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The debate heats up

Low carbon heating is among the toughest challenges when it comes to formulating climate policy, according to the Intergovernmental Panel on Climate Change.

Star Renewable Energy's David Pearson says, on page 16, that part of the answer is heat pumps, which could help decarbonise existing buildings in cities. One of his first projects – a district heating system upgrade in Drammen, Norway – uses a water source heat pump to take low-grade heat from a fjord and turn it into high-grade heat. The key driver, Pearson says, was to move away from biomass and gas.

As Huw Blackwell points out on page 8, however, a move away from fossil fuels for heating is not so straightforward in the UK. Although electricity is getting cleaner, many issues need to be addressed before the industry switches to electric en masse. The costs of direct electric and heat pumps are high, requiring substantial investment in infrastructure and buildings.

We must also take into account whole-life carbon, of which carbon emissions from refrigerant leakage can make up a large proportion, says Clara Bagenal George on page 12.

LIZA YOUNG, DEPUTY EDITOR lyoung@cibsejournal.com

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Boiler control steps forward

As legislation around energy efficiency increases, heating is a natural target for improvement. Replacing old or inefficient plant with higher-efficiency equipment is the starting point – the acknowledged cost-effective solution to energy savings. But implementing a well thought out control strategy is equally important if optimal system performance is to be achieved and maintained.

Commercial boiler plant remains at the heart of heating systems in many non-domestic buildings, whether as the sole supplier of heat or working alongside renewable technology. With condensing boilers now capable of achieving near-maximum efficiency, manufacturers have turned their attention to providing increasingly advanced onboard and optional commercial heating controls.

The latest smart controllers give sophisticated levels of information that can be accessed rapidly via a user-friendly interface and integrated into the BMS for enhanced heating efficiency. Designed for ease of use, the next-generation controls on boilers such as those in our new Quinta Ace range enable faster, more accurate configuration, commissioning, servicing and diagnosis. They also encourage straightforward day-to-day monitoring and use by the building operator.

Ensuring full use is made of boiler controls might seem a small step. But it could lead to big changes in a building's overall energy performance. Improved control will reduce energy demand, for lower operating costs, emissions and life-cycle costs. Better heating control also results in a more comfortable building environment that contributes to improved occupant wellbeing and productivity.

It's a simple but effective solution towards reduced energy demand, and one that can deliver welcome benefits.

PAUL ARNOLD is product manager at Remeha

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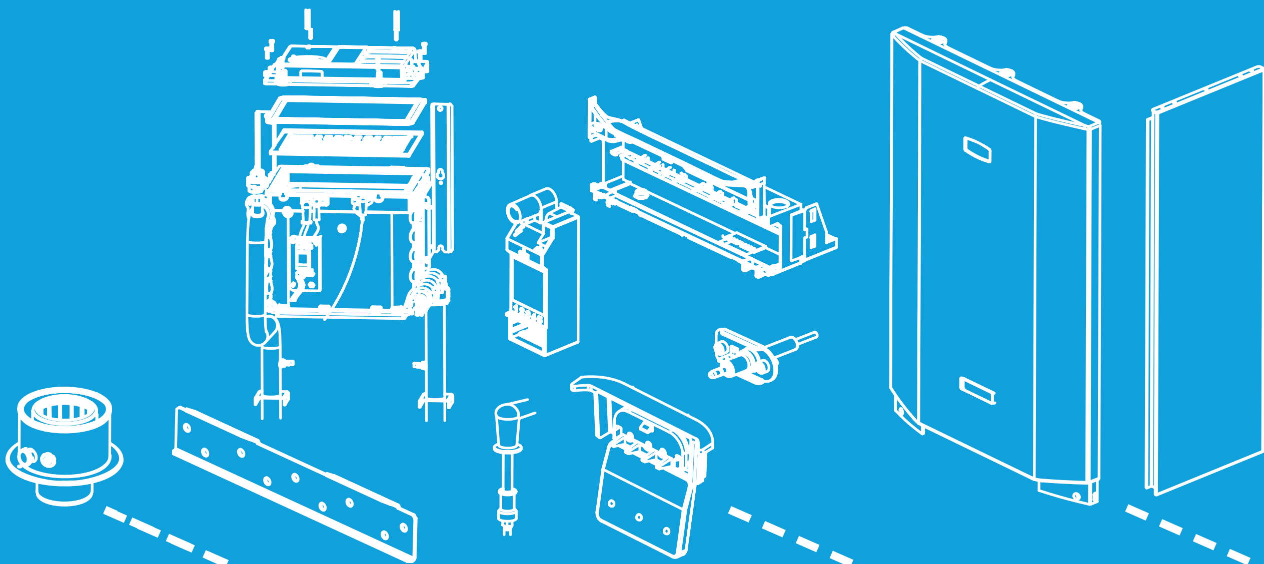

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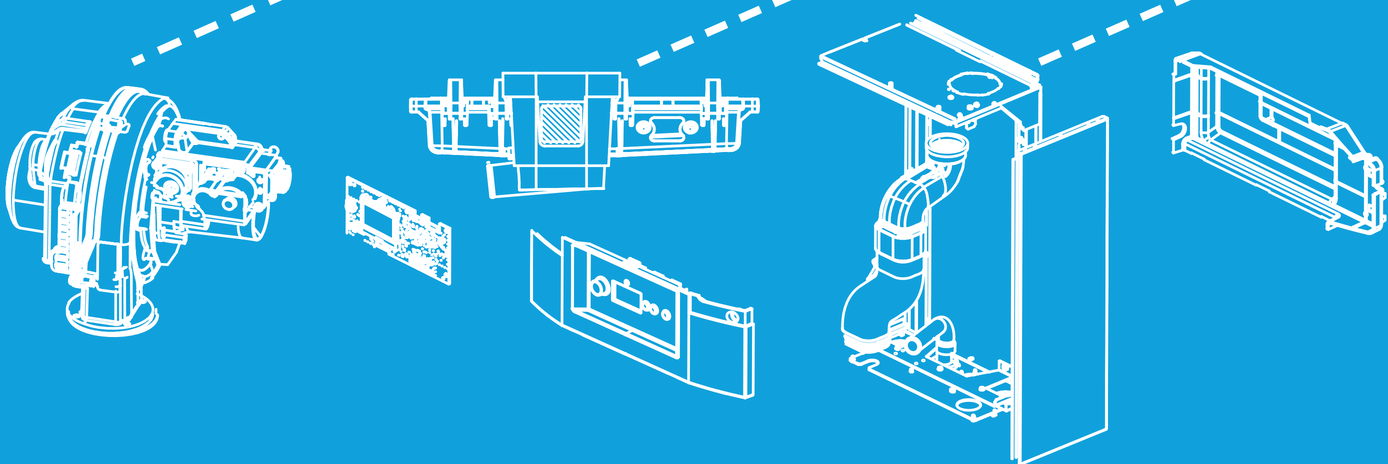

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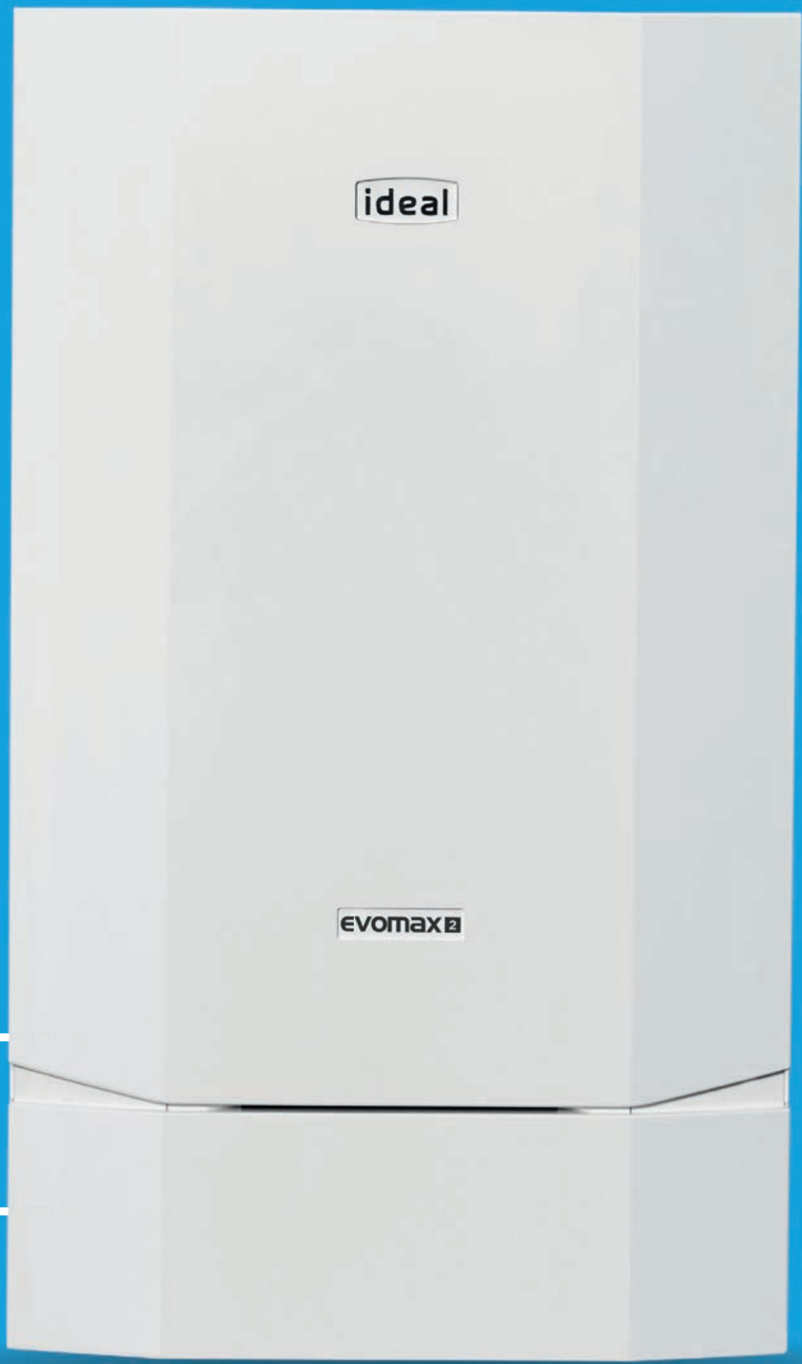

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Fuel cell mCHP boiler may rival heat pumps

Product can cut CO_2 emissions by up to 30%, says manufacturer

Viessmann will launch its new fuel cell micro combined heat and power (mCHP) boiler at this year's Installer 2019 and the All-Energy Show in May.

Vitovalor PT2 will have an Energy-related Product (ErP) rating of A+++, which corresponds to an annual seasonal efficiency of up to 192%, making it an alternative to heat pump systems, the manufacturer has said.

The unit has a 40,000kWh heat load demand, and generates electricity as well as heat. It can generate enough electricity to cover the basic demands of an average household, save up to 40% of household energy consumption and reduce CO_2 emissions by up to 30%, the manufacturer has claimed.

With fully-integrated hydraulics and a footprint of 0.72m^2, the product comes in pre-assembled modules, and includes a 220L integrated stainless steel hot water cylinder, making it more suitable for larger properties.

The unit is available in four heating outputs – 11, 19, 25 and 30kW – and is equipped with a new control platform, which offers faster communications between the end-user, installer and manufacturer.

The unit will be launched on 7-9 May at the Ricoh Arena Coventry, and the All-Energy Show in Glasgow on 15-16 May at SEC Glasgow.

Compressor delivers 15% efficiency

A heat pump, featuring a new compressor, delivers a 15% increase in efficiency, Daikin has claimed.

As well as variable refrigerant temperature and continuous heating during defrost, Daikin says the VRV IV+ system has a redesigned compressor to ensure good performance at part loads – its main operation mode throughout the year.

To avoid refrigerant leaks that can occur during low-load operation from the high-pressure side to the low-pressure side in the compression chamber, resulting in loss of efficiency, the compressor has a back-pressure control port that sends a small amount of high-pressure refrigerant from the compression chamber to the back of the scroll.

This separation of lower- and higher-pressure sides within the compression chamber boosts seasonal efficiency, resulting in a 15% increase in efficiency, according to the manufacturer.

Kenwood Hall hotel upgrade for Vokèra

Six outdated boilers serving rooms, the kitchen, restaurant and public areas at the recently rebranded Mercure Sheffield Kenwood Hall Hotel and Spa (formerly Best Western Plus) have been replaced with three units by Vokèra, through its parent company Riello Group.

The 90kW boilers are installed in a linear cascade configuration, and each boiler can be operateed either as a primary or secondary in the cascade, ensuring constant operation even while being serviced. The units have an optimised stainless steel heat exchanger, with single- or double-coil patented sections and premix burners for high turndown ratio and low emissions, according to the manufacturer.

As well as working with a confined plant room space, specific requirements at Kenwood Hall meant an extended external flue was required to clear the roof.

Heat for Good team delivers rugby club makeover

The Heat for Good collective, including 11 heating engineers from around the UK, has installed a free heating system to the Clayton Rugby League Club in Bradford, West Yorkshire.

Eleven installers gave up their time to fit a combi boiler, with radiators, and a low-loss header, in a 'community kindness' initiative sponsored by Viessmann.

Darren McMahon, marketing director at the firm, said: 'The old heating system was in dire need of replacement; it's something that clubs like Clayton struggle to fund without some help.'

District heating market growth on the horizon

The district energy (DE) market, including district heating and cooling, is projected to grow by almost 5% by 2030 across seven countries covered in a BSRIA study.

The six European DE markets researched by BSRIA in 2018 – France, Germany, Italy, Poland, Russia and the UK – have a district heating and cooling installed capacity of slightly under 250,000MWth, and China alone has 750,000MWth.

The main drivers are that construction players embrace DE for its competitive advantage and financial benefits. If there is sufficient demand and the projected income makes a scheme profitable, the provider will take the necessary steps to create or upgrade a network, said Socrates Christidis, research manager – heating and renewables, at BSRIA's World Market Intelligence Division.

'Closely related to the progress of DE networks and the growing popularity of communal heating systems is the growth of central transfer stations and heat interface units [HIUs],' Christidis said. 'How they perform is central to the overall efficiency of the heat network in a district heating scheme. Overall, there is a healthy growth for HIUs on a pan-European basis of 6-7%.'

Packaged plant room at Hereford Hospital

Hereford Hospital is making use of a fully prefabricated boiler room, manufactured and commissioned on site by Stokvis Energy Systems.

The unit was craned onto a prepared base at the Hereford site of Wye Valley NHS Trust, where old-style ward blocks will be replaced with a new in-patient bedded facility.

The 5x4m steel framed, self-contained plant room features a pair of modulating gas boilers, along with two pressurisation units and a bare plate heat exchanger to provide hydraulic separation for the new plant from the ageing heating mains. The contractor, manufacturer and the mechanical engineering consultants aimed to create a turnkey package, offering both speed of installation on site and future flexibility.

Lee Mason, contract manager at Interserve, said the unit supplies heating and hot water to an existing ward building, which will remain following the demolition of four other buildings, including the plant room that served them, to make way for a new 72-bed block.

'The unit is planned to be in place for two years but, eventually, when the project is complete, there is potential to relocate the boiler room elsewhere,' he added.

Proceed with caution

Lower carbon factors for electricity suggest an imminent move from fossil fuels for heating, but Huw Blackwell says we are not ready to switch en masse

> "Electrification of transport is on an upward trajectory and is competing with buildings for electrical resources"

The vision of the future is clear: heating is going electric. The Intergovernmental Panel on Climate Change (IPCC) says as much, and the fall in average carbon factors below that of gas means it appears to make environmental sense. That's that sorted. No more debates required; let's roll out the heat pumps and brush up on our electrical engineering.

If only it was so straightforward. While electricity is getting cleaner, many complex issues need to be addressed before the industry switches to electric en masse.

The IPCC says heating systems will have to electrify, and states that if we wish to restrict global warming to below 1.5°C, rapid change is required over the next 10 years. The implication is that we need to decarbonise heat now, with technologies already to hand; there is no time to wait for hydrogen, although this may have a role later.

The National Infrastructure Committee (NIC) has investigated what electrifying heat might mean on a macro strategic level. Surprisingly, direct electric and heat pumps come out at broadly similar levels of costs. According to the NIC, the expense of retrofitting energy efficiency measures to allow the use of heat pumps offsets the reduction in grid-reinforcement costs required to run systems using direct electricity.

But the main headline is that the costs of direct electric and heat pumps are high, with both requiring substantial investment in infrastructure and buildings. It is not surprising the IPCC concluded that 'low carbon heating is among the toughest challenges facing climate policy.'

The National Grid has decarbonised faster than anticipated, but is facing local capacity restrictions arising from the rollout of decentralised energy technologies, which are already putting connection costs up.

Bear in mind also that the electrification of transport is on an upward trajectory and is competing with buildings for the same electrical resources.

New refrigerants

Under the Kigali Agreement, traditional HFC refrigerants are being phased out, with limitations on alternative technologies available and, often, additional risks present in the replacement gases. This is naturally impacting on the heat pump market.

There are many pitfalls awaiting the unwary as these changes take place. As new F-Gas regulations prevent the use of refrigerant gases with a global warming potential (GWP) >2,500 post-2020, and drive up the cost of gases with high GWPs <2,500, heat pump technology is changing rapidly.

The HVAC industry is rapidly migrating to R32, but this can only be used in small or external systems because of its flammability. The refrigeration industry is migrating to low-GWP refrigerants such as CO_2, hydrocarbons, hydrofluoroolefins (HFOs), HFO/hydrofluorocarbon (HFC) blends and ammonia, but these bring their own design and operational challenges.

This is not to say these systems are inherently unsafe, but that different and informed design approaches will be needed to manage the risk, with an ongoing requirement for good maintenance of refrigerant and refrigerant-safety systems.

It is easy to see a role for this technology in commercial buildings with a cooling load, but the situation becomes more complex in dense residential deployment. Large-scale heat pumps require novel low-temperature district heating distribution systems and specialised maintenance.

Similarly, if ambient loop heat pumps aren't treated, maintained and run as a coherent system by a single landlord or operator, the risk of a systemic problem (for example, water quality), inadvertent tampering or alteration at an individual residence – leading to wider system issues – is high. Some heat loads may also be just too large to be met from heat pumps, given the available ground or roof area.

Whole-life costs

Some simple 'low regrets' options have been identified by the scientific community. A continued focus on energy efficiency is required in new and existing building stock. New-build must be designed, from the outset, to fit low carbon heating systems within the next 15 years. This will probably mean a continued focus on low-temperature water systems to allow future flexibility in heat supply.

Similarly, low carbon district heating systems in the right geographical locations are needed, but they are not a silver bullet for the wider challenge.

Whole-life cost is likely to be the key issue. The government's electricity price forecast for the National Grid estimates a 12-25% rise in real prices over the next 10 years for residential, service and industrial users.

Any proponent of direct electric heating should bear this in mind when promoting these systems. Also, electrical

HUW BLACKWELL is principal associate at Anthesis Group

infrastructure restraints in some parts of the country – such as the West and South West – are already having material impacts on project feasibility and capital cost

Electrical capacity – future risks

There is no doubt that some spare capacity exists in our distribution systems – for example, in London. But there needs to be careful consideration of how this is used, particularly with the rise of electric vehicles (EVs). Under current rules, a connection may be made to the electrical network for a given fee, provided capacity is available.

However, once significant reinforcement of the local power system is required, the connection or connections driving this pay a proportion of the costs of the local supply reinforcement. These costs can be large, potentially making development unviable – something that is already being seen in some parts of the country.

Furthermore, the balance of costs for reinforcement – that is, the costs not met by the connecting party – are met by the distribution network operator (DNO) and, ultimately, the consumer.

This continues to push up the price of electricity ahead of inflation, with the associated fuel poverty and economic impact of this. These costs may also be large. For example, if upon a new connection a 10MVA transformer needs replacing with a 15MVA unit to reinforce a system, the connecting party pays its share (the 5MVA uplift). However, existing consumers pay for the replacement of their equivalent capacity (the 10MVA).

This leads to a cliff-edge scenario, whereby connections for those who can get them are relatively cheap, up to the current system capacity. However, subsequent connections may be very expensive or have increasingly greater impacts on consumer electricity prices.

There is a risk that if we continue allowing development without strategic foresight, some new projects may absorb local electrical capacity, but once a critical level is met, connections for other electrically heated developments or transportation become too onerous in a given location.

This can affect not only large cities, but also rural towns and settlements where the electrical distribution system is weaker, and fewer alternatives to EVs exist for future personal transportation.

OFGEM and the DNOs are aware of these challenges, but there is a need for wider industry debate as to how these costs will be apportioned fairly in the future, particularly where the driver is new-build electrically heated development. Therefore, it's likely that the capital costs of connection and upgrading local electrical power networks to accommodate heating and transport, as well as traditional loads, will come to dominate future debate and decision-making on low carbon heating system selection.

Building owners, DNOs, operators and service engineers are likely to need to work very closely to understand these interactions, and particularly their long-term cost and maintenance implications.

Improvement by stealth

The benefit of system monitoring is evident at Chichester Festival Theatre, where a change in valve settings produced tangible energy savings. By Jake Piner

If engineered correctly, a building energy management system (BEMS) will control indoor climate dynamically, in a cost-effective manner, ensuring the comfort, safety and wellbeing of occupants. It will only be effective, however, if the performance is maintained once the building is in use. So it is important that operational data is monitored. To demonstrate the benefits of ongoing monitoring, a live building – Chichester Festival Theatre – was chosen as a case study. Operational data was gathered, temperature changes over time were analysed, and potential improvements to the building's energy control system were suggested and implemented.

The theatre consists of a large, 1,300-seater auditorium, backstage area, offices and hospitality space. It underwent a refurbishment in 2014, which included the installation of a modern BEMS that controls and monitors the building's heating, cooling and ventilation plant. The aim was to improve its environmental performance. The installation of an open-source ground source heat pump (GSHP) as the primary heat source reduced reliance on fossil fuels to give comfort control. Gas-fired boilers were installed as a backup, should the GSHP not provide the required amount of heat.

The project studied the low temperature hot water circuit (LTHW), which supplies heating to the whole building, including two large air handling units that heat and ventilate the auditorium. This circuit is primarily pumped from the LTHW stored in the GSHP buffer vessel. Should this buffer vessel fail to reach a setpoint, however, a mixing valve allows the boilers to 'top up' the LTHW circuit to a second – higher – setpoint. The schematic is provided opposite.

The primary focus of this study was to improve the use of the GSHP and reduce the reliance on gas-fired boilers. Understanding this reliance involved monitoring the boiler blending valve. Figure 1 demonstrates how the blending valve is required to 'top up' the heat delivered to the LTHW circuit, opening 100% for considerable amounts of time.

Observation showed the buffer vessel temperature – and, consequently, the flow temperature – was dropping well below the setpoint (45°C) before the valve was operating to bring it back up. This is reinforced by the CT flow temperature varying between 35°C and

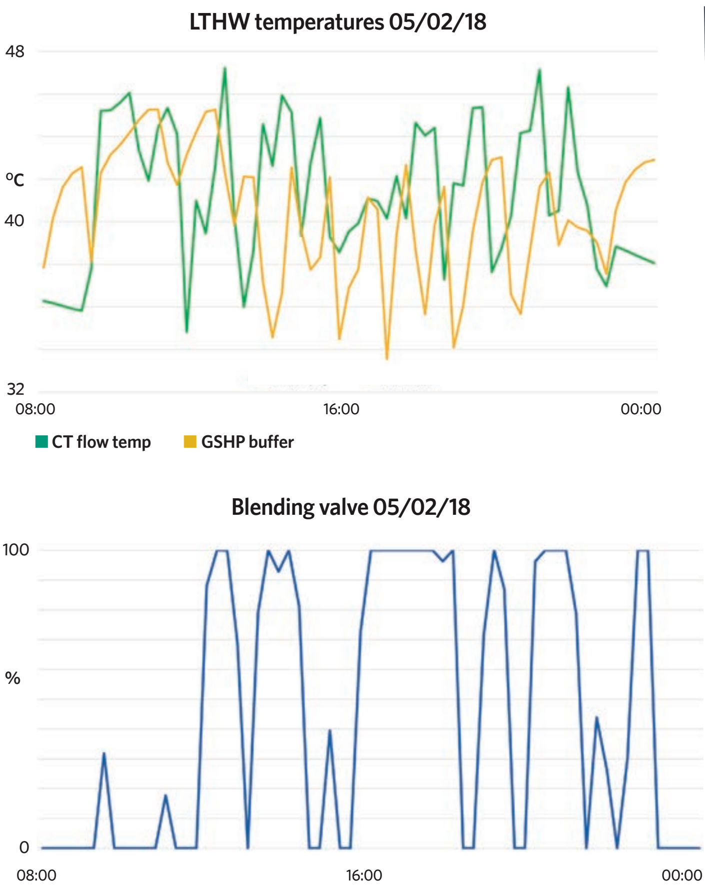


Figure 1: LTHW temperature and blending valve operation on 05/02/18

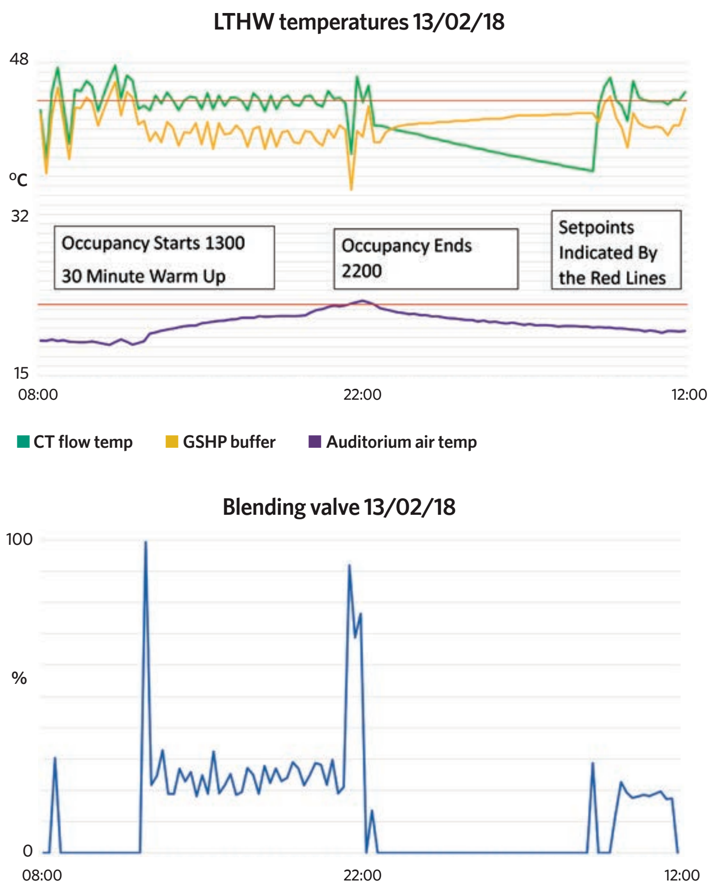
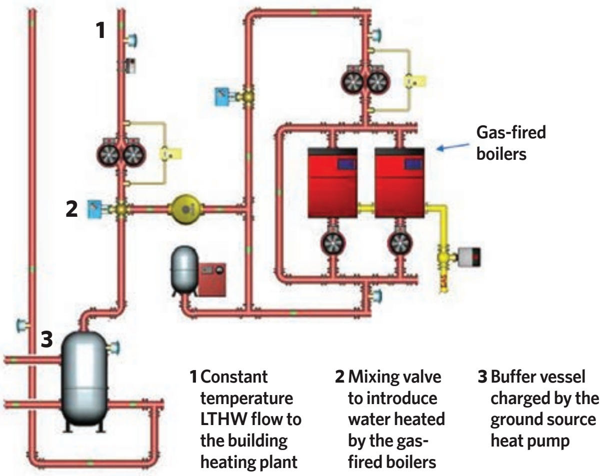


Figure 2: LTHW temperature and blending valve operation on 13/02/18

LTHW plant schematic



1 Constant temperature LTHW flow to the building heating plant

2 Mixing valve to introduce water heated by the gas-fired boilers

3 Buffer vessel charged by the ground source heat pump

47°C. The temperature drop-off is caused by the demand for heat not being met by the heat pump. Such a large drop is a result of the delay in the top-up valve opening. When it does open, it uses a considerable amount of heat from the boilers to 'shock' the system back to setpoint. As a result, it was overshooting the required 45°C setpoint. A significant amount of energy will be required to react to the large temperature change required.

System adjustments

1. Reduce the time taken for the valve to react to a temperature drop-off from 15 to five minutes. The temperature setpoint for this action would remain at 42°C, but the quicker reaction would mean the effect on the system temperature would be less.
2. Reduce the setpoint for LTHW flow temperature (the catch) to 44°C. The setpoint for the GSHP to generate water at 45°C would remain the same.

The results of these changes can be seen in Figure 2. This demonstrates that the control of the heating circuit stayed closer to the setpoint of 44°C, with a reduction in the peaks above the setpoint and the large temperature troughs previously seen. With the valve staying open at around 20-30% all day, the efficiency of the demand upon the boilers has greatly improved. Any reduction in heat use from the boilers is a direct saving. The outside air temperature and building occupancy pattern were similar on both the days studied.

Conclusions

A notable steadying of the heating circuit control was achieved, with the large peaks and troughs replaced by a steady variation around the flow temperature setpoint. This project investigated a comparatively small part of a building with a complex BEMS. It has, however, highlighted how small, targeted improvements to a control system can lead to tangible energy savings. **CJ**

■ This paper, presented as a poster at the Technical Symposium, was part of **Jake Piner's** degree dissertation at the University of Portsmouth, which won the CIBSE Undergraduate Award in 2018.

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The meaning of life

Whole-life carbon in the selection of heat-generation equipment

As electricity generation reduces its carbon intensity, embodied carbon represents a higher proportion of whole-life carbon. Clara Bagenal George's study, summarised at last month's CIBSE Technical Symposium, considers the implications for building services

Since the early 2000s, Building Regulations and local, national and EU policy has shifted our attention away from energy cost to operational carbon emissions. These continue to fall because of measures to reduce demand, increase efficiency and optimise operation.

Transitional technologies, such as combined heat and power (CHP), have been central to our industry's efforts to reduce the climate-change impacts of heating systems. As the UK's electricity Grid continues to decarbonise, however, CHP units no longer deliver operational carbon reductions and, in fact, pose a threat to urban air quality.

Building Regulations and energy policies in our cities are poised to promote the large-scale adoption of all-electric systems, most notably heat pumps. This significant shift deserves scrutiny and requires new tools if we are to avoid repeating the well-intentioned mistakes of the past and future-proof our decision-making today.

Whole-life carbon (WLC) offers a powerful way to understand and compare climate-change impacts of building systems, which includes embodied-carbon impacts from manufacture to installation and operation.

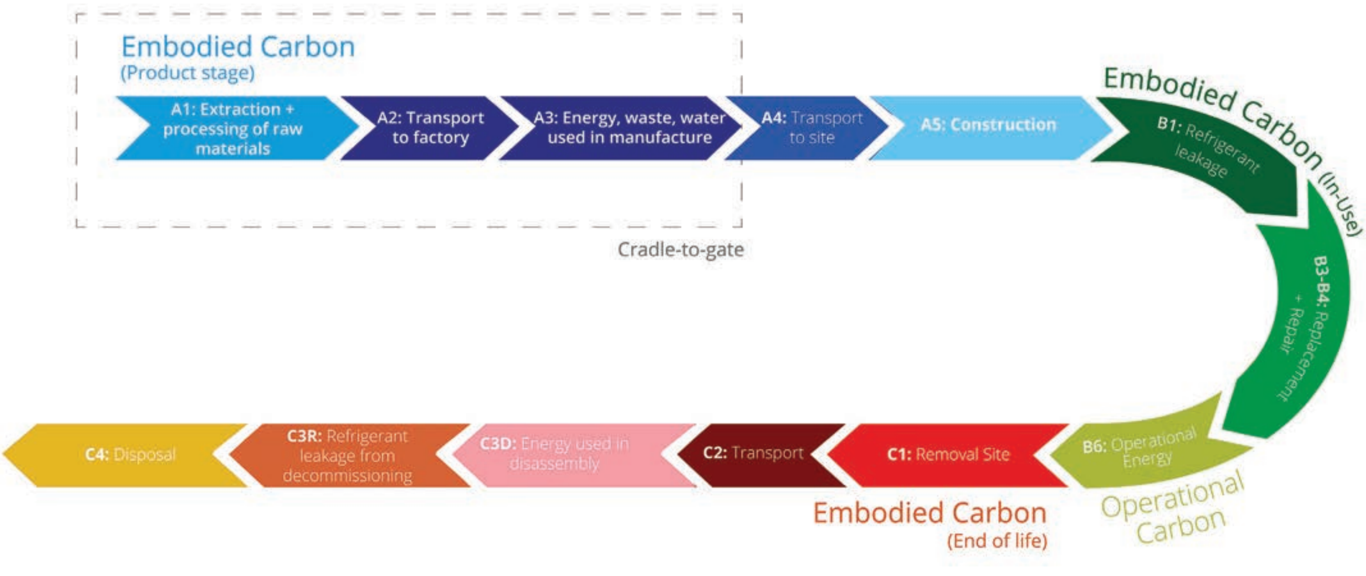
Our study provides a starting point for investigation into the WLC of building services. It investigates the WLC of four types of heat-generation equipment: natural gas boiler, natural gas-fired CHP, air source heat pump (ASHP), and variable refrigerant flow systems (VRF). As part of the study, primary data was collected from manufacturers of 27 heat-generation units.

Operational energy is the largest contributing component of WLC across a 20-year horizon for the majority of the scenarios investigated. Irrespective of systems selection, effective passive design-efficiency measures, to reduce heat demand, and appropriate plant sizing, remain key.

For ASHP and VRF systems, carbon emissions from refrigerant leakage can make up a large proportion of WLC. This is because of the global warming potential (GWP) of the most commonly used refrigerants. In some scenarios, refrigerant leakage could have a higher impact than operational carbon emissions, and the

"Whole-life carbon offers a powerful way to compare climate-change impacts of building systems"

Figure 1: The three stages of embodied carbon – product, in-use, and end of life



WLC impact of ASHP can become similar to gas boilers (see lighter banded bars in Figure 2 [2019]). The Kigali amendment to the Montreal protocol came into force on 1 January 2019. It is supported by F-Gas Regulations, which, among other measures, will ban GWP over 2,500 in new stationary refrigeration equipment from January 2020.

The effect will be to dramatically reduce the global warming impact of refrigerant leakage. In installations after 2022, ASHP and VRF should now have significantly lower WLC than natural gas boilers or CHP (see darker banded bars in Figure 2 [2022]).

The results of this study are very dependent on the electricity grid-carbon factors used. Figure 3 shows how the WLC of the heat-generation equipment changes with varying carbon factors.

This could be used to understand the relative WLC of heat-generation equipment in different countries or at different points in the future.

The study found that the WLC reduction measures that have the biggest impact are:

- Refrigerant GWP
- Refrigerant leakage rate
- High thermal efficiency
- Reducing the emissions associated with extraction and processing of raw materials, including: reducing material usage; re-using components; using materials with lower embodied carbon.

The following measures, however, had negligible impact:

- Where the equipment is fabricated
- Emissions associated with transport
- Emissions associated with energy and water use in manufacture.

Recommendations from the study include: widespread and consistent performance reporting to gain more reliable data; further studies into refrigerant leakage in ASHP and VRF; and ensuring that the F-Gas Regulation is implemented. **CJ**

- The article summarises a paper titled *Understanding the importance of whole-life carbon in the selection of heat-generation equipment,* presented at the CIBSE Technical Symposium in Sheffield last month.
- For more information on the embodied-carbon breakdown of heat-generation plant, and for more details, see the full paper at **www.cibse.org.uk/symposium**
- **CLARA BAGENAL GEORGE** is a senior engineer at Elementa Consulting

DEFINITIONS

Operational carbon: The carbon dioxide and equivalent global warming potential (GWP) of other gases associated with the in-use operation of the building. This usually includes carbon emissions associated with heating, hot water, cooling, ventilation and lighting systems, as well as energy used in cooking and by equipment and lifts. As this study is focusing on heat-generation equipment, operational carbon refers to the carbon emissions associated with generating heating and hot water.

Embodied carbon: This is defined as including the following stages:

- **Product: extraction and processing of materials, energy and water consumption used by the factory or in constructing the product or building**
- **In-use: maintenance, replacement and emissions associated with refrigerant leakage**
- **End of life: demolition, disassembly and disposal of any parts of product or building, and any transportation relating to the above.**

Whole-life carbon (WLC): This includes embodied carbon, as defined above, and carbon emissions associated with operational energy. The purpose of using WLC is to move towards a building or a product that generates the lowest carbon emissions over its whole life (sometimes referred to as 'cradle to grave').

Whole-life carbon: heat-generation equipment – low energy (for example, Passivhaus type)

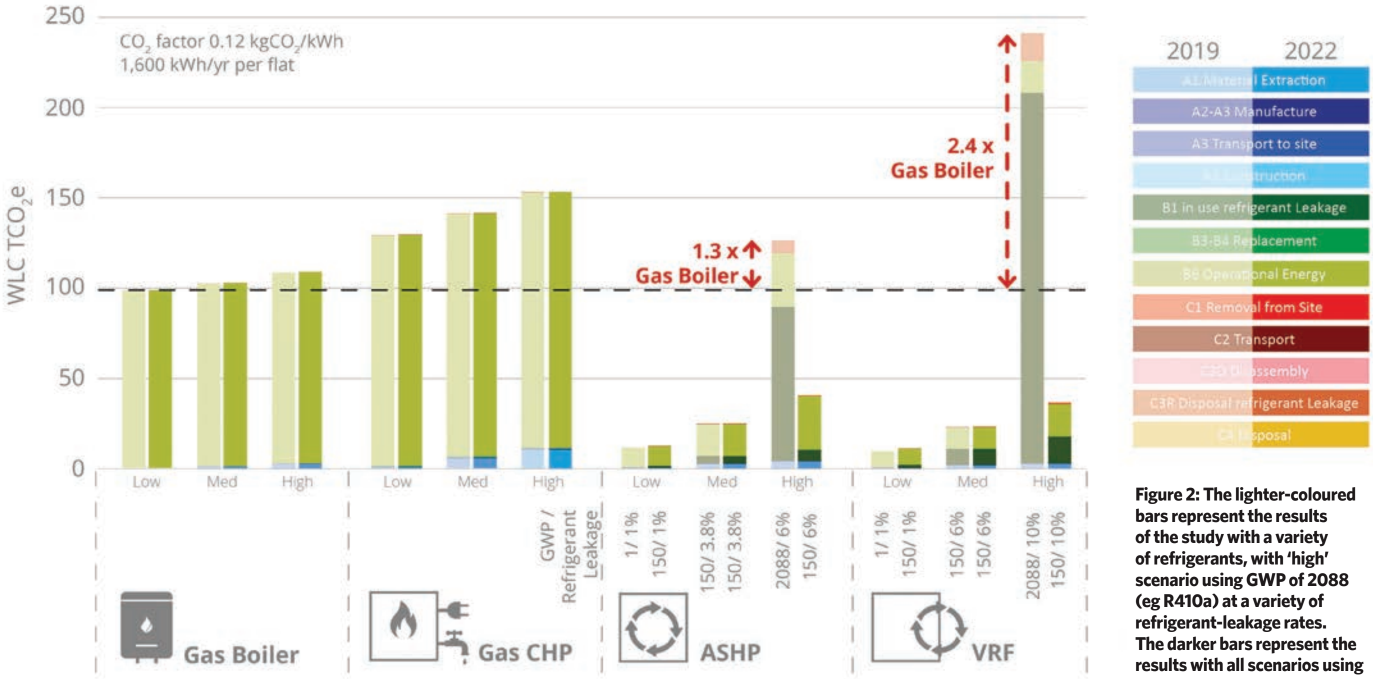


Figure 2: The lighter-coloured bars represent the results of the study with a variety of refrigerants, with 'high' scenario using GWP of 2088 (eg R410a) at a variety of refrigerant-leakage rates. The darker bars represent the results with all scenarios using a refrigerant GWP of 150

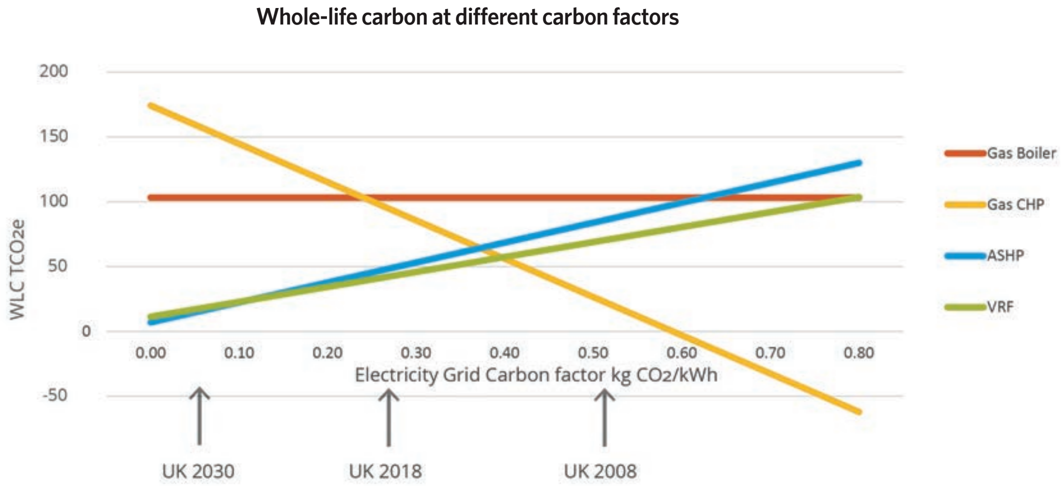


Figure 3: How the WLC of the heat-generation equipment changes with varying carbon factors

THE RESEARCH

Goal: The goal of this study was to calculate and understand the carbon-emission equivalent (referred to as Global Warming Potential in Life-Cycle assessments) of heat-generation equipment, to inform selection of building service equipment with the lowest WLC.

Systems assessed: The study considered the WLC of four types of heat-generation equipment: gas boiler, gas CHP, ASHP and VRF.

Application to building types: The study is relevant for multi-residential, schools, hotels and office developments, as these have a similar kWh heating and hot-water demand per kW of installed capacity. Although data was collected for a range of heat-pump capacities, the calculations are carried out based on a 100kW heat pump.

Boundaries: The study includes all elements of the building life-cycle, A1-C4, as defined by BS EN 15978:2011, excluding B7 – operational water use, and B2 – maintenance. It is assumed that the maintenance is carried out by in-house facilities management.

Time horizon: A service life of 20 years has been applied to all equipment and the reference period of the study is 20 years.

Method: Very little data is available on embodied carbon or WLC of heat-generation equipment in published data sources. So WLC calculation models are based on primary data collected from manufacturers of 27 heat-generation units for this study. The WLC calculation methodology is based on the RICS guidance, as this is seen as industry standard. The methodology deviates from the RICS methodology for the end-of-life stages (C1-C4). When carrying out these calculations, assumptions on carbon emissions in the extraction and processing of raw materials (A1) were taken from the ICE database. Assumptions for transport, disposal and disassembly were used from the RICS guidance.

Scenarios: For each of the four heat-generation equipment types, a low, medium and high WLC scenario was established. These were based on the WLC calculations from the primary data collected. Manufacturer refrigerant-leakage rates were amended using published information. The scenarios were sense checked against published data, using the Oekobaudat database and Environmental Product Declarations (EPDs) of similar products. The scenarios considered the following factors:

- Operational efficiency
- % reused materials
- Weight and embodied carbon of materials
- Transport type and distance
- Refrigerant leakage and global warming potential.

See table opposite for details.

Carbon factors: A 20-year projected average carbon factor of 0.12kgCO_2e/kWh was used for grid electricity; the carbon factor for natural gas used was 0.21 kgCO_2e/kWh.

Variables of whole-life carbon (WLC) scenarios

Elements of building life-cycle	Scenario Low	Scenario Medium	Scenario High
A1: Extraction and processing of raw material	40% lower than the medium scenario This value is then further multiplied by 0.25, to account for 75% reused components Adjusted as per published databases	Average A1 for products with capacity close to 100kW Adjusted as per published databases	25% more than the medium scenario Adjusted as per published databases
A4: Transport from factory to site	Locally manufactured (50km by HGV)	European manufactured (300km by HGV)	Global manufactured (1500km by sea and 200km by HGV)
B6: Operational energy	Boiler: 98% CHP: 56%Th 34% El ASHP: COP 5 VRF: COP 6	Boiler: 95% CHP: 52%Th 37% El ASHP: COP 3 VRF: COP 4.5	Boiler: 91% CHP:47%Th 38% El ASHP: COP 1.8 VRF: COP 3
B1/C3R: Refrigerant leakage	Boiler: 0 CHP: 0 ASHP: 1% annual, 99% end of life GWP 1 VRF: 1% annual, 99% end of life GWP 1	Boiler: 0 CHP: 0 ASHP: 3.8% annual, 98% end of life GWP 150 VRF: 6% annual, 90% end of life GWP 150	Boiler: 0 CHP: 0 ASHP: 6% annual, 90% end of life GWP 2088 VRF: 10% annual, 85% end of life GWP 2088

Carbon-emission equivalent of heat-generation equipment

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NOx <24mg/kWh
(2 Credit Points)*

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In the hot seat

Large heat pump installations could change the way heat is generated in the UK and help decarbonise existing buildings in cities, says Star Renewable Energy's David Pearson, who speaks to our journalist Andy Pearson

'I never imagined a core part of my life would be influenced by throwing dog biscuits into a river during a school geography project,' says David Pearson, director of Star Renewable Energy, the division of Star Refrigeration focused on the design of large heat pump systems for district heating.

'Dog biscuits are cheap, they float, and if you measure the time it takes a floating biscuit to travel 10 metres – and divide that by 10 – you'll get the river's flow velocity in metres per second,' he says. Knowing the river's velocity and cross-section is fundamental to calculating how much heat is available to be captured by a water source heat pump, which is Pearson's interest.

It is this knowledge, acquired from his geography class, that has led Pearson to the conclusion that large heat pump installations could fundamentally change the way heat is generated in the UK – and, critically, help to decarbonise the existing energy-inefficient building stock in cities.

'Our cities are typically located on larger rivers, where gravity drains the upper reaches, delivering solar thermal energy right to where we need it most,' he says. 'We won't win the decarbonisation battle with new houses. It's the old stuff that is the challenge, and it's too tricky to decarbonise many of these buildings on an individual basis. So the best way is to take a district heating system into the centre of a city and use that to supply buildings with low carbon heat.'

For Pearson, the obvious source of low carbon heat for cities are their rivers. 'By our rough calculation, for example, there is about eight times as much heat in the river Clyde as you would need to heat Glasgow's entire city centre.'

Pearson has worked at Star Refrigeration for 20 years. The business was started by his father and two colleagues in Glasgow, in 1970, to specialise in commercial and industrial refrigeration, and it is still based in the city. His father, who is nearly 88, is also still involved, but Pearson's older brother Andy [not the author of this article] is now group managing director. Although the business is privately owned, there are more than 300 shareholders, mainly past and present staff and their families. Independence and long-term thinking are of paramount importance, says Pearson, who graduated from university with a degree in engineering with business management and European studies. He worked for another Glasgow-based engineering business, Howden, before being asked to join Star to help design refrigeration systems for ice rinks and cold-storage projects. After a four-year spell at a spiral and tunnel freezer acquisition, Starfrost, in Lowestoft, he returned to Star's Glasgow headquarters to work on 'where next?'.

'The UK is a solid market, but not growing,' Pearson says. 'Sustainable heating caught our eye, and high-temperature heat pumps draw the same skills as industrial refrigeration, so was an obvious match.'

One of the big schemes he subsequently worked on was proof of this – a £25m upgrade of the district heating system in Drammen, Norway. This innovative project uses a water source heat pump to take low-grade heat from the adjacent fjord and turn it into high-grade heat to supply heating for the 60,000-strong community. As well as air quality, the key driver was to move from biomass and gas.

The fact that Star's heat pump solution uses only three systems of 780kg of ammonia as the refrigerant was one of the reasons the company was awarded the contract, says Pearson. 'We won the job ahead of a company that had promoted a solution using up to 7,000kg of R134a, an HCFC with a global warming potential (GWP) 1,430 times that of carbon dioxide.' He adds that it is not unreasonable to expect a large refrigerant system, such as the one at

WORKING WITH AMMONIA

Delivering heat at 90°C using an ammonia-based heat pump is not without its challenges. According to Pearson, the International Energy Agency acknowledged the potential of ammonia as a refrigerant in 2007, but said it was not possible for systems operating above 70°C because they thought the pressure needed would be too high for commercial systems. Not so for Star, with its compressor partner Vilter (now owned by Emerson). It had experience of using CO_2 as a refrigerant at pressures up to 110bar, so the 65bar working pressure of the Drammen heat pump was well within its capabilities if a compressor was available.

Pearson says Star has always worked with ammonia because such refrigerant systems are the most energy efficient and environmentally friendly. 'If you look at the lifetime costs of a refrigeration plant or heat pump, about 70% of the cost is down to electricity consumed running the system, 15% is capital cost and 15% is the cost of maintenance over a 20-odd-year life,' he says.

'That said, we've built large projects using propane, CO_2 and HFCs – whatever refrigerant the client wants we'll consider using it in the best possible way.'

"To me, act faster means deploy what we know works: don't dream of unicorns"

Drammen, to leak about 1% a year: '70kg of R134a at a GWP of 1,430 is a big number – equivalent in GWP to driving 800,000km a year. Whereas, by using ammonia, our GWP is the fat end of nothing. Ammonia is also about 25% more efficient, so consumes far less electricity, the primary operational cost.' (See panel 'Working with ammonia'.)

It is not the ammonia refrigerant that makes the Drammen district heating system unique. 'As far as I'm aware, it is still the only large-scale 90°C district heat pump in

»

Twin water source heat pumps to be installed at Queens Quay

Pearson is passionate – fanatical even – about the potential for heat pumps to replace burning fossil fuels, such as natural gas, to provide heat

» the world,' says Pearson. He admits there were some elements of the Drammen installation that were 'a wee bit sticky', but he points out that 'innovating is not without its challenges' and says Star 'stuck with it and got it right'.

The ammonia-based heat pumps are now delivering 85% of Drammen's near-70GWh of heat each year. Gas is only for top-up on the coldest days.

At about the same time as the Drammen heat pump was coming on line, the UK government was talking about the need to decarbonise heat as a consequence of the EU's renewable energy sources directive. Star saw an opportunity to use its experience of Drammen to grow its business. 'We'd decided that a big part of the business going forward would be in heating as well as cooling,' says Pearson.

However, biomass and gas combined heat and power (CHP) – as well as a reluctance to change – left Star frustrated at the slow uptake. So, in 2013, it set up Star Renewable Energy, a new division to focus specifically on big heat pump projects for district heating systems.

'We understand heat exchangers and compressors and thermodynamics; if there is going to be a trend for heat pumps, then we should be part of that,' Pearson says. 'I now lead that business unit, which is able to draw on all the refrigeration skills we already have at Star, but for a totally different application.'

Pearson is passionate – fanatical even – about the potential for heat pumps to replace burning fossil fuels, such as natural gas, to provide heat. 'Heating is about 50% of the energy consumed in the UK, so we have this challenge of how to do

QUEENS QUAY – A WATER SOURCE HEAT PUMP ON THE RIVER CLYDE

Client: Vital Energi
Refrigerant: Ammonia
Capacity: 5.2MW
Temperature: 80°C/60°C, then 75°C/45°C
Supported by the Scottish Government Low Carbon Infrastructure Investment Programme

Scotland's first major district heating network served by a river-source heat pump is currently being installed under West Dunbartonshire Council's £250m regeneration scheme for the Clydebank area. This residential-led, 23-hectare development, on the site of the former John Brown shipyard, includes the addition of new homes and business premises.

The scheme's location, on the banks of the river Clyde, made it the perfect application for a water-source heat pump. The 5.2MW heat pump will extract heat from the river and use it to supply the district heating system. The heat pump has been designed to run on an open-loop design, with water abstracted from the river in direct contact with the evaporator heat exchanger.

The £15m district heating system will connect to existing buildings in the area, the majority of which are currently heated by gas and generally run at 80°C flow/70°C return.

Initially, the temperature of heating mains will be 80°C flow, 60°C return. However, to improve the heat pump's efficiency, the temperature of the heating mains will be lowered to 75°C/45°C over time. New developments are being built with heating systems designed to operate at 75°C/45°C, while the heating systems in existing buildings will be adapted to enable them to operate effectively at these temperatures.

Properties are connected to the district heating network via a heat interface unit. »

heating without burning gas and biomass – and that's where large heat pump solutions come into their own,' he says.

'Although not originally a strategic driver, we have observed the growing emphasis on air quality. Drammen still shows us a fantastic outcome in this regard, with 85% lower nitrogen oxide (NO_x) emissions, the gases now attributed to lung, heart and brain disorders, but largely invisible. Although largely attributed to transport in cities, some studies have suggested 40% is actually from gas boilers and other gas devices, such as CHP.'

Pearson adds: 'The problem with replacing gas boilers with heat pumps on a piecemeal basis is that gas heating systems are, generally, designed to operate at 82°C flow, 71°C return temperature. 'If you want to replace that system with a heat pump, you cannot turn up with a domestic unit that only provides heat at 45°C,' he says.

Star has three systems nearing completion in 2019. The Clydebank river-source scheme will provide heat at 80°C, the Hillpark air source heat pump scheme at 62°C, while the ground source heat pump serving the renovated old Post Office at Islington Square provides heat at 65°C. 'The residents won't be aware of the heat pumps, but they will enjoy cleaner local air with less gas being burnt.'

Does he see a time when cities will have both district heating and cooling? 'If you want district cooling and heating systems, you could have four-pipes going into the buildings or a two-pipe ambient loop system and a heat pump in each building,' he says.

'A heat pump in each building would be tricky if aiming for close to 80°C and, if you've got dozens of buildings on a network, they will each require a heat pump sized for their individual max demand – whereas, if you've got district heating and separate cooling systems, the central heat pump will be sized for the aggregate demand, which could be 50-60% smaller. And, because they are centralised, they'll be easy to turn off very quickly if the grid gets stressed – a very valuable technique, far preferable to running auxiliary diesel peaking plant.

'We can also force-run and store heat, which is far more sensible than curtailment of wind farms, and turns the surplus electricity into three or more units of heat.'

Pearson has taken his fixation with heat pumps home. 'As part of renovations to my house, I'll probably deploy a ground source heat pump – but it's a monstrous amount of money when a gas boiler would work fine,' he says. 'But gas will eventually fade and any provision of hydrogen is predicted to be three or more times the cost of gas currently.'

Water-source heat pump scheme in Drammen, Norway

The late Professor Sir David MacKay, the government's chief scientific officer, was a huge influence on Pearson's thinking, encouraging critical thought of populist ideas in his book *Sustainability without hot air*.

'He'd question where hydrogen was going to come from, how much it would cost, whether it would require additional methane imports, and how dependent it would be on as yet unproven at-scale solutions, such as carbon capture,' says Pearson.

'If I've heard anything from the upsurge in thinking from [Swedish schoolgirl] Greta Thunberg – who initiated the school "strike for climate change" movement in November 2018 – it is "act faster", and that, to me, means deploy what we know works: don't dream of unicorns.

'I hope they start encouraging a move forward from what we know is the major component of the problem – "burning gas" for the rather simplistic need of heat.' **CJ**

HILLPARK, GLASGOW – A HIGH-TEMPERATURE AIR SOURCE HEAT PUMP

Wooden building adjacent to Hillpark high-rise blocks housing Star's air source heat pump

Client: GHA Wheatley Group
Refrigerant: R134a
Capacity: 400kW
Temperature: 62°C/40°C
Supported by the Scottish government

An air source heat pump providing heat at 62°C (40°C return) is being used to provide 351 homes with low carbon heat. The relatively high water temperatures enable conventional radiators to be used to heat the homes.

The Hillpark Drive estate in south Glasgow comprises eight apartment blocks, built in the 1970s, and is operated by Glasgow Housing Association, part of the GHA Wheatley Group. It secured a £2.5m grant from the Scottish government's Local Energy Challenge Fund, plus money from Glasgow City Council, to carry out a £5m project to: upgrade the estate's heating system; replace the inefficient and impractical electric storage heaters to provide affordable heating; and reduce carbon emissions.

The solution, developed by project consultants WSP/Parsons Brinckerhoff, is based on an air source heat pump providing heat for a new district heating system. Gas is used as a top-up/back-up energy source.

The linear layout of the eight blocks lent itself to a district heating solution. A piped central flow and return spine was formed from Rehau's Rauthermex polymer pre-insulated pipework, with heat taken off for individual blocks.

The heat pump has in-built control systems for remote monitoring, to ensure optimum efficiency is maintained. A single energy centre houses the 8m-long heat pump – which means only one device has to be maintained – and it is expected to have a service life of more than 20 years.

Superior control at the touch of a button: the new Quinta Ace

Leading commercial heating manufacturer Remeha has unveiled the new Quinta Ace range, an advanced, wall-hung condensing boiler series that combines robust, reliable, high operational performance with superior control capability to maximise lifetime boiler efficiency.

The new Quinta Ace, successor to the hugely successful Quinta Pro series, builds on its predecessor's pioneering technology with a next-generation control platform and an all-new human machine interface (HMI) panel.

The new controller has been designed for easy installation, commissioning and programming. Via a new full-text, full-colour interface, it provides intuitive access to an extended range of parameters using a rotary selection dial and smartphone-like buttons.

The clear design encourages improved boiler control for higher efficiencies, increased comfort levels, minimum emissions and lower life-cycle costs. At the same time, the ready availability of greater technical detail makes servicing and diagnosis more straightforward and rapid.

Time and temperature controls are supplied as standard, with inbuilt 0-10V and volt-free contacts giving direct connection to any building management system (BMS) at no extra cost.

Available in 30, 45, 55, 65, 90 and 115 models, in addition to the existing Quinta Ace 160, the new Quinta Ace series has been designed to meet all retrofit and new installation requirements.

'Inadequate boiler control can add 15% to fuel consumption compared with a well-controlled system,' said Paul Arnold, Remeha's product manager. 'That's why we've focused on enabling enhanced control with the new Quinta Ace range. We've received excellent feedback during field trials on how user-friendly and intuitive the controls are to use, so we are delighted to bring the Ace platform to market.

'In terms of design, the Quinta Ace is fully backwards-compatible with the Quinta Pro regarding dimensions and connections, so there'll be no learning curve for installers. And with its high 40°C temperature differential, the new Quinta Ace is hybrid-ready, providing the perfect heat source selection for heat interface units, low-temperature heating and hybrid installations.'

'With the introduction of the Quinta Ace series, we have achieved a universal design philosophy across the Remeha boiler range that will simplify design, installation and commissioning for our customers,' continued Arnold.

'Importantly, the revolutionary Ace control platform will help maintain high efficiencies and ultra-low NOx levels throughout the life-cycle of our boilers, so that end-users continue to benefit from low operating costs and minimum environmental impact.'

The new Quinta Ace range is supported by a two-year warranty* as standard, extended to five years for the heat exchanger, and by one-to-one expert advice.

* Visit bit.ly/2GktTal

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- **Next-generation Ace control platform**
- **All new, easy-to-use, intuitive interface**
- **Rapid, straightforward programming, commissioning, servicing and diagnosis**
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- **Cascade and rig options up to 1.3MW**

The BEN being trialled at LSBU serves two buildings

Intranets for heat

The balanced energy network at London South Bank University has been part-funded by Innovate UK to help accelerate the creation of smart heat-sharing networks. These balance the heating and cooling needs of different buildings and act as a virtual energy store to help the National Grid match supply and demand. Andy Pearson reports

For more than 50 years, the UK has relied primarily on natural gas to heat its buildings. That will need to change if the country is to transition from a reliance on fossil fuels towards low carbon energy sources, to meet its national and international commitments to tackle climate change. It will not be easy: 'Decarbonising heat may be the greatest challenge we face in meeting our legally binding carbon targets,' the government warned in *A Future Heat Framework for Heating Buildings*, published in December last year.

One way in which the challenge of delivering low carbon heat could be overcome is with a new type of district heating system called a Balanced Energy Network (BEN). Developed by Icax, working with London South Bank University (LSBU) on a project part-funded by Innovate UK, the system is being trialled on LSBU's south-east London campus.

A BEN works by circulating water at ambient groundwater temperature through a piped loop to buildings on the network. Each building uses a heat pump to extract heat from the network for heating or to reject heat into it when the buildings need cooling.

It does not matter where heat comes from. 'We're doing experiments on pulling heat out of sewers, data centres and other buildings; all we need to know is how much heat it gives us and the profile,' says Dr Aaron Gillich, associate professor in energy and building services engineering at LSBU. 'The more you add, the more robust the heat network – it's like an intranet for heat.'

By managing the use of available energy, a BEN offers the efficiency benefits of a heat network without the air pollution created by gas combustion in dense urban areas.

What makes the system at LSBU unique is that, as well as transferring heat, it has been designed to respond to price signals from the electricity Grid. It can turn off electrical plant, such as heat pumps, to smooth peaks in demand or to store electricity as heat when there is a Grid surplus, for example, at night when the wind is blowing and wind farms are active. 'Everything – from the heat pumps, the heat network, the buildings served by the system, and the thermal storage – becomes

PROJECT TEAM

Heat network: Icax
Building estate: London South Bank University
Thermal storage: Mixergy
Energy aggregator Upside Energy
Heat: Origen

a giant distributed heat-storage device, to provide a balancing service for the Grid,' says Gillich.

The BEN currently being trialled at LSBU serves two buildings. At the heart of the system is a network loop that distributes ambient groundwater from the London aquifer. This uses two, 110m bore holes to tap into the London chalk aquifer beneath the campus; water is abstracted through one bore hole and rejected at a lower temperature through a rejection well.

The London aquifer is a giant inter-seasonal heat store, with a temperature profile determined by the annual seasonal energy balance in the UK, plus the net energy abstracted from – or rejected to – the store by building heating and cooling. The aquifer is an excellent source of water at 14°C throughout the year, from which heat pumps draw heat and then reject water at 10°C back to the aquifer.

If any building needs cooling, its heat pumps can reject heat to the network – which, in turn, is a benefit for those buildings needing heating. This leads to

> "At the heart of the BEN system is a network loop that distributes ambient groundwater from the London acquifer"

Network pipes for the BEN installed at the LSBU

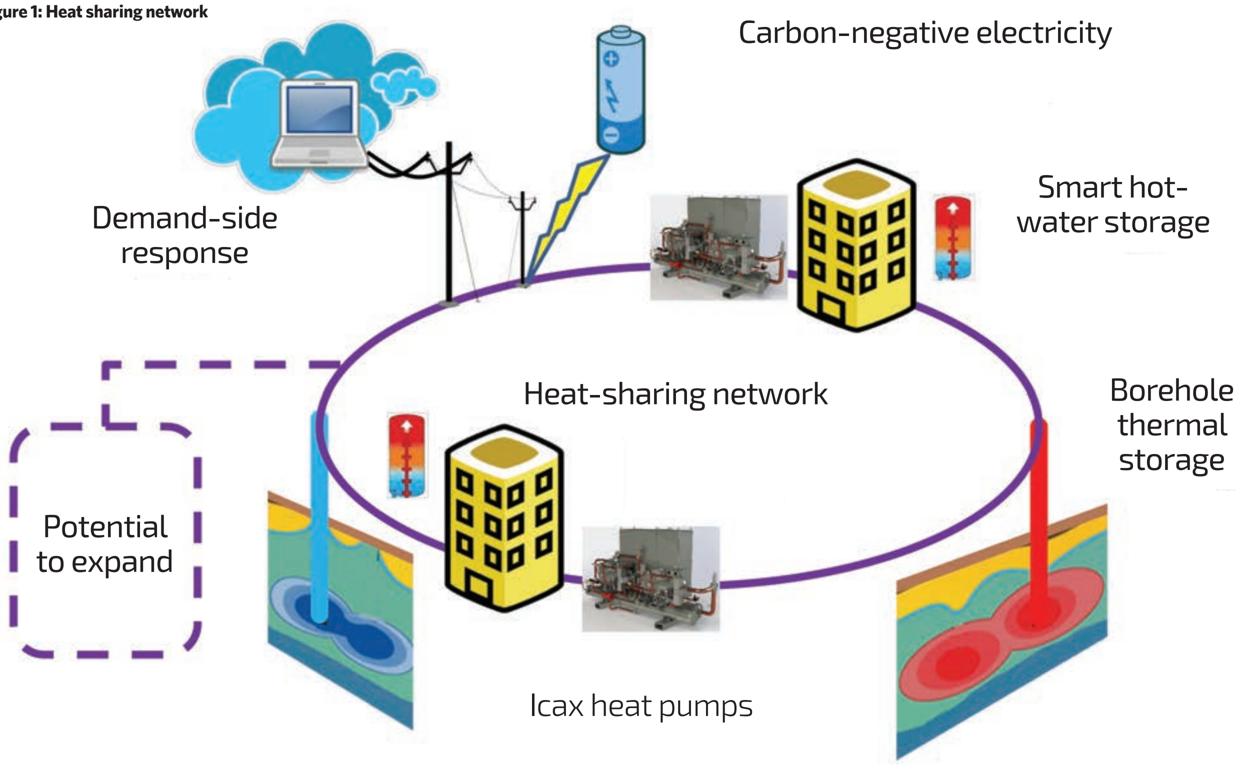
a 'heat-sharing network' that can balance the heating and cooling needs of different buildings. In addition, heat is stored, short term, in two 10,000-litre insulated hot-water tanks, manufactured by Mixergy, which Gillich calls thermal batteries. These are heated by the heat pumps using cheap night-time electricity to allow hot water to be drawn by day, when domestic hot water is needed, or for space heating.

'If the Grid needs to shed surplus power and we don't have anywhere else to put it, we can store heat generated by low-priced electricity as hot water, for use later in the day,' explains Gillich.

Heat pumps transfer the heat from the network to the buildings instead of burning fossil fuels. 'A big part of the challenge in decarbonising heat is retrofitting buildings that have gas boilers,' says Gillich. 'Everybody expects 80°C temperatures coming from the gas boilers, so all of the heating circuits – such as the ones we have at LSBU – were sized for 80°C water.'

The heat pumps at LSBU were seamlessly integrated with boilers in existing plantrooms, de-risking the transition from a client perspective and allowing maximum efficiency to be achieved. They have been developed by Icax to deliver »

Figure 1: Heat sharing network



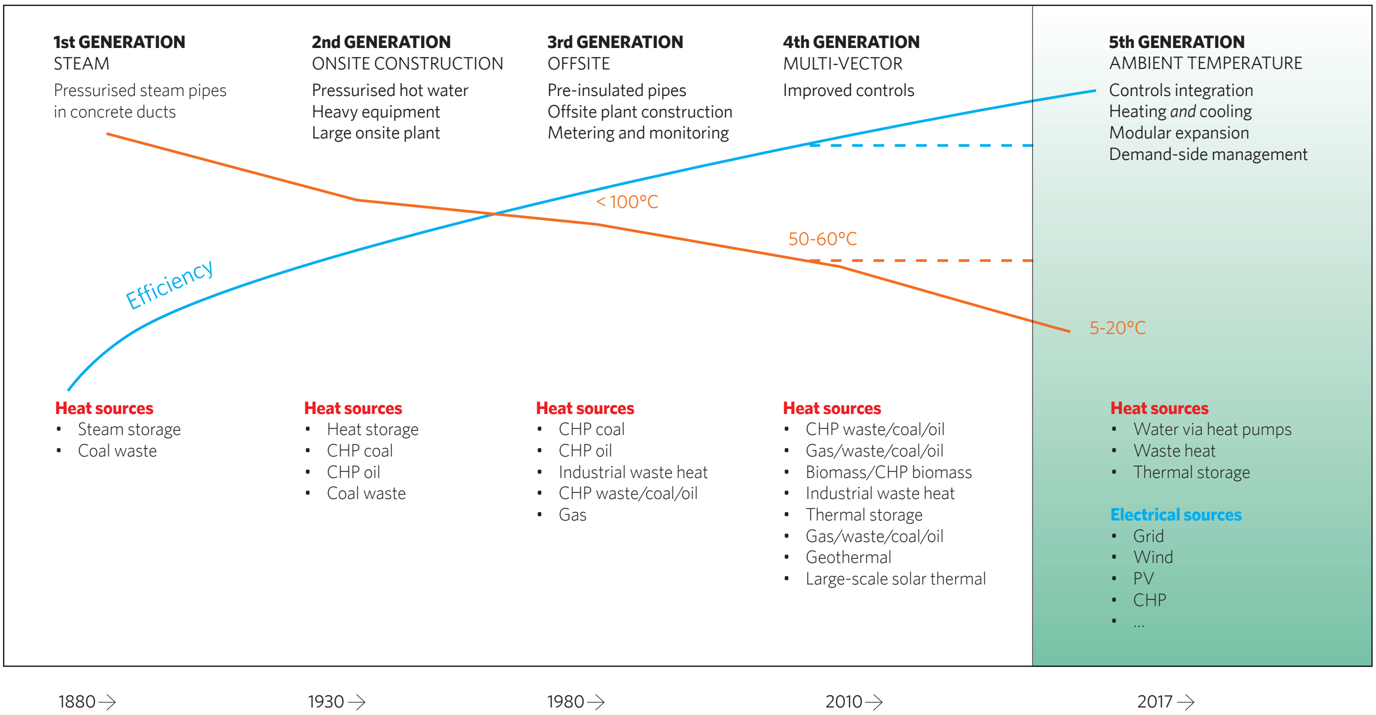


Figure 2: Heat network trends to lower distribution temperatures and higher efficiency

» water at temperatures of up to 80°C. This allows them to be retrofitted into existing buildings –in place of, or alongside, gas boilers – without the need to modify the existing heat-distribution systems.

In addition, using the aquifer water at a constant 14°C gives the heat pumps a higher starting temperature than if air source heat pumps had been used on cold winter mornings, so they have a higher coefficient of performance (COP). Icax has developed the control systems for the heat pumps and connected the BEN system to

WHAT IS A FUEL CELL CALCINER?

The calciner works by feeding natural gas into a standard fuel cell to generate electricity. This process generates heat, which is used to break down limestone into lime (CaO) and pure CO_2, to be used or stored underground. The lime produced can also be used in industrial processes, during which it absorbs CO_2 and is converted back into calcium carbonate – the original limestone.

Overall, the process is carbon negative, absorbing 800g of carbon for every kilowatt hour of electricity generated, as opposed to releasing 400g of CO_2 for every kilowatt hour with conventional combustion technologies. Origen Power's Tim Kruger suggests using the lime to counter ocean acidification. 'You absorb about twice as much carbon dioxide when you add it to seawater as when you use it industrially,' he says.

> "Using a BEN to support the Grid opens the door to additional revenue streams – the biggest of which is from avoiding the Use of System charges through DSM"

the first demand-side management (DSM) network in the world. There were concerns that replacing gas boilers with electric heat pumps, would raise peak electric loads. By working with energy aggregator Upside Energy, however, the BEN systems are all controlled by a set of algorithms. These tell the different systems when to turn on and off, when the system should store electricity as heat, or when to deliver cooling by moving heat to storage at optimal times.

This creates a 'virtual energy store', which can be combined with other systems and used to help the Grid balance supply and demand. 'The Grid doesn't care about something the size of our heat pumps, which each consume about 100kW of electricity and produce 300kW of heat. To make a difference to the Grid, you are talking about loads of the magnitude of 5MW, which is the reason we're using an energy aggregator; our campus is just one piece of their portfolio,' explains Gillich.

Using the BEN to support the Grid in this way opens the door to additional revenue streams – the biggest of which is from avoiding the electrical Grid's Use of System charges through demand-side management.

'The Distribution Network Operators say: "If you shift the timing of your electrical demand to avoid the 4pm to 7pm peak, then we'll pay you X-amount of money,' says Gillich. 'That is what our control system is designed around – taking every single electrical component, including the heat pumps and storage tank, and making those addressable as demand-response assets.'

Other potential revenue streams include short-term operating reserve (STOR) and frequency response. Revenue from STOR is based on a user agreeing to reduce their demand in a matter of minutes; revenue from frequency response is based on a user being able to flex demand in a matter of seconds.

As well as turning individual electrical loads on and off in response to Grid demand, LSBU is experimenting with using the buildings themselves. 'The more fun, experimental bit was using the buildings as demand-response assets,' says Gillich.

LSBU doesn't want to turn on the heat pumps between 4pm and 7pm because it is expensive. 'We're trialling running the temperature up to 24°C and then letting it coast back down during peak time. We're basically taking thermal comfort in the building and making that the asset you're selling to the Grid.'

Gillich says business models for the BEN are still being developed. The LSBU system offers an excellent platform for proving the robustness of the system and the business model.

As part of the trial, the team is also working with Origen Power and Cranfield University to incorporate a fuel cell calciner into the BEN, to give a non-intermittent way of generating electricity to power the heat pumps while removing CO_2 from the atmosphere (see panel, What is a fuel cell calciner?). 'The use of the fuel cell shows that any renewable can be plugged into the BEN,' says Gillich.

A big advantage of the BEN is that it is scalable. At an urban scale, BEN infrastructure allows heat networks to be delivered in small increments and expanded over time, avoiding many of the barriers that currently hinder investment in heat networks. At the national scale, any building or system linked to a BEN network becomes a distributed storage device, and offers a low-cost balancing service to the National Grid. This will help to address some of the capacity challenges that the Grid faces as fossil-fuel plants are replaced with more intermittent renewables.

The BEN trial shows it is possible to retrofit low carbon heat into existing buildings

The trial at LSBU has successfully demonstrated the potential of BENs. 'We had the best feedback we could possibly have had when we ran the new system – which was none at all,' laughs Gillich. 'It means nobody noticed because it worked exactly as the old heating system did from the end users' perspective.' More importantly, the trial shows that it is possible to retrofit low carbon heat into existing buildings in central London and that there is a low-cost organic approach to integrating them into future heat networks.

BEN partners are applying the technologies in other projects: Icax is deploying the network design and high-temperature heat pump in UK schemes; Origen Power is developing a 400kW fuel cell calciner; Mixergy is rolling out its thermal store on UK domestic projects; and Upside is developing a large-scale aggregation portfolio. Thanks to BEN, the future of low carbon heat is becoming a little clearer. **CJ**

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Fan coil evolution - quietly combining compact with powerful

Commercial requirements often create conflicting design needs, especially when providing the building's energy demand. This is no different for fan coil units, with space, noise levels and efficiencies seemingly a trade-off – until now.

Commercial projects such as hotels and offices often make use of fan coil technology to provide space heating and/or cooling. As the industry evolved, fan coils units changed too – introducing smarter controls and more efficient components to meet new requirements.

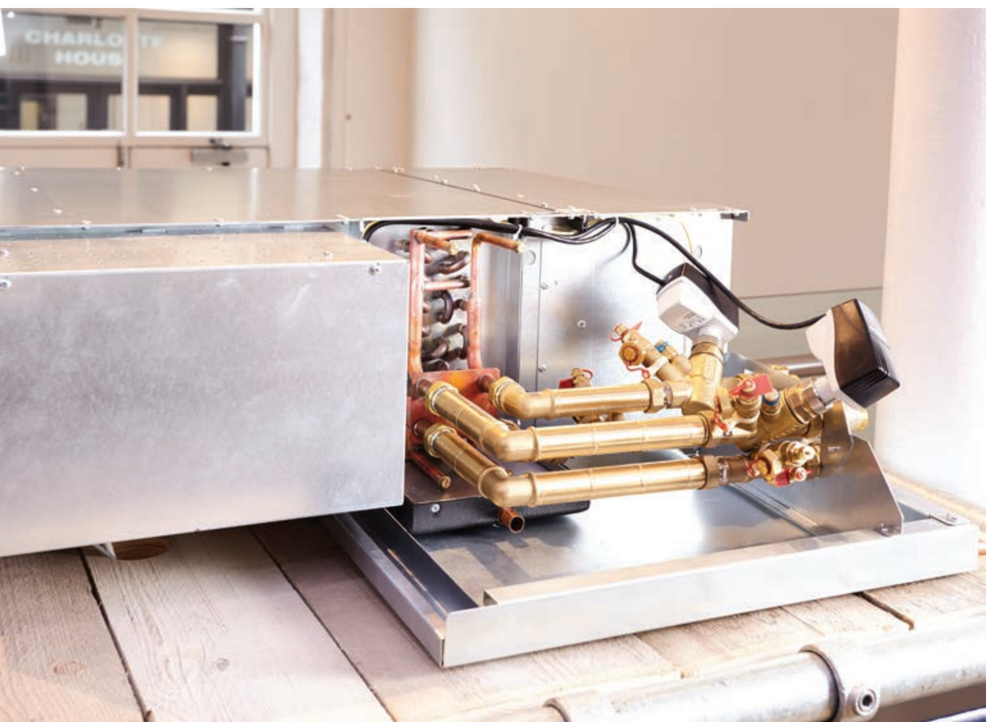
However, a by-product of aiming for lower running costs is often an increase in capital expenditure. As we move towards nearly zero energy buildings (NZEBs) at the end of 2020, there will be a legal requirement for all new buildings to use less power – which, it is feared, will only add to this issue.

The challenges of 2020 aside, there is a greater need for fan coil systems to adapt to changing commercial building trends. There is also an increasing demand for large open-plan areas combined with smaller collaborative spaces – yet there is also an expectation of higher efficiencies and lower noise levels.

These requirements – space, efficiency and noise – are often at odds with each other. For example, a lower noise rating requires a unit increase in size to utilise more fans, which can run more slowly and, therefore, quieter. Another solution for a quieter unit is to increase the casing to allow for inlet and or discharge attenuation – but, again, this increases the size of the fan coil, and additional cost.

In the search for energy efficiency, plant technology is increasingly running at temperatures closer to ambient, decreasing the system network losses. Although positive for building efficiency, this does mean that compatible fan coils require more airflow over the coil to produce the specified water to air thermal transfer, leading to larger units.

It is these conflicts that led UK fan coil manufacturer Ability to create a new evolution of fan coil design – one which takes these modern requirements into consideration from the start, rather than as costed changes to existing solutions. This solution reduces compromise to create a compact, powerful, yet quiet, fan coil unit: the EVO270 Plus Range.



The defining factor in where the three variables of size, noise and output meet is defined by the design of the fan. By taking an innovative new approach to this design, Ability has been able to produce a unit that can move more air for a given size – without an increase in noise output. As size is a critical factor in cost, building designers are now offered a solution with the above advantages at a lower cost to existing solutions.

The EVO270 Plus has already been successfully specified in multiple different commercial applications, offering high outputs and lower noise levels within a compact case size.

If you'd like to know more about how this range can reduce cost and improve performance in your projects, speak to the team at Ability on **01202 305 800.**

The urban balancing act

As long as CHP systems have ultra-low emissions, there are still advantages to using them in urban commercial projects, says Adveco's Bill Sinclair

Nitrogen oxides (NO_x) are a major contributing factor to poor air quality, a combination of nitric oxide (NO) and nitrogen dioxide (NO_2) being the most toxicologically significant. Though half of the current NO_x pollution in London is attributed to vehicles, there is now recognition that more needs to be done to address NO_x emissions from the built environment.

With greater emphasis on renewables to make our cities more resilient in terms of meeting energy needs, low carbon electricity's share of generation has risen to 50.1% across the UK, 33.4% of which is renewables. As old power plants go offline, however, and are replaced by more unpredictable energy sources – such as solar and wind – combined heat and power (CHP) still has advantages. It reduces reliance on the Grid, offers a reliable power source, and gives high-grade heat at lower cost in conditions where a heat pump's coefficient of performance falls and the energy cost increases beyond that of gas.

All CHP systems that employ a catalytic converter are cleaner than the Grid, but localised NO_x emissions from 'dirty' cogeneration is a concern (See 'Aiming to land a NO_x out punch', *CIBSE Journal*, April 2019). Consider a CHP that is used to offset condensing boiler operation; if it is more polluting than the condensing boiler, the local emissions are worsened. NO_x emissions from new CHP units within built-up areas should be lower than condensing boilers if they are to have a positive effect.

The 2018 Ecodesign directive sets a NO_x emission limit for CHP units of 240mg·kWh^{-1}. This threshold is too lenient, despite being approximately equal to emissions that would result from producing heat from a gas boiler and consuming electricity from conventional power plants.

Air quality has been a critical driver in the revisions within the draft London Plan, which now treats CHP less favourably. The plan accepts, however, that there remains a strategic case for CHP systems as long as the NO_x emissions are equivalent or lower than those of ultra-low NO_x gas boilers. A new generation of 'clean' CHP has the advantage of onsite, on-demand cogeneration, and exceeds the draft London Plan's expectations of 'very low levels' of NO_x, meeting Euro 6 standards for emissions. Micro-CHP units – in accordance with EU standards at electrical power rated 50kW or less – are available with far lower emission rates. The Adveco Totem m-CHP, for example, is independently certified at just 10mg·kWh^{-1}.

> "New 'clean' CHP exceeds the draft London Plan's expectations of 'very low levels' of NO_x"

Using such a unit of 20kW electrical output, a gas input of 70kW, with an average annual run time of 6,500 hours for a standard application – such as a hotel or apartment block – the yearly NO_x emission will be 4.55kg. The equivalent for a 'dirty' CHP would be 109.2kg. This option is also improving local air quality because the micro-CHP is being used to offset the run hours of a condensing boiler – which, at emissions of more than 30 mg·kWh^{-1}, is 'dirty' compared to the micro-CHP.

Increasingly, consultants are struggling to pass any kind of gas-CHP-based heating system because of the issues around NO_x. Simply opting for heat pumps, with a lower grade of heat, isn't always practical. One answer is to use a combination of technologies for high-heat temperature systems with low costs and NO_x emissions. This is relevant in large buildings, where a heat pump alone may not be suitable. Such projects typically need an additional, high-grade source of heat. If gas is chosen as the primary fuel, a micro-CHP could, potentially, sit after a heat pump.

CHP can also work for existing buildings that have gas boilers but not the electrical supply needed for a heat pump. It would not be applied to offset the benefits of low-temperature heat pumps, but would be placed after a heat pump, offsetting the gas heating. Such an approach can offer carbon savings, cost savings and – if the CHP is a low-NO_x appliance compared to the boiler – NO_x savings. At worst, such a system will be carbon neutral, but cost- and NO_x-effective.

The move towards all-electric in smaller buildings also reopens the door to solar thermal, with improved payback and carbon savings. Used with low-temperature air source heat pumps, in an arrangement to offset the alternative high-emission heat source, it offers a hybrid approach that does not require CHP. However, we believe gas-fired micro-CHP will continue to play a role as part of many hybrid systems.

We would never advocate ignoring the risk of increasing air pollution locally with 'dirty' CHP systems. If CHP is the best fit for a project, it is vital to choose the lowest NO_x-emitting equipment available. If micro-CHP, either stand-alone or in hybrid systems, can offset condensing boiler run hours and make emissions cleaner, there is surely a place for the technology, even in our busiest cities.

References:

1 Every breath we take: the lifelong impact of air pollution, 2016, Royal College of Physicians **bit.ly/CJMay19CHP**

BILL SINCLAIR is technical director at Adveco

Getting the measure of NO_x

As regulators tighten NO_x emissions targets, Hamworthy Heating's Andrew Dabin answers questions on what it means for gas boilers from a manufacturer's point of view

Why should NO_x emissions be reduced?
All combustion sources produce nitric oxide (NO) and nitrogen dioxide (NO_2). In the atmosphere, NO is oxidised to NO_2, the most toxic form. Natural gas boilers are relatively clean compared to other combustion sources – such as oil – but, in densely populated areas, the total emission becomes significant. Exposure to NO_2 can increase respiratory symptoms in people with asthma. It also creates ozone.

What legislation is in place for gas boilers?
From September 2018, Ecodesign reduced the emission level for natural gas boilers up to and including 400kW to 56mg/kW. This changed from net figures to gross.

The previous best classification was Class 5 at 70mg/kWh net; 56mg/kWh gross converted is 62mg/kWh net, so a reduction has been made. BS EN 15502 outlines how these measurements are done and a Class 6 was set up to comply with the energy-related products (Ecodesign) requirement.

What affects the production of NO_x?
For a fully premixed burner, the NO_x emission is correlated to the flame temperature and this is dependent on:

- **Air dilution λ value** – higher λ values lower the flame temperature and reduce the NO_x emission
- **Burner and gas-air ratio controls** – advances in burners and combustion controls permit combustion in leaner conditions, which enables lower NO_x targets to be achieved
- **Modulating characteristic** – the NO_x value assessed in BS EN15502 is weighted over the modulating range to 20% load. Attention to the way the modulating characteristic interacts with this formula can optimise NO_x emissions
- **Efficient heat transfer** – the lowest flame temperature will be achieved by enabling the most efficient heat transfer away from the combustion chamber
- **Gas group** – the gas type will influence the flame temperature by relation to its calorific value (CV); higher CVs create a higher-intensity flame and higher NO_x.


Andrew Dabin

These measures are applicable to conventional premixed steel, metal fibre and ceramic burner types, in combination with a well-designed gas-air ratio control system. This will enable low NO_x emission levels sufficient for the next generation domestic and small commercial boilers.

Taking one of our boilers as an example, the gas-air mixture is premixed before entering the burner, which ensures the combustion gas is fully mixed. The burner has a metal-fibre surface, which distributes the combustion gas evenly. Combined with a high-efficiency condensing heat exchanger, this keeps the combustion temperature low and inhibits the formation of thermal NO_x.

This burner/heat exchanger design helps to cut NO_x emissions up to a point, but lowering the combustion temperature further can reduce the seasonal efficiency of the boiler. Ecodesign and CO_2 budgets, however, have been the main drivers of increased seasonal efficiency to reduce carbon emissions. As a result, there would be a trade-off in efficiency to achieve substantially lower NO_x levels.

Is there a standardised way to measure NO_x?

BS EN 15502 prescribes a weighting formula to create an annualised emission and corrects to reference conditions. We need to be careful when comparing quoted emissions, as not all literature is quoting on this standard. I have seen some at maximum gas rate, at minimum gas rate, and uncorrected to dry air free values. The protocol in BS EN15502 section 8.13 for boilers up to 1,000kW is defined by a weighting formula across the boiler modulating range and adjusted to reference conditions of 0% O_2. The published data of Hamworthy products is defined in this way.

If less than 70kW, the manufacturer's product fiche should have a section detailing emissions. This should be checked against published data, as it could be quoting wet NO_x levels (not dry air free) or levels at minimum modulation.

What other action has been taken to reduce NO_x emissions?

In London, schemes for natural gas boilers with maximum NO_x levels that vary from 24mg/kWh to 40mg/kWh are now being specified. Advances in burners and combustion controls permit combustion in leaner conditions, which allows manufacturers to investigate and adopt these lower NO_x targets where achievable.

A £10m commercial boiler scrappage scheme, Cleaner Heat Cashback, for London's small and medium-sized businesses has also been launched. CJ

ANDREW DABIN is product manager for Hamworthy Heating

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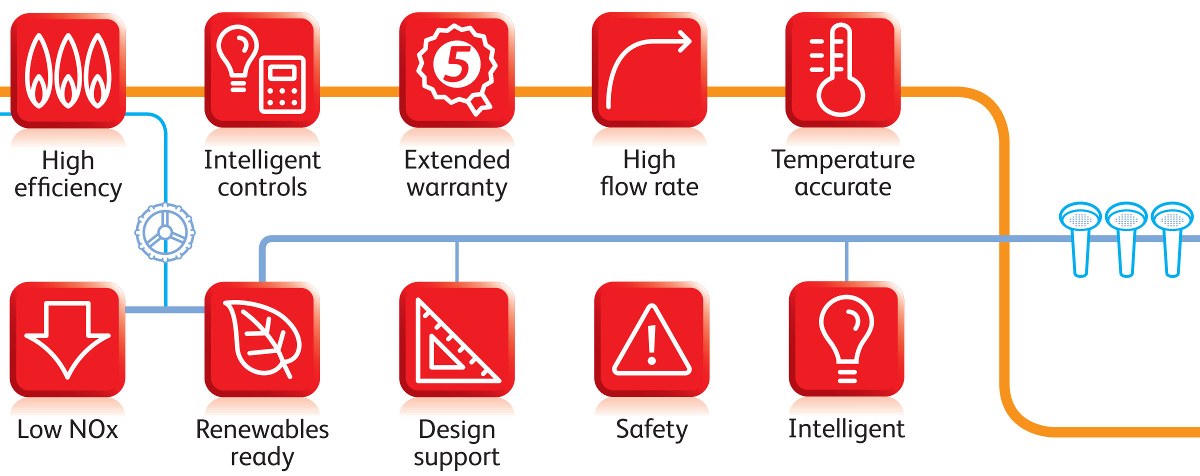

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True to size

Identifying the correct size of tank for a project and ensuring it meets your needs at the point of specification will deliver effective heat or hot water supply, says Mibec's managing director Mitch Cadd

The rise in demand-response systems, smart grids and heat networks in UK commercial and residential developments has increased the number of buffer tanks included in project specifications.

Buffer tanks support the delivery of district heating projects where the centralised heat source is usually based on renewable technology such as biomass, geothermal, biogas, or combined heat and power (CHP).

In a district heating application, the buffer tank retains thermal energy for later use and can supplement the heat source when demand is high, or store heat when demand is lower. The stored heat can be accessed immediately without the heat source needing to get up to temperature. This can be useful for maintaining a constant output when the scheme has to supply multiple properties all year round and with variable demand.

> Incorrectly sizing the tank can have a significant impact on both the system's performance and the life of the heat source

One of the most important things we have to resolve with our customers is how to size a buffer tank correctly for a project specification. This is important not only for successful delivery of the heating or cooling, but also for the tanks. They can be substantial and heavy, so ensuring the project can accommodate a tank at the correct size – and in a suitable location – for optimum system performance is key to the specification process.

The size of the tank required depends on numerous factors, including the heat source type and size, and the load demand on the system. The size and type of the heat source is one of the most important elements to consider in buffer tank sizing.

A batch-fired biomass boiler tends to provide rapid burning of fuel and is not ideal for turning on and off regularly. So a buffer tank is useful because the tank will retain heat for later use, with the flexibility of immediate access without the heat source needing to get up to temperature – useful for maintaining a more constant output.

To define the tank size in this log-burning application, our calculations begin with the rule of thumb that 50 litres of water capacity are required per kW of output – so a 50kW heat source would require a minimum 2,500-litre buffer tank. The volume required will vary according to the system's design, so other biomass heat sources can be different. For example, with a wood-pellet burner, we often only need to take around a third of the heat source's output into account, as it has far better modulation over on and off. For a 1MW heat source, for example the tank size would need a capacity of around 16,500 litres (1,000kW x 0.33 x 50 litres/kW). Many factors, including moisture content of fuel, can still have a bearing.

The final tank size in these examples will also depend on key factors, such as the flow rates in the system, the ΔT and the pressure (both the starting point and what the system reaches). Different methods are used for other renewable technologies, such as heat pumps, or for chilled water applications rather than heating or hot water.

Examining the load demand profile for the buildings using, for example, the predicted number of occupants, enables prediction of the likely peak-demand times on the system – often morning and evenings, as people depart for and return home from work. For instance, if it is a 100kW CHP system supplying 20 apartments – and an investigation concluded the full capacity was only needed for 15 minutes in every hour (25%) – then the buffer-tank sizing calculations could be based on a 25kW output.

Working with a typical ΔT of 40°C, another 'rule of thumb' is that to raise the temperature of 500 litres of water by 40°C needs 25kW heat input – so a 500-litre capacity tank would be a good starting point. In this case, if the load demand was increased to 50kW, a 1,000-litre capacity tank would be needed, and so on.

Incorrectly sizing the tank can have a significant impact on the system's performance and the life of the heat source. The heat source manufacturer's instructions are a crucial consideration, alongside CIBSE guides and relevant standards. Plant cycling, stratification, flow rates, minimum operating time or even maximum cycles an hour to deliver the most efficient output from the source for the project will also inform the tank size. **CJ**

MITCH CADD is managing director at Mibec

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Resilient and efficient parallel pump systems with controlled redundancy

This module explores the application of parallel pump systems in maintaining efficient and reliable HVAC services

The need for reliability of pumped services in buildings is practically linked to the consequences associated with failure. Designs that maximise redundancy may be at odds with other criteria, such as the life-cycle costs, energy efficiency and sustainability. Without appropriate redundancy, however, a pumping-system failure can lead to inconvenience, at least, or – at worst – practical catastrophe. This article will consider how, with appropriate analysis and control, parallel pump systems can be implemented to maintain reliable service in HVAC systems and operate more efficiently than traditional, duty-standby arrangements.

As comprehensively discussed in CIBSE TM56,[1] life-cycle resource efficiency should be an integral part of every building design. As pumped circulation water systems are in practically every serviced building, and will use a significant proportion of operating resources, they are prime candidates for attention. So it is essential that appropriate consideration is given to the design of both the pipe network (materials, velocities and resulting pressure drop) and the pumping systems that provide the motive force for the water circulation.

'Redundancy' has traditionally been used in building services to refer to the level of back-up equipment, or system, that is available in case of a full, or partial, system failure. There is no simple formula to determine what redundancy should be included in a system. It is a matter of assessing the risks, and evaluating the acceptable minimum level of service and the impact of full, or partial, failure, weighed against the resources required to provide a means of protection. It may be tempting to add high levels of redundancy for every project; this will not always be sustainable or necessary, however, and will depend on many, often dependent, factors. For example, in a climate with few cooling hours, a redundant chiller is difficult to justify based on thermal comfort alone. In contrast, in many climates, a hospital would consider redundant chillers, boilers and pumps as normal practice. The availability of onsite technicians will also affect the impact of failure on the building users – fewer trained onsite technicians encourages the adoption of increased levels of equipment redundancy.

Historically, constant speed pumps – and constant-flow distribution systems that employed diverting control at the load – were the norm, so the pumps were selected to operate most efficiently at the flowrate able to meet the continuous maximum demand. Variable-flow networks and associated variable-flow pumps were rare, so it made good sense to operate pumps alternately at 100% design on a 'duty- »

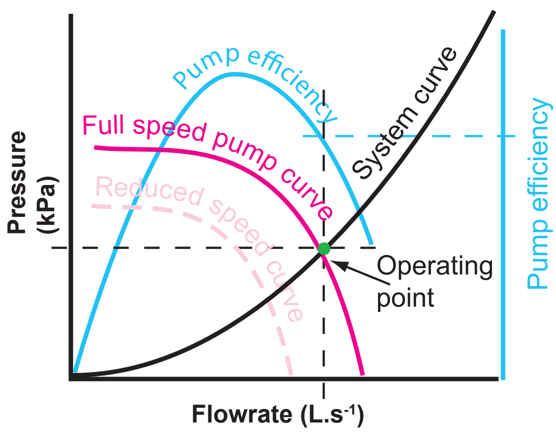

Figure 1: A simple closed-loop pump system operating point

standby' arrangement. So installing two pumps in parallel – with one pump selected to give full design flow and a second to provide a complete backup – is common in many building projects, regardless of their sensitivity to failure. It is typical, in this duty-standby installation, to alternate the active duty pump on a timed basis to even out the wear on both pumps. In the event of one of the pumps failing, the standby pump takes over the duty.

The pumps are each likely to have a pressure-flow characteristic similar to that shown in Figure 1, where the system curve represents the characteristic of the pipework system. The pressure drop through the system, ΔP_{design} kPa (or 'head' in metres water) is determined as part of the design process for the pipework system at a flowrate, Q_{design} $L{\cdot}s^{-1}$, that is required to meet the design loads. The system curve is then produced for a range of flowrates using the relationship that $\Delta P \propto Q^2$. The pump curve is a function of the pump geometry and would be provided by the manufacturer. The operating point indicates the flowrate (and system pressure drop) if a specific pump, operating at a particular pump speed, is installed in the system. Ideally, a pump should be selected so that its operating efficiency is high when the pump is operating in the system. When the speed of a pump is reduced, the shape of the pump efficiency curve will typically maintain approximate correspondence with the shape of the pump characteristic, but manufacturers' data will be able to offer more accurate detail.

To prolong pump life, a pump should be selected so that it does not operate consistently towards the left end of the pump curve, where the flow is very low and the pressure is high.

If two identical pumps were running at the same time – and same speed – in parallel (such as in Figure 2), the flowrate will be twice that of one pump operating on its own particular generated pressure. (By comparison, if the two pumps were operated in series, then the flowrate would remain the same as for one pump, but the generated pressure would double.) If this parallel pump arrangement is used so that both pumps concurrently share the flow, then each of the pumps would be smaller than the equivalent duty-standby arrangement as, at full flow, each one would be responsible for delivering just half the design flowrate. These pumps are likely to be physically smaller than the duty-standby pumps that they replace, so will be lower-cost units and have less embodied carbon.

If one of the pumps fails, leading to just one of the parallel pumps operating, it might be assumed, erroneously, that the single pump operation would deliver 50% design flow. However, considering the operating point in Figure 3, due to the shape of the system characteristic and the particular pump characteristic, this example would still be able to deliver 80% of design flow; for comparison with more traditional descriptions, this is known as having '80% redundancy'.

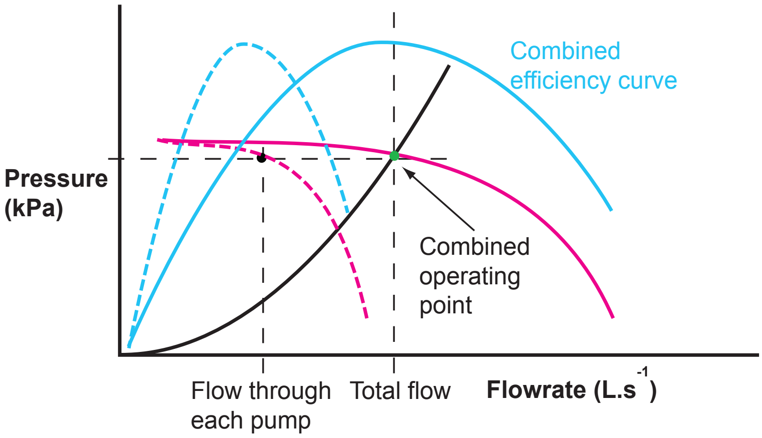

Figure 2: Two pumps operating in parallel arrangement

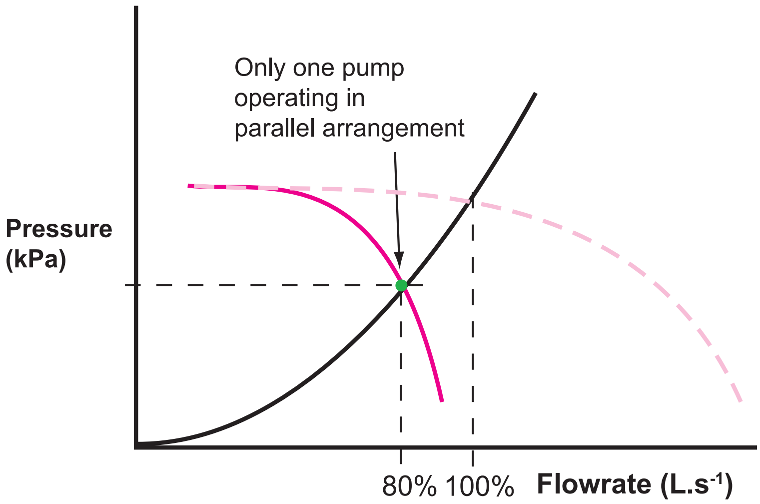

Figure 3: Single pump operating in parallel arrangement (one having failed)

At most times, commercial HVAC systems operate at part load. For example, considering monitored installations in central London, the demand exceeds 80% for less than 3% of the operating hours. So if one pump were to fail (in a dual-duty pump application), it would only potentially impact on building operation if it coincided with that 3% of the occupied period. In any case, there would still be 80% of maximum design flow – so not a complete system failure – even if it was to fail in the peak 3% hours.

For a chilled water system, the cooling coil output characteristic is such that 95% output would be delivered to the air at 80% water flowrate, although the dehumidification at the coil will be less than design, as the mean coil temperature will be higher. Heating coils have a similar, and slightly greater, proportional heat output at 80% flow.

In practice, there are likely to be considerations that increase this redundancy factor – so reducing the risk. For example, building chilled water systems are likely to have a 'safety factor' added to the system design pressure drop (around 10-15%), and when variable speed pumps are selected, they often have excess speed capacity that could be used when one of the pumps fails or is taken out of service. Together, these factors may increase the redundancy by 5% and so reduce the potential hours when failure of a pump may impact the building operation. In the case of the London office example, it would bring this down to approximately 1.5% of occupied hours.

	Flow	Pressure	Pump types	Total installed pump power	Reduction in installed power	Three-year total cost saving
Example 1 design load 95L·s^{-1} @ 300kPa	Design: 95L·s^{-1}	300kPa	Two off variable speed inline pumps	75kW	–	–
	50%: 47.5L·s^{-1}	300kPa	Three off variable speed inline pumps	55kW	20kW	10%
Example 2 design load 315L·s^{-1} @ 448kPa	Design: 315L·s^{-1}	448kPa	Two off variable speed inline pumps	370kW	–	–
	50%: 157.5L·s^{-1}	448kPa	Three off variable speed inline pumps	270kW	100kW	11%
Example 3 design load 473L·s^{-1} @ 448kPa	Design: 473L·s^{-1}	448kPa	Two off variable speed inline pumps	630kW	–	–
	50%: 236.5L·s^{-1}	448kPa	Three off variable speed inline pumps	500kW	130kW	21%

Table 1: Comparative three-year cost of installing and operating three duty parallel pumps, compared with a two-pump, duty-standby arrangement in example applications (Source: Armstrong)

There are many applications where less than 100% redundancy is unacceptable. However, non-critical HVAC installations – such as those serving teaching spaces and apartment blocks, and where there are particularly restrictive budgets – typically do not have any redundancy, and, in the event of a failure, it may take some time to repair or replace parts. Historically, this type of application may have been installed with a single duty pump, but there may be an opportunity to re-evaluate the benefit of a parallel duty-pump arrangement to give a reasonable level of redundancy.

For high reliability, or comfort-sensitive installations – such as hotels, offices and shops – the HVAC is not essential to business operation, but a failure would result in uncomfortable guests, office workers or shoppers, and would be inconvenient and, possibly, costly. Such a scenario would be an ideal candidate for the redundancy offered by parallel duty pumps.

For critical installations, the HVAC system is considered essential to the primary activity and requires redundancy of 100%.

An option that is commonly employed, as an alternative to a duty-standby pump arrangement, is to use three pumps and size each for 50% maximum flow – the premise being that, should any one pump go out of service, 100% redundancy is still assured. Using data as provided by a manufacturer in Table 1, there are potential financial advantages with this arrangement – this cost saving was calculated based on the capital cost of the pumps and subsequent operation for three years.

The greater the system flow, the larger the potential three-year total cost savings. Greater savings may be shown in new installations if the need for concrete plinths for the larger duty-standby pumps had been negated by the 50-50-50 arrangement employing smaller vertical inline pumps. If the total system flow is higher than 315L·s^{-1}, then a four-pump configuration – each pump sized for 33% flow – should be considered.

When adopting parallel duty pumps, it is important to consider the staging methodology for the pumps. This 'best efficiency' staging approach is preferable where, as the required flowrate varies, pumps are 'staged on' and 'staged off' based on the best overall combined efficiency. So, for example, in a two-pump parallel system, one pump would operate to deliver low flowrates and, as the load demands greater flowrates, the second pump would 'stage on' when the efficiency of the two operating together is greater than the single pump operating alone at a higher speed.

Controlling pumps in this way enables higher efficiencies over the load profile of the system, and it prolongs the life of the pump, as it will be operated away from the left side of its curve. The traditional, less-efficient, approach – as is typical in building management system (BMS) control – is based on pump speed, where pumps are staged on at around 95% of full speed and off at 55% speed.

When considering parallel pumping, the means of controlling the pumps can affect not only the energy efficiency of the system, but also its reliability. Typically, parallel pumps are controlled using either a BMS or dedicated pump controls. There are likely to be more sophisticated – and, possibly, more accessible – controls from the pump manufacturer that may include:

- Best efficiency staging control
- End-of-curve protection
- Auto pump sequencing

Figure 4: Pumps with integrated touchscreen that wirelessly link through to cloud-based interfaces, such as smartphones, for set-up, monitoring, control and alerts (Source: Armstrong)

- BMS connectivity for alarms and performance monitoring
- Pre-configured algorithms for standard applications, including variable primary flow control.

Increasingly, the availability of 'intelligent' controls, using local and internet cloud-based processing, is enabling condition-based monitoring, optimised control and data collection. Some manufacturers are able to supply pumps with controllers that use integrated, pump-mounted, touch displays (such as in Figure 4) to give local feedback and communication with local BMS and cloud-based data services.

As well as providing commissioning engineers and operating teams with real-time operational information, the diagnostic software is able to warn of events such as excessive vibration, 'deadhead' (obstructed flow) and failure of impeller/motor coupling. By accessing the processing power and databases held in the cloud, more sophisticated analysis will soon be available, such as predicting failing bearings, identifying imbalance in the impeller and alerting operators to pump cavitation.

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Turn to page 38 for references. »

Module 145

May 2019

1. Which CIBSE TM specifically considers resource efficiency?

- ☐ A CIBSE TM41
- ☐ B CIBSE TM47
- ☐ C CIBSE TM53
- ☐ D CIBSE TM56
- ☐ E CIBSE TM61

2. If a closed pumped water system had a pressure drop of 360kPa at a flowrate of 6L·s^{-1}, what is its pressure drop likely to be at 7L·s^{-1}?

- ☐ A 360kPa
- ☐ B 430kPa
- ☐ C 490kPa
- ☐ D 540kPa
- ☐ E 600kPa

3. If one pump fails in the two-pump parallel duty setup illustrated in the article, what flowrate will still be delivered?

- ☐ A 40% of that delivered by the two pumps working together
- ☐ B 50% of that delivered by the two pumps working together
- ☐ C 60% of that delivered by the two pumps working together
- ☐ D 70% of that delivered by the two pumps working together
- ☐ E 80% of that delivered by the two pumps working together

4. In the examples discussed in the article, what was the three-year saving of applying a three-pump parallel duty setup compared with a two-pump parallel duty setup with a design load of 315L·s^{-1} @ 448kPa?

- ☐ A 5%
- ☐ B 10%
- ☐ C 11%
- ☐ D 21%
- ☐ E 26%

5. Which of these was not specifically noted as being a benefit of dedicated pump controls?

- ☐ A Ability to increase pump speed beyond specified value
- ☐ B Auto-pump sequencing
- ☐ C Best-efficiency staging control
- ☐ D End-of-curve protection
- ☐ E Pre-configured algorithms for standard applications including variable primary flow control

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References:

1 CIBSE TM56 *Resource efficiency of building services*, CIBSE 2014.


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Fan Coil Evolution

Quietly combining compact with powerful

The EVO270 Plus

Based on the hugely popular EVO270 range, the Plus introduces a new fan for even better performance.

Increased airflow at lower noise levels allows us to reduce the unit size in most applications, and the improved energy efficiency means specific fan powers are also significantly lower.

A high performance chassis fan coil unit for commercial, hotel and residential projects with customers already achieving significant savings when reviewed against existing specifications.

Key benefits include:

- Reduced footprint for duty point
- Low noise levels
- Improved efficiency
- Extensive range of units available
- Ease of installation
- Multiple control and connection options
- Potential commercial benefits through reduced project costs

To learn more about the EVO270 Plus range and benefit from this solution, contact **01202 305 800.**

www.abilityprojects.com

Ability

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