MVHR systems installed in Hayes development

Domus Ventilation's HRXE-HERA mechanical ventilation systems have been specified for the be:here Hayes build-to-rent residential project in west London.

Using a built-in heat exchanger, the new units filter and pre-warm waste air extracted from the kitchen and bathroom, meaning up to 95% of waste heat can be recovered.

For more information contact vent.info@domusventilation.co.uk or visit www.domusventilation.co.uk

Trade up on hot water heating

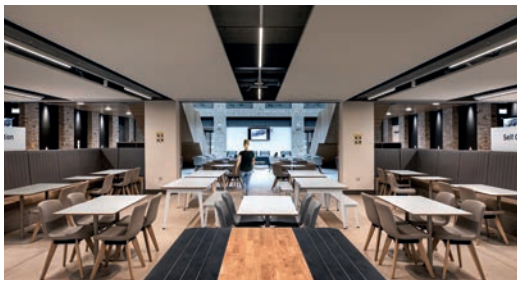
'Like for like' is the assumed replacement when a stored water system comes to the end of its working life. But is it the best option? Replacing an old unit with a new version of the same device can actually involve a large amount of expensive site work and installation.

With its range of cost-effective continuous flow heating systems, Rinnai aims to eliminate this extra work and make replacing a hot water system easier and cheaper.

Most conventional water-storage systems are made of steel lined with glass or enamel, which makes them too heavy and fragile to be moved without specialist equipment. Rinnai's continuous flow heaters are light enough for a one-man lift without compromising on volume.

A typical water storage-based installation costs £5,662.13 per year, whereas a Rinnai continuous flow water system costs £2,736.02.

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



Exciting new venue to enhance experience at Durham University

Zumtobel Group's lighting brands Zumtobel and Thorn have supplied an energy-efficient lighting scheme for Durham University's new Teaching and Learning Centre at the Lower Mountjoy Building, a £40m study space project.

Zumtobel and Thorn have supplied a wide range of internal and external luminaires for the project, providing LED energy efficiency and an excellent working environment.

The brief for the study space required recessed luminaires with good cylindrical and horizontal illumination that could be installed in various ceiling types. Thorn's IQ Wave provided the ideal solution to support comfort and alertness by taking into consideration the variety of functions, forms of communication, and the physical nature of modern learning spaces.

The efficiency of the new luminaires enabled the building to achieve an Energy Performance Certificate of A.

For more information on Zumtobel, please visit www.z.lighting. For Thorn visit www.thornlighting.co.uk.

Sewage pumps for dry well applications ›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In large buildings, such as shopping centres, stadiums, airports, temporary accommodation and government establishments, where it is easier to install a dry-well system rather than a below-ground pumping station, the Jung 1500/2500 range of sewage-lifting stations, from authorised Jung Pumpen distributor Pump Technology, can provide the ideal solution.

The company's team of experts is available to help engineers select the right pump for any project.

For more information, call 0118 9821 555 or visit www.pumptechnology.co.uk and www.jung pumps.co.uk.

Warwickshire pub installs Panasonic nanoe X to improve indoor environment ›

Panasonic has fitted a pub in Warwickshire with its Etherea air conditioning units to create a more pleasant environment. The New Inn, in Norton Lindsey, needed an updated air conditioning system. With the help of air conditioning distributor Oceanair, the pub committee installed a Panasonic Etherea unit with built-in nanoe X technology, which generates hydroxyl radicals to inhibit the growth of pathogens.

Visit www.aircon.panasonic.eu/GB_en

‹ Modutherm boiler range delivers on all levels

Modutherm has just introduced the Genesis FS ULTRA range of gas-condensing boilers. Ideal for schools, offices, retail outlets, hotels and heat networks, the FS ULTRA is available in eight models, with outputs ranging from 334kW to 2,666kW.

The range delivers excellent durability and efficiencies of up to 109%, thanks to a NHEXT stainless steel heat exchanger.

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Visit www.modutherm.co.uk.

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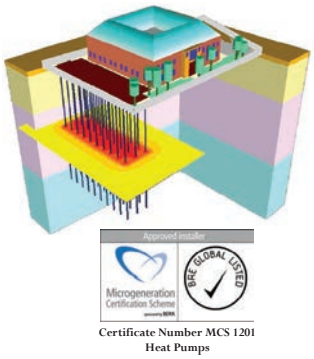

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EVENTS

NATIONAL EVENTS AND CONFERENCES

CIBSE AGM and Presidential Address
5 May
AGM followed by incoming President Kevin Mitchell's address. This will be run as a hybrid event
www.cibse.org/agm

Responsible outdoor lighting at night (ROLAN) conference
12-13 May
This two-day online event will connect research and practice. It aims to facilitate collaboration and the support needed to improve lighting practice and enhance research. The conference will feature 31 international speakers offering insights into their field of expertise.

CIBSE REGIONS AND GROUP EVENTS

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

HCSW: Heat recovery ventilation utilising run around coils
4 May
Seminar targeted at mechanical engineers and anyone interested in the application of ventilation within a hospital. It will give special consideration to Covid-19 and its impact on types of heat-recovery devices and differing heat-recovery efficiencies.

HCNE: General introduction to UPS systems
24 May
This webinar will look at identifying the need for uninterruptible power supplies (UPSs), the basic operation and building blocks of a UPS system, energy storage options, and communication and monitoring options.

CIBSE online application workshop
14 and 21 June
'Bitesize' membership application workshop, to help you prepare to apply for ACIBSE or MCIBSE, with CIBSE interviewers to guide you.

LIVE ONLINE TRAINING COURSES

CIBSE training courses have been reformatted to work online, with a live trainer, meaning you can expect the same interaction and participation as you would in a classroom setting.
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11 May

Energy efficiency related Building Regulations: Part L
11 May

ISO 50001:2018 Energy management system
17 May

Electrical services explained
17-19 May

Air conditioning inspection for buildings
18 May

Energy efficiency related Building Regulations: Part L
18 May

Low Carbon Consultant design
24-26 May

Mechanical services explained
24-26 May

Building services explained
7-9 June

Design of ductwork systems
14 June

Below ground building drainage
15 June

Energy efficiency related Building Regulations: Part L
16 June

Low carbon buildings and energy infrastructure for local authorities
21 June

Air conditioning and cooling systems
22 June

High voltage (11kV) distribution and protection
23 June

Low carbon consultant building operations
28 June – 1 July

Power system harmonics
28 June

Energy efficiency related Building Regulations: Part L
29 June

Energy Savings Opportunity Scheme (ESOS)
29 June

For details and the full programme visit **www.cibse.org/training**

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

CIBSE JOURNAL WEBINARS

26 May Upfurbishment – designing new pump technology into older spaces, sponsored by Grundfos.
CIBSE Journal hosted two webinars in April:
- Building Regulations and Building Safety Bill update, and the role of heat pumps, sponsored by Daikin.
- Space – the first frontier: what affects the space required for emergency generators and how to use it effectively, sponsored by Kohler.

Visit: **www.cibsejournal.com/cpd/webinars**

Membership webinars

CIBSE Membership hosts a free, two-part webinar series to support members with applications for the Associate and Member grades and registration with the Engineering Council at Incorporated Engineer and Chartered Engineer level.

To register for this, and for all other membership webinars: **www.cibse.org/webinars**

Upcoming webinars:
- 10 and 17 May
- 7 and 14 June

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

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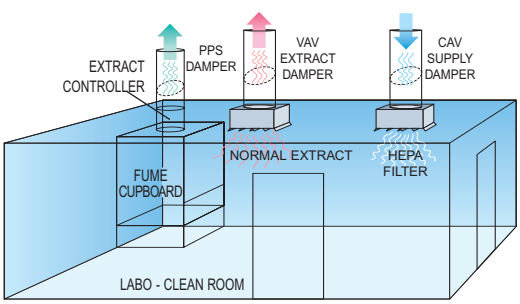

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