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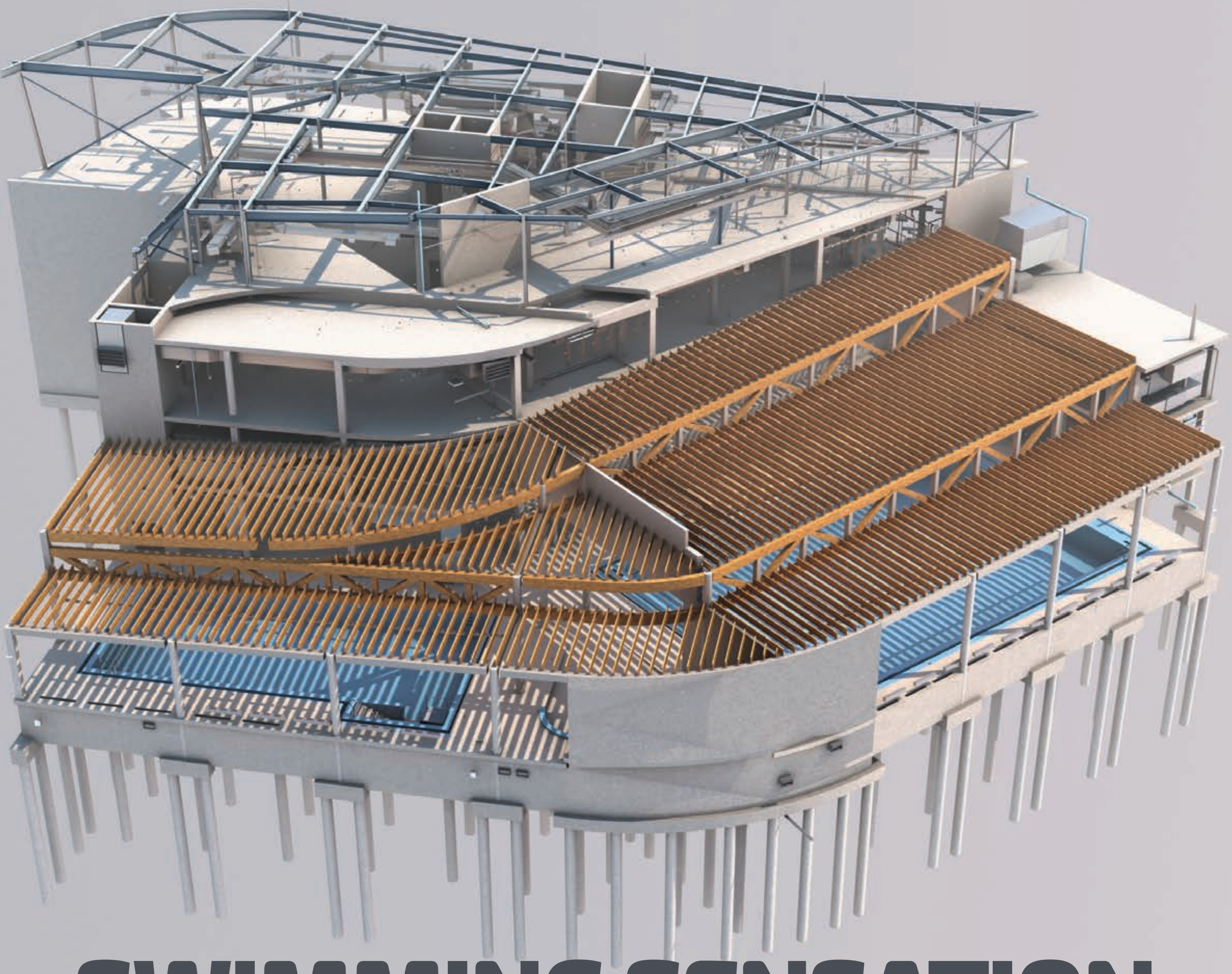
HOTEL AND LEISURE SPECIAL



SWIMMING SENSATION

Exeter City Council's new leisure centre will set new standards for Passivhaus pools

GOLF RESORT TEES UP HEAT PUMP RETROFIT

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Responsibility for energy and environment

Pooling ideas

Exeter City Council is one of a handful of local authorities that have pioneered the use of the Passivhaus building methodology in the UK. Having developed housing schemes to the standard for more than a decade, it is now delivering its most ambitious scheme to date – a Passivhaus leisure centre with three swimming pools. Utilities bills for the £35m development are forecast to be a third of a typical sports centre, and the Passivhaus Institute is using the construction to define new standards for swimming pools in the UK using the methodology.

Another great example of progressive engineering is a £700,000 heat pump retrofit at The Oxfordshire, a golf resort in the county. The scheme uses water from man-made lakes in an ambient heat network, which aims to contribute significant energy savings.

While gas boilers are still viable from a cost and carbon point of view, it's important they are optimised to minimise fossil fuel use. A new CHP boiler at Penrith Leisure Centre is a case in point, where careful specification has led to a 35% drop in energy use.

LIZA YOUNG, DEPUTY EDITOR lyoung@cibsejournal.com

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Healthy choices

For hotel and leisure facilities, protecting the integrity of the water supply is crucial, not only to protect the health of visitors but also to prevent damage to the business. Any issues with a system as fundamental as the water supply can seriously damage the organisation's reputation and will discourage people from visiting. A best-practice approach to the design, specification and installation of the pipework will help prevent these issues.

One of the main causes of contamination in otherwise well-maintained systems is stagnation, which can often occur as a result of poor design or interruptions in use. Avoiding layouts that create system dead-legs, ensuring correct pipe sizing and carefully selecting the pipe and fittings to minimise friction in the system all help maintain flow and water pressure levels. This will prevent stagnation and significantly lower the risk of contaminated fluids being accidently drawn back into the system from appliances connected to the pipework.

Furthermore, the nature of hotels and leisure facilities means that it is important to consider usage patterns. If there are likely to be times when certain areas, rooms or buildings will not be used, this must be factored in. For example, for hotels that experience significant seasonal variation in occupation levels, there might be rooms or floors that are used far less frequently at certain times of the year. In these circumstances, water can stagnate in the pipework allowing potentially dangerous bacteria such as legionella pneumophila to grow. Automatic flushing systems can be used to prevent stagnation and the build-up of contamination in the pipework.

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Hamburg football club nets a first with LiFi

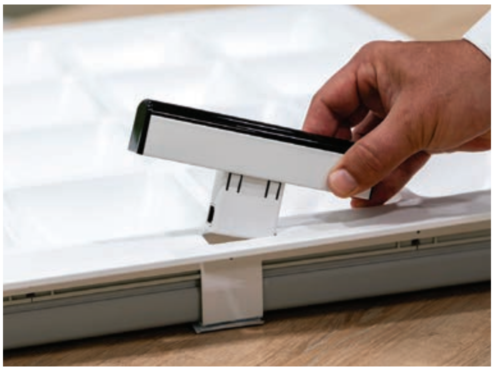
Press can access internet through lights via the technology

Hamburg football club has installed the wireless communications system LiFi in the press centre of its Volkspark stadium.

The Trulifi system was installed by Signify and provides journalists at the press centre with a reliable, secure and fast internet connection through the room's ceiling lights. It is thought to be the first LiFi system installed at a football club.

The technology uses light waves instead of radio waves to provide an internet connection (see 'Facts of LiFi', *CIBSE Journal Lighting Special,* December 2015 **bit.ly/CJOct19LiFI**).

Signify installed 84 energy-efficient Philips PowerBalance gen2 LED recessed luminaires in the stadium's press centre. Eight have an integrated Trulifi 6002 transceiver, which modulates infrared light waves to provide a data connection of up to 150 megabits per second (Mbps). Journalists using the system receive a USB access key that plugs into their laptop. This picks up the LiFi signal and transmits data back to the luminaire.



Reznor wins at Newcastle sports arena

Reznor has delivered an energy-efficient heating solution for the new Eagles Community Arena, a purpose-built 2,800-seat sports arena in Newcastle that is home for the Eagles Community Foundation and the Esh Group Eagles Newcastle basketball franchise.

Reznor provided a total Nor-Ray-Vac continuous radiant tube heating system of 12 24kW modulating NRV burners suspended at approximately 9m, complete with ball guards arranged in two temperature zones controlled by two SmartCom3 controllers. The single discharge fan is located remote from the hall. The modulating NRV burners can turn down to 50% of capacity, maximising comfort conditions and efficiency while minimising fuel consumption.

The NRV system design layout gives blanket heat coverage of the sports facility, eliminating any cold spots. Suspended from the roof, the heaters emit infrared rays that warm only objects and people in its path, rather than wasting fuel heating the volume of air in the building – boosting energy efficiency.

Customer control

Distech Controls has introduced Eclypse Sky Ecosystem, a new Bluetooth-based technology solution for improving occupant comfort in hotels. The new platform allows occupants to interact easily with the place they're visiting through a familiar technology, such as a mobile device or app.

The technology offers guests the opportunity to change the temperature, air conditioning or even lighting within a space to suit their own requirements and maintain a comfortable environment.

Stratford hotel completes kitchen installation

Specialist kitchen contractor C&C Catering Equipment has completed a major installation project at The Stratford hotel in London.

The 145-room hotel required commercial catering environments over multiple floors, including a basement kitchen, show kitchen, back of house kitchen, dry-curing room, bar, barbecue area, CO_2 coldrooms and fridges.

ISG was the main contractor and Tricon was the consultant on the project. C&C Catering Equipment worked at the site for more than 12 months to ensure the scheme was completed to a high standard and any challenges, such as time restraints because of the nature of the building, were overcome through planning and attention to detail.

Exeter's new Passivhaus swimming pool and leisure centre

Testing the water

The UK's first Passivhaus swimming pool, currently being developed by Exeter City Council, seeks to halve energy use and create a chemical-free, healthy environment. **Andy Pearson** speaks to project team members about the innovative design that aims to set new Passivhaus standards for pools

Exeter's new £35m Passivhaus swimming pool and leisure centre complex is predicted to save the city council about £200,000 a year in energy costs compared with a conventionally constructed design.

The savings mean it will take fewer than 10 years to pay back the increased construction costs of building the scheme to Passivhaus quality standards. Emma Osmundsen, managing director of Exeter City Living, the development arm of the council, says: 'It was a case of why wouldn't you build to Passivhaus standards, rather than why would you.'

St Sidwell's Point leisure centre, which is currently under construction, houses three swimming pools – a 25m competition pool, a 20m community pool, and a children's play pool – a spa, gym and studio, and a cafe. In addition to being the UK's first Passivhaus pool complex, the scheme has been designed to be climate resilient up to 2080 and to be a healthy building, and it will be the first pool in the UK to comply with the German water treatment standard DIN19643.

It is an ambitious set of firsts for a public authority-funded leisure centre, but the rationale for each is based on a sound business case. According to Osmundsen, the scheme's utility costs are predicted to be around £20 per m^2 per year, which compares favourably with the typical utility costs for a conventional leisure centre of £57 per m^2 per year.

'The energy savings will pay for capital uplift in construction costs; the enhanced internal environment should attract more customers and strengthen revenue potential; the high specification finishes will reduce life-cycle costs; and climate-proofing the design mitigates against future retrofit requirements and running costs,' Osmundsen explains.

The council's decision to build the UK's first Passivhaus swimming pool and leisure complex is less of a surprise when you consider that it has been developing schemes to Passivhaus standard for a decade. It started with a housebuilding programme, then launched a housing development company and, more recently, developed a supported-care housing scheme using the methodology.

The concept of a Passivhaus swimming pool is not without precedent: two such pools have been built in Germany. Despite the lack of a UK example, Osmundsen appears unfazed by the council's pioneering ambitions. 'We've come to understand, respect and see the benefits of Passivhaus – in terms of build quality, performance and indoor air quality – with our housing programme, so we were not particularly daunted in considering it for a leisure centre,' she says.

> "To meet the energy target, the design team took a holistic approach to the building's design, which included orientating the pool hall glazing to face south"

PROJECT TEAM

Client: Exeter City Council
Architect: Space & Place
Mechanical and electrical services and civil and structural engineering: Arup
Passivhaus/envelope designer: Gale & Snowden Architects
Passivhaus accreditation: Passivhaus Institute

The pioneering nature of the project has not been lost on the Passivhaus Institute, which will be the certifier for the scheme. It will monitor the project extensively when it is up and running, with the results used to inform a new Passivhaus standard for UK leisure centres.

For Passivhaus accreditation, the total primary energy demand – including space heating, hot water, cooling, ventilation and electrical loads, including lighting – is 375kWh·m^{-2} per year. (See panel, 'Energy targets'.)

'Our target was to achieve an approximate 50% reduction in energy consumption for the leisure centre compared with contemporary good practice,' says Stephen Platt, associate at Arup, the project's building services engineer.

To meet the energy target, the design team took a holistic approach to the design, which included orientating the pool hall glazing to face south. 'Swimming pools often have large north-light windows to give good, glare-free daylighting, but this can lead to an increased heat loss from the pool hall,' says Platt.

So a decision was made to glaze the south-facing façade of the swimming space to maximise beneficial solar gain, while brise-soleil have been added to minimise the risk of glare.

'Instead of attaching the brise-soleil to the outside of the building, as is common, Arup identified that locating them internally would allow beneficial heat gain in the pool hall,' says Platt.

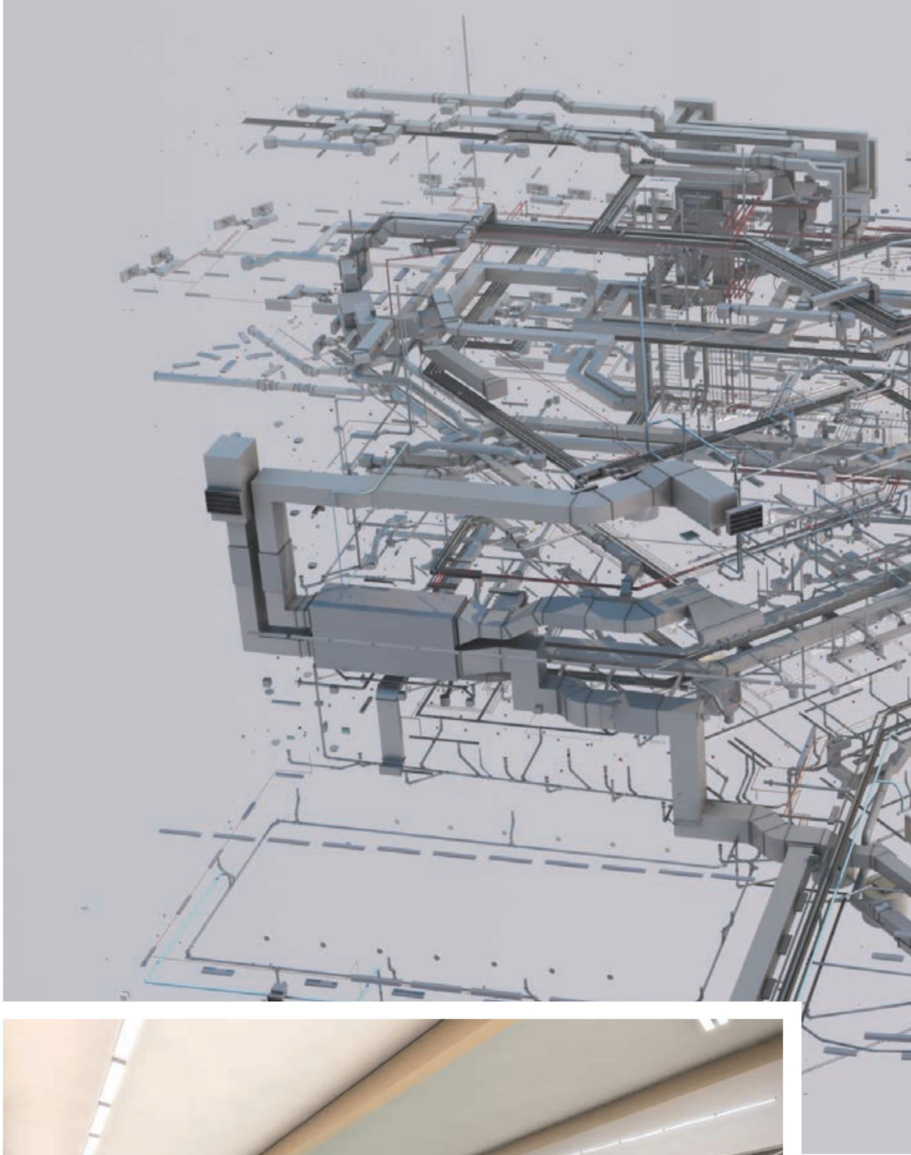
The future climate study, conducted by the University of Exeter, indicated that the leisure centre's unconventional orientation would also work best under future climate scenarios. It found that wet areas of the building would require heating almost all year round and so would benefit from a south-facing orientation. By contrast, the study found that the dry areas – the gym, cafe and crèche – would be more likely to overheat and so benefit from being orientated north.

The temperature of each room relative to the adjacent room has also been considered. 'In developing the spatial planning, the architect was asked to consider this; the aim was to reduce internal heat losses by limiting the adjacency of high- and low-temperature areas,' explains Platt.

Use of simultaneous heating and cooling air-source heat pumps will enable heat rejected from the gym and studio areas to be used to offset heat losses from the pool water. The heat pump output is supplemented by additional heat from gas-fired boilers when the load is too high to be met by the heat pumps alone.

Energy loss from a swimming pool is closely linked to evaporation. When water evaporates, the latent heat of evaporation is effectively absorbed by the process, resulting in heat loss from the body of water and the surrounding air.

To help minimise evaporation at St Sidwell's Point, the pool hall will be maintained at a relative humidity of 64%. Even at this level, evaporation from the pool surface will still take place, and need to be offset by dehumidification using a »



PASSIVHAUS ENERGY TARGETS

- Space heating demand for the pool hall of <40kWh·m^{-2} per year
- Space heating demand for all other areas of <20kWh·m^{-2} per year
- Gym cooling demand <22kWh·m^{-2} per year
- Pool water heating demand <73kWh·m^{-2} per year
- DHW heating demand <56kWh·m^{-2} per year
- Total electricity demand (ventilation, lighting, appliances, pool water treatment and circulation <120kWh·m^{-2} per year
- Total primary energy demand for Passivhaus accreditation, including space heating, hot water, cooling, ventilation and electrical loads, including lighting, is 375kWh·m^{-2} per year.

mechanical system. 'It was found that increasing the relative humidity set point by just 5% resulted in a 30% reduction in peak air flow required for dehumidification,' says Platt. 'Once you factor in the reduced fan- and heating-energy associated with this adjustment, as well as the reduced heat loss to the evaporation process, this element of the design proved to be a game-changer.'

To further reduce evaporation, two of the pools will be drained at night.

Osmundsen is unconcerned that maintaining the pool hall at a high humidity level might increase the likelihood of condensation occurring within the building envelope. 'It is a Passivhaus scheme; the fabric of the building is high-performing and designed to be free of thermal bridges, so it will easily withstand these levels of humidity,' she says.

In addition, the likelihood of the fabric or any fixtures and fittings corroding is reduced because a lower level of chlorine will be used to treat the pool water. 'By using fewer chemicals to treat the water, we're expecting to extend the lifespan of the building fabric,' Osmundsen says.

Chlorine free

It is believed that this will be the first leisure centre in the UK to use a process called 'microfiltration', which achieves exceptional filtration efficiency by forcing the water through a ceramic membrane, while using significantly less energy and water than traditional sand filtration.

According to Osmundsen, children 'typically consume a pint of water in a 45-minute swimming lesson'. The groundbreaking microfiltration technology will filter out contaminants with great efficiency and the chlorine dose will be reduced by using UV light as a primary means of water treatment, making the bathing experience much more pleasant and safe. 'It will offer swimmers exceptional water quality with minimal chemical content,' she adds.

In addition to its exceptional levels of water treatment, the building's design for health means that its finishes have been selected to minimise off-gassing and the release of VOCs.

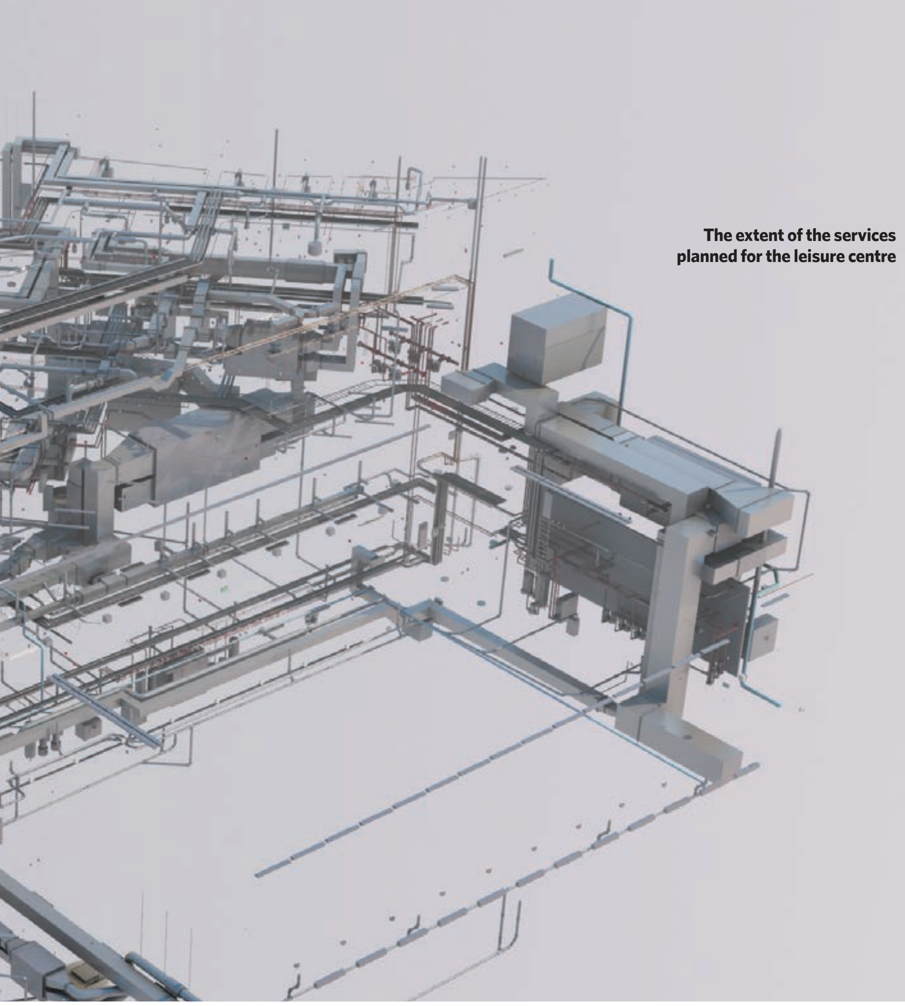
'We're developing the building to German biology standards SBM-2015 [see panel, Building biology testing methods], so the pallet of materials is very natural and neutral,' explains Osmundsen.

To comply with the standard, the scheme even includes a Faraday cage around the children's creche to protect them from electromagnetic fields. Even

BUILDING BIOLOGY TESTING METHODS

The Institut für Baubiologie+Nachhaltigkeit (IBN) Standard of Building Biology Testing Methods (SBM-2015) has been used to define critical levels of electromechanical radiation and indoor pollutants, to create an indoor environment that is exposure-free and as natural as possible.

The scheme is designed to comply with SBM-2015 Parts A (fields, waves and radiation) and B (indoor toxins, pollutants and indoor climate).



The extent of the services planned for the leisure centre

the mechanical ventilation systems will incorporate pollen filters and CO_2 sensors to limit its concentration to 800ppm, in line with the guidance.

A mixed-mode ventilation system, using natural ventilation from openable windows, will aid ventilation and prevent the complex from overheating in summer. The system will incorporate night-purge, using mechanical ventilation provided by the air handling units in bypass mode. 'The scheme ensures good summer comfort without compromising energy performance, even when the climate changes,' says Osmundsen.

The scheme is expected to open to the public in spring 2021. In use, its performance will be monitored extensively and Osmundsen's expectations for the scheme are high.

'Both the [Passivhaus] pools in Germany have exceeded their design performance criteria as their operators have become familiar with the building,' she says. 'We'll be looking for the operators to optimise the building's performance to ensure we retain the predicted cost savings.' **CJ**

Energy drive

The Oxfordshire golf resort is investing £700,000 in a major services retrofit, including a solar array, that will see heat pumps replace oil-fired boilers and potentially deliver sufficient energy and resource savings to boost annual profits by up to 30%. Alex Smith looks at how the challenges were addressed

The Oxfordshire Golf, Hotel & Spa has attracted some of the biggest names in golf, with the likes of Nick Faldo, Seve Ballesteros and Laura Davies all testing themselves on its championship course, which features more than 130 bunkers and four artificial lakes.

The lakes are water hazards to golfers, but to Lolli Olafsson, CEO and founder of Geyser Thermal Energy, they offer the opportunity to tap into a reliable source of energy for the clubhouse and adjoining hotel and spa.

Geyser is currently installing a closed-loop water source heat pump system as part of a £700,000 energy retrofit for The Oxfordshire. The retrofit will see pipework take water from the lake to the heat pump in the main plantroom. The aim is ultimately to replace the resort's oil-fired boilers and chiller with a low-energy heat pump system, linked to a 250kW solar array installed onsite.

Taking aim at energy savings

Geyser's retrofit heat pump strategy, along with the solar array installation, offers a payback of five years for the resort owners Leaderboard Golf. For Ryan Bezuidenhout, the general manager at The Oxfordshire, the return on investment had to based on the most conservative estimates of potential system savings. 'We have been very honest. I wanted the most pessimistic numbers possible,' he says.

Bezuidenhout is banking on a reduction in energy costs to maintain the resort as a top-end destination and increase its profits by up to 30%, as well as reducing its environmental footprint, a key commitment backed by Leaderboard Golf owners, Paul, Jennifer and PJ Gibbons. 'Energy is such a big cost to our business, and utility costs are only going to head north.'

The project, which is eligible for grants via the renewable heat incentive (RHI), centres on the installation of two modulating heat pumps in the main hotel plantroom. These will replace a R22 chiller and will partially replace the boilers – oil consumption is

New pipework installed on external walls to connect the pool with heat pumps

expected to be cut by two-thirds when the system is turned on, and by even more as the project progresses. Some split air conditioning systems will still be in operation, as they were added locally and are not connected to the plantroom.

The resort has three connected facilities: the golf clubhouse, built in 1994, and the hotel and spa added to the complex 10 years ago. Pipework has already been installed around the outside walls to connect the heat pumps with the spa and pool. Thermal storage has been increased to reduce the peak demand on the heat pumps, and the BMS has been upgraded so that the new plant can be closely monitored (see panel 'The Oxfordshire's £500,000 retrofit').

Olafsson says energy retrofits should be approached in three stages: first, reduce consumption; then calculate future loads; and, finally, see what energy resources are available onsite.

In January, Bezuidenhout initiated stage one – an energy-saving strategy whereby heating and cooling of hotel rooms was controlled manually by guests rather than left on permanently. 'Aircon used to be blasting 24/7, as were the towel rails. That's bad practice and complacent,' he says. 'The argument is you're providing a comfortable environment, but you don't have to have air conditioning on 24-hours a day.'

Bezuidenhout says guests have not noticed the change because rooms only take 20 minutes to regulate and maintain a desirable temperature. He says hotel staff carrying out inspections of bedrooms after guests check out ensure everything is turned off (to prevent staff changing corridor temperatures, TVRs were installed on the radiators and set at 20°C). Since the initiative began, energy consumption has already fallen by 11%.

Calculating future energy loads and establishing a benchmark for energy use was not straightforward, says Olafsson. Energy use was not monitored for different buildings, but the resort did have occupancy reports and they knew how much oil was being used. Electricity use was fairly steady over the year.

The savings are based on oil consumption; reduction in other M&E plant, such as pumps and fans, has not been included. For example, the use of heat pumps rather than boilers means the air handling units (AHUs) have been changed to run on lower temperatures, saving energy (as running AHUs at higher temperatures would require high temperature heat pumps, which are more expensive and use more electricity). There is also a saving from belt-driven fans replacing direct fans.

THE OXFORDSHIRE'S RETROFIT

- **Replace chiller with two heat pumps totalling 350kW (50kW of which are high temperature for the hot water)**
- **Upgrade AHUs: replace belt-driven fans with direct-drive fans, fix broken doors and leaks**
- **Replacement of fan coils**
- **Increase thermal storage to prevent peak demand on heat pumps**
- **Installation of tamper-proof TRVs on radiators and limit to 20°C**
- **Upgrade BMS to monitor and control system. Alerts added for when system operates outside set parameters**
- **Replace water softener with chemical-free alternative (Next Scale Stop)**
- **Add biological water treatment to waste in the kitchen to reduce fats, oils and grease in grease traps, and in sewer pipework and pumps**
- **Add variable speed drives to circulation pumps**
- **Add water treatment and sludge protection in heating system**

Future phases

- **Removal of oil boilers**
- **Upgrade of taps and shower mixers**
- **Reduction in use of DX air conditioning**

For Olafsson, using lake water as a source for the low-temperature heat network was a no-brainer. 'The beauty of water is that it is a fast-replenishing energy source, as water absorbs heat much more quickly than earth,' he says. 'There is plenty of capacity in the lake, and we can add more if we have to in the future.' The lakes were built originally to function effectively as a rainwater harvesting system.

One of the alternatives was a ground source heat pump, but the ground loops would have taken up space where the PV array is set to be installed, says Olafsson.

The lakes are used as a source of irrigation for the greens, which creates movement in the water, reducing the risk of freezing. 'We don't have to worry about the cold,' says Olafsson. 'The temperature of the lake in winter can go down to 7-8°C, and we could potentially take heat out with the temperature down to 3°C.'

Six 90mm pipes at 600mm depth will run from the hotel to the lake between golfing holes, so the trench work will not disturb the golfers on the course.

> "The beauty of water is that it is a fast-replenishing energy source, as water absorbs heat much more quickly than earth"

It is a low temperature system – the flow temperatures for the heating are 50°C/45°C and 60°C/55°C for the hot water – which means heat losses through the pipework are minimised and that cheaper plastic pipes can be used rather than steel, says Olafsson.

A closed rather than open water loop was selected in part because of the low maintenance required, says Olafsson. 'An open system can have issues with filtration. A closed loop is more reliable as long as the water is well maintained. The circulation pumps are the only moving parts,' he says.

Buffer tanks for both hot and cold water will reduce peak loads and enable the hotel to take advantage of cheaper off-peak electricity, says Olafsson.

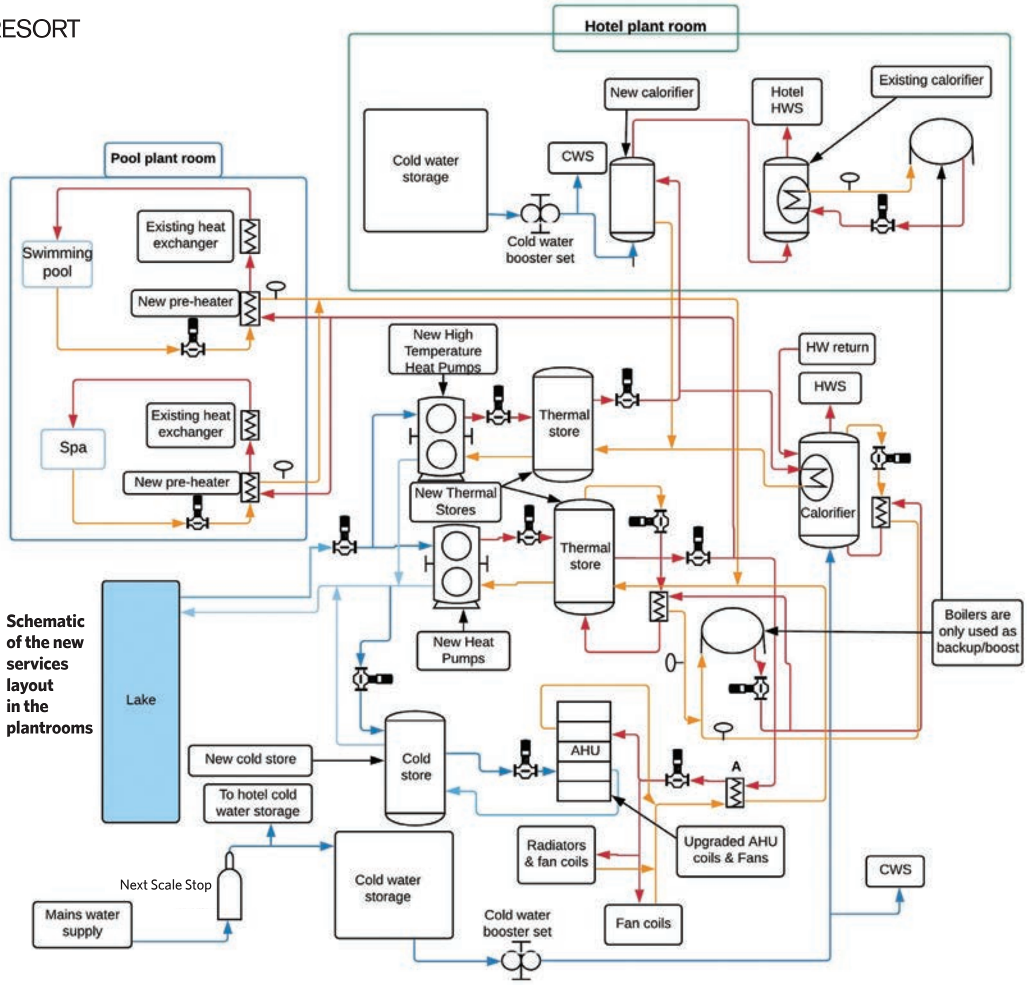
'If you base your heating system on peak loads for an hour a day, you might have a system that's 50% larger than if you had a buffer tank,' he says.

The BMS has been upgraded to help the team understand how the system works and what the loads are in the pool, spa and air conditioning. 'The unknown is what the total load will be. There will be continual improvement,' says Olafsson. 'We are pre-heating the pool and spa, and the idea is to eventually increase the capacity of the system to do all spa and pool heating.'

The system's existing water softener is being removed and replaced by a non-chemical treatment called Next Scale Stop. Olafsson says this uses a process known as template assisted crystallisation to convert the minerals in hard water to harmless, minuscule crystals. He says the system requires no electricity, saves » water and prevents excessive brine water from contaminating waterways. Olafsson estimates that adopting this method of scale prevention will save the hotel and spa 1.5-2 million litres of water a year.

The pipework, solar array and plantroom will be installed this autumn, and the heat pumps turned on, initially working alongside the oil-fired boilers that act as a backup. 'The fun part will be switching it on and seeing what the performance is,' says Olafsson, who is keen to continuously assess system loads and performance so the heat pumps can provide all the heating demand onsite – including the spa and swimming pool – and all oil boilers can be removed.

Needless to say, a proper maintenance regime will be in place. 'If they are not maintained, the efficiency can be eroded and we're back to where we came from,' says Bezuidenhout, who is bullish about how the retrofit will affect The Oxfordshire's bottom line: 'The potential energy savings, RHI and solar installation gives us a fighting chance of making a huge impact,' he says. **CJ**



Schematic of the new services layout in the plantrooms

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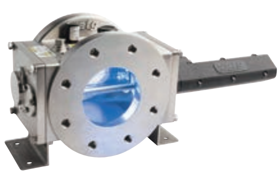

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It's all going swimmingly!

A leisure complex in Penrith is reaping the benefits of CHP thanks to good design, sizing, integration and maintenance, plus effective collaboration with end users says Remeha's **Mark Gibbons**

Total primary energy usage at Penrith Leisure Centre, in Eden, has fallen by 35% since it installed a combined heat and power (CHP) and boiler solution.

When the leisure complex's existing plant began to fail, its owner – Eden District Council (EDC) – wanted a high-efficiency solution that would improve the site's energy performance without affecting comfort levels or visitor satisfaction. Increasing operational efficiency was another consideration for the managers of the site, GLL.

Leisure centres are, typically, intensive energy users, with associated costs often amounting to as much as 30% of the total operating expense. In complexes with swimming pools, the heating and hot water provision alone can account for as much as 65% of energy consumption. Electricity use is also high, especially in centres that use it extensively for air conditioning, ventilation, lighting, fans, pumps and more.

To meet the requirements at Penrith Leisure Centre, M&E engineers Thomas Armstrong recommended replacing the old plant with a Remeha 20/44kW condensing CHP unit, operating in conjunction with three Remeha gas high-efficiency condensing boilers.

Best-practice design

CHP generates electricity and heat simultaneously on site, in one highly-efficient process. As such, it is capable of delivering a 30% reduction in primary energy use compared with traditional generation. To generate maximum returns, however, a CHP unit needs to operate for as many hours of the year as possible.

Penrith Leisure Centre has a 25m swimming pool and 13m studio pool, as well as a gym, studios, sports hall and changing rooms. It is open almost every day of the year, so has high, constant demand for heat and power, making it well suited to using CHP. In fact, it had previously been heated by a turbine CHP, boilers and water heaters. Unfortunately, this unit was oversized and failed to achieve the anticipated performance levels, energy savings benefits and life expectancy.

Thomas Armstrong sized the new condensing CHP on base load, to ensure maximum run hours and prevent cycling, with the boilers meeting peak demand.

Good design

Pairing CHP with high-efficiency condensing boilers is an effective way of ensuring the system performs to its full

potential, reducing operational costs while generating electricity at lower gas prices. However, good integration with the system – and, in this case, the condensing boilers – is essential to optimise system performance.

Close collaboration between the manufacturer and Thomas Armstrong through design, installation and commissoining was instrumental in achieving the required high operational performance. The CHP has been running non-stop ever since. 'The CHP produces 44kW of heat and it's using it all, even in the summer months,' says Thomas Armstrong's Stephen Clarkson. 'It's heating the constant temperature circuit, feeding radiators, fan convectors and air-handling units, providing hot water for shower facilities, and, of course, heating the two swimming pools.'

Service plan

From the outset, Thomas Armstrong was clear about the need to consider long-term maintenance of the equipment. 'For us, it was important to install a unit that was not only sized correctly for maximum run time, but that also had a service programme to keep the CHP operating at its optimum' says Clarkson. 'We looked at the service plan offered with the unit before we even purchased the CHP.'

Implementing a service plan, usually with the supplier, ensures that the CHP operates continuously and at optimum performance, maximising whole-life efficiency and related benefits. 'A CHP unit is a specialist piece of plant,' Clarkson added. 'Taking out the service plan gave us peace of mind that we have the support of engineers, trained by the manufacturer, who understand the plant they are working on.'

Suppliers will usually offer a choice of CHP service levels that encompass remote monitoring and timely maintenance and services. 'Servicing the CHP allows the engineer to monitor the multiple moving parts and electrical components, identify any wear and tear, and react quickly to any issues,' explains Clarkson. 'That way, the CHP continues to produce electricity and heat for the building.'

Visualisation

Remote monitoring is an important part of the service programme, because an estimated 85% of reported CHP

Remeha's CHP unit has helped cut energy use at Penrith Leisure Centre by 35%

"Remote monitoring is an important part of the service programme, because 85% of reported faults can be corrected and reset remotely"

faults can be corrected and reset remotely. This visualisation also removes any responsibility on the facilities manager to monitor the unit or report on its operation. 'If the unit has stopped working, is in alarm, or the performance drops, this is picked up within hours and action is taken to rectify the problem without prolonged downtime,' says Clarkson.

With experienced engineers taking care of the CHP, maintenance is carried out promptly, with minimum disruption. This reduces inconvenience and costs – for the installer as well as the end user – because issues can be resolved before they become a problem. 'A service plan also takes the responsibility away from the end user or building operator to monitor the unit and to report problems on something they may not fully understand,' says Clarkson.

Long-term benefits

The potential financial savings from a condensing CHP such are considerable – in the region of £60,000 over its 10-year lifetime, inclusive of a service plan. As it is also engineered to meet ultra-low NO_x criteria, it is capable of reducing greenhouse gas emissions by up to 60% compared with traditional generation.

From potential to real-world savings, initial reports from EDC have revealed a higher-than-average 35% reduction in total primary energy consumption at Penrith Leisure Centre since the CHP and boilers were installed. The council and GLL are extremely pleased with the smooth running of the CHP system and the significant improvement in energy performance at the centre, with its associated cost savings.

As CHP generates electricity on site at gas prices, the greater the 'spark spread' – or difference between gas and electricity costs – the greater the savings from a CHP system. Given that electricity prices are currently nearly four times the cost of gas, the wide 'spark spread' is boosting the financial rewards still further at Penrith Leisure Centre.

Implementing a long-term service plan and ensuring correct sizing have been key to maximising the financial and environmental returns. Enabling the CHP to operate continuously will maximise its whole-life performance to deliver the full compelling advantages that this highly-efficient technology can offer.

As Penrith demonstrates, CHP gives leisure centre owners and managers a strategic, economic tool to improve the energy performance of their buildings. The project exemplifies how – with effective collaboration between contractors, suppliers and end users, and adherence to good design, sizing, integration and maintenance – the full potential cost and NO_x savings of CHP can be reaped. Energy efficiency alone might not deliver a net-zero carbon zeconomy, but best practice implementation of a highly-efficient technology such as CHP can make huge strides towards this goal. **CJ**

■ **MARK GIBBONS** is a sales manager at Remeha CHP


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Pumping wholesome water in buildings

This module explores the requirements for boosting wholesome cold water pressure in certain building applications and considers possible solutions

As structures become taller and more extensive, with more demanding water requirements, and statutory mains water pressures remain modest, there are good reasons for boosting the pressure of the water supply serving a building. This CPD module will consider the need for wholesome cold water pressure boosting and explore some of the possible solutions.

UK water authorities are obliged[1] to supply water at a minimum 70kPa (0.7 bar) at the point where the communication pipe joins the consumer supply pipe, which equates to approximately 7m head (height) of water. This provides a minimum standard that could be sufficient to supply water to the top of a two-storey house, but in newer homes – especially those with unvented heating systems – all the hot and cold taps are likely to be supplied directly under mains pressure,[2] and 70kPa may not be sufficient to serve showers on the first floor properly. There are good reasons for moderating mains pressures to reduce network costs and losses and, in many cases, sanitary fittings that have a high inlet water pressure can use excessive water (as discussed more fully in the Wrap publication *Reducing water use – pressure, pipework and hoses*). There are, however, many sanitary fittings (particularly showers and commercial equipment) that require water static pressure in excess of 1 bar to operate correctly.

For larger and taller installations, mains water pressure can be an issue, as it is unlikely to be able to deliver water beyond three to five storeys, and is then dependent on any subsequent changes in the water network, such as new local developments and the deterioration of supply pipes. If the supply pipework is undersized or installed based on the assumption of a higher mains pressure (that has subsequently dropped), the static pressure may fall below that required for adequate flow through the outlets.

The methods for assessing the required flow of water in building pipework systems are increasingly under review, with traditional estimating methods apparently leading to oversizing (as recently reported by *CIBSE Journal* in articles by David Glossop and Achala Wickramasinghe in the April 2019 issue). It is not an exact science, since it is dependent on the vagaries of the occupants' water consumption. The designed water service must also comply with current UK building regulations, such as described in England Building Regulations AD G,[3] that limit the designed daily water consumption 'for the prevention of undue consumption of water'. Very few systems will be sized for all outlets to be supplied simultaneously. The CIPHE loading unit system,[4] which accounts for diversity of use, currently 'offers a recognised industry standard for the sizing of pipework systems within the UK',[5] and is the method that is adopted in chapter 2 of CIBSE Guide G.[6]

Whatever the flowrate that has been assessed, the regulations to ensure water quality require that the water supplied must be 'wholesome'.[3] The building's water systems must also be designed to ensure that there cannot be any backflow from the building systems that could contaminate the water supplier's main distribution network.

In smaller, typically domestic applications, a pump can be used as a direct booster by drawing water directly from the water mains »

» at a maximum flowrate limited by the water suppliers, but must not allow backflow into the mains. However, in larger systems, the booster pump typically draws water indirectly from an intermediate – or 'break' – water store. Such stores will be referred to as 'cisterns' in this article, and may include one-piece cisterns, sectional tanks or any other vessel open to atmospheric pressure but sufficiently sealed to prevent airborne contamination. The stored water provides a physical break from the main supply, so preventing backflow while also maintaining water supply to outlets under peak flow demands, possibly when the supply from the mains supply is insufficient. Depending on application, this can provide storage sufficient for, typically, up to 24 hours' consumption (as detailed in CIBSE Guide G section 2.3.2). As described by CIBSE Guide G, pumping will provide flexibility in the positioning of storage cisterns, as well as ensuring that there is sufficient remaining operating pressure at the outlets to deliver the required flow at times of peak simultaneous demand.

Pump 'booster' sets may be used to move water from smaller low-level break cisterns to larger high-level cold-water storage cisterns, so that water can then be supplied using a gravity flow system. The pump set can move water to the higher-level cisterns (or multiple cisterns at intermediate levels serving groups of floors) at a rate that is significantly lower than the peak water usage, making use of the buffer provided by the distribution cisterns. This combination of pumped and gravity feeds would continue to provide water in the event of a failure of the pump. Depending on the application, such a system may also require pumping (from the high-level tank) to the final outlets on the top floors of the building in order to meet the pressure requirements of fittings that cannot be fully met by the available static head.

Booster sets may also be used to pressurise both the hot- and cold-water systems directly, drawing from a break cistern without any further storage, as in the example shown in Figure 1. This is the most popular arrangement[6] for contemporary UK commercial multi-storey buildings and reduces the risk of contamination by removing the need for distributed storage cisterns.

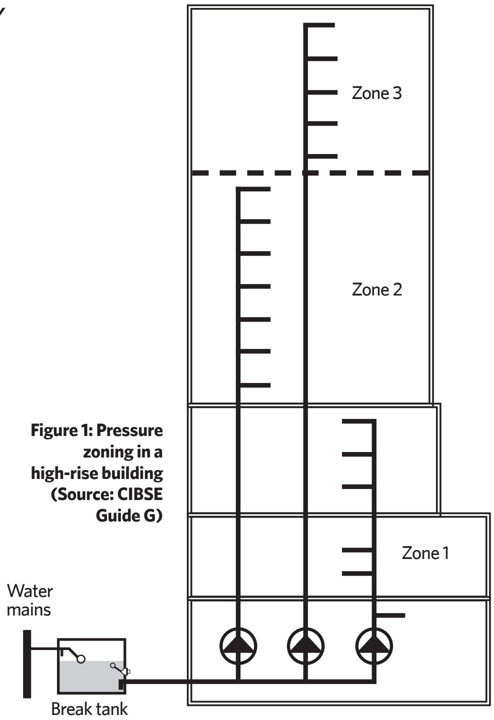


Figure 1: Pressure zoning in a high-rise building (Source: CIBSE Guide G)

Where this is used in high-rise commercial developments, the pressure delivered (see 'Water pressure' panel) will typically be zoned with a separate pump set and riser pipe for each pressure zone, as in the high-rise building illustrated in Figure 1. This reduces the risk of developing excessively high pump pressure within system pipework and fittings in the lower levels of the building. CIBSE Guide G provides guidance for the appropriate delivery pressure to the initial floor in a group ranging from 800kPa for groups of six floors up to 1,000kPa for a 12-floor group. There may be a need for pressure-reducing valves on the lower floors of the groups to moderate the pressure for some fittings.

For low-rise buildings – such as small apartment blocks (up to six floors) – and light commercial applications, a simple variable speed pump set can be used, such as that shown in Figure 2. The pump normally has a flooded suction (that is, the inlet is below the water level in the break cistern), and delivers water to each tap and outlet to meet demand.

For applications such as single dwellings, an automatic pressurised pumping system supplying water direct from the water supply to all taps and outlets can be used but must be carefully selected and operated, otherwise it might cause significant issues in the systems. The UK water regulations allows up to 12 litres per minute to be drawn from the water main by such an arrangement without the requirement for water authority consultation.

Fixed speed booster sets, by virtue of their on-off control, create varying pressures that lead to fluctuating flows at the system outlets and pressure surges within the system, with consequent noise and potential damage. Despite the application of buffer vessels, switchgear and contactors can wear quickly as a result of the high number of starts and stops, particularly when demand is low. In tall buildings or large system layouts, fluctuating water demand can lead to pumps regularly stopping and restarting, causing pressure surges throughout the system.

Variable speed pumps deliver a more smoothly controlled water system and, because they employ soft start and stop, the hydraulic and electrical stresses are reduced. Electrical energy consumption is less than when using fixed speed pumps, since they can be operated to meet the load at best operating efficiency more closely.

As with any pump selection for building services, the pump should be selected to operate at high efficiencies for the range of expected pump speeds (typically 25% through to 100%).

So, for example, in the variable speed pump characteristics in Figure 3, the dark blue section is where the pump should normally operate and, ideally, as close to its most efficient operating point as marked by the orange curve. This is possible with carefully considered pump staging and control.

Figure 2 shows a small combined break cistern and

Figure 2: Example of an all-in-one tank and booster set

WATER PRESSURE

Common units: 1 bar = 100kPa ≈ 10m head.
Static head is because of the height difference, z (m), between the water source and the point of use. Static pressure = ρgz where ρ=density of water (≈ 1,000kg·m^{-3}), g = acceleration as a result of gravity (9.81m·s^{-2}).
Distribution dynamic pressure loss is because of flow losses through pipe length, valves and fittings, and is normally calculated for the index run of pipework.
Required 'dynamic' outlet pressure is typically between 0.2 and 4 bar, depending on the type of fitting.

booster set that employs two submerge variable speed pumps for duty/assist or duty/standby configuration, connected in parallel into a common flow and return manifold. Such multi-pump configurations are typically supplied complete with pressure vessels that allow for expansion and reduced impulse forces. These also act as buffers to prevent the pump set operating on every reduction in the system pressure, and provide a delay between pump 'start' and 'stop'. The vessels will recharge when the pumps are not being fully used to deliver water to the outlets. Expansion vessels fitted to pump sets with variable speed drives are typically smaller than those required on fixed speed pump sets, as they only need to store water for very low flow conditions. To prevent high-pressure overrun when demand is less than the design, a pressure-limiting or variable control flow device is fitted on the pump outlet.

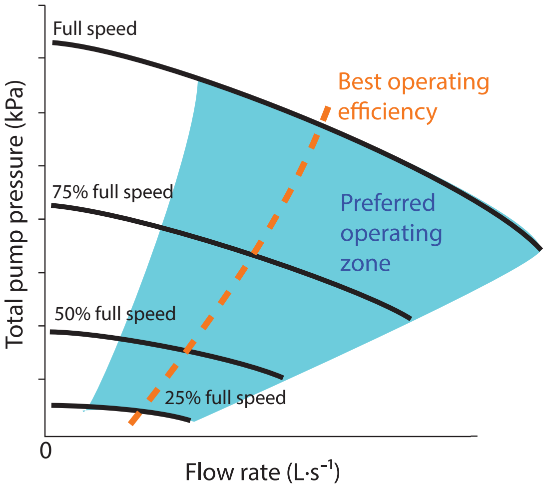


Figure 3: Example variable speed pump performance curves. The most effective operating points are indicated by the orange peak efficiency curve

Larger arrays of pumps, such as shown in Figure 4, with discharge and suction manifolds mounted on an anti-vibration base, are supplied in modular form typically with an integrated control panel. Where there are multiple pumps, the minimum recommended flowrate of each pump should be considered and, where necessary, a smaller lead pump may be used. For systems with wide flow variation, the pump controller can automatically minimise energy consumption by operating each pump closer to its peak efficiency, and cascading the operation of the other parallel pumps to ensure that best operating efficiencies are maintained. Multi-pump arrays have inherently higher levels of redundancy, and the smaller pumps, non-return valves and pump isolating valves are easier to maintain and repair.

The vertical multistage centrifugal pumps, as in Figure 4, are likely to be applied in larger and taller buildings, and the modularity provides the opportunity to readily meet the needs of future changes in building use. These are available in many configurations, with different numbers of impellers stacked vertically, and are likely to be able to deliver 2,500-3,000kPa or more. Although pressure vessels are shown mounted on this set, large, floor-mounted expansion vessels are commonly supplied separately for connection to the discharge pipework. These are used in applications such as high-rise accommodation, larger multi-storey buildings, and those with high-pressure requirements.

Typically, if a standby pump is required then there is only one available. However, for critical duties it may be considered necessary to allow for more than one unit failing. There may be an advantage in employing all pumps as duty pumps so they can all operate together at the most efficient operating point for the maximum time (as discussed more fully in the May 2019 *CIBSE Journal Commercial Heating Special* CPD).

Protected, prefabricated enclosures may be used that include a storage cistern and pump set in one space that is located externally to the main building. Such heated, illuminated enclosures can contain other plant such as water treatment equipment, and should be constructed and insulated to moderate heat losses and solar and thermal gains. Similarly, fully prefabricated arrangements are also available that can be located underground, as shown in Figure 5.

Whatever the form of booster set, some suppliers believe it is acceptable to bring together components such as pumps, drives and controls, and rely on the individual items' CE marking as compliance for the set. As highlighted by the BPMA[7], 'the complete set is a machine in its own right and must therefore have a label affixed with a CE mark and be supported by all the appropriate documentation, including a Declaration of Conformity'.

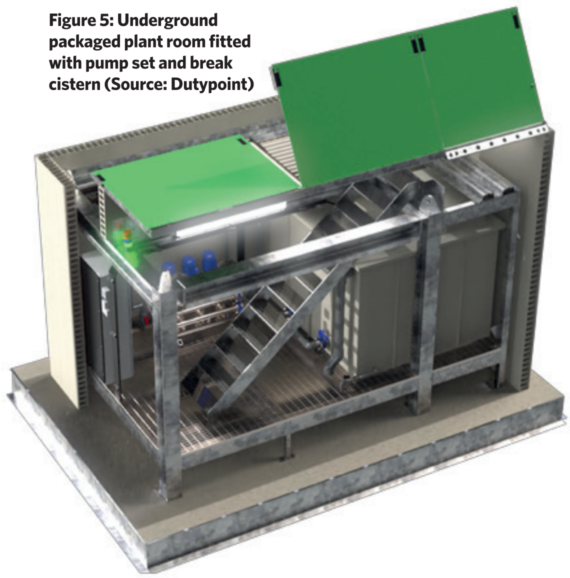
In assessing the suitability of systems, it is important to consider the range of conditions, including extreme (but possible) operation, such as when the distribution is obstructed and pressures rise beyond those normally expected. As with all building services, appropriate installation and commissioning is key to avoiding operational problems and premature failure. Importantly, this includes ensuring that there is ready access and space for maintaining and exchanging pump set components.

■ With thanks to Frazer Ross from Dutypoint for the use of his material in the production of this article.

■ Turn to page 22 for further reading and references. »

Figure 4: An array of five parallel connected vertical pumps, each with an expansion vessel

Figure 5: Underground packaged plant room fitted with pump set and break cistern (Source: Dutypoint)



Module 153

October 2019

1. What is the minimum pressure at which UK water authorities are obliged to supply water?

- ☐ A 0.1 bar
- ☐ B 0.3 bar
- ☐ C 0.5 bar
- ☐ D 0.7 bar
- ☐ E 1 bar

2. Which CIBSE Guide is likely to be most useful when assessing the design of a building's water system?

- ☐ A A
- ☐ B C
- ☐ C E
- ☐ D G
- ☐ E M

3. What is noted as the most popular arrangement for contemporary UK (multi-storey) commercial buildings?

- ☐ A Drawing water direct from mains without the interference of booster pumps
- ☐ B High-level booster pumps drawing water from a low-level break cistern and then pumping water direct to outlets
- ☐ C Low-level booster pumps drawing water direct from the mains and then pumping water direct to outlets
- ☐ D Low-level booster pumps drawing water direct from the mains supplying high-level cisterns, and gravity supply of water to outlets
- ☐ E Low-level booster pumps drawing water from a low-level break cistern and then pumping water direct to outlets

4. What potential outlet pressures are noted in the article as being typical of the multi-pump sets that are illustrated in Figure 4?

- ☐ A 500-1,000kPa
- ☐ B 1,000-1,500kPa
- ☐ C 1,500-2,000kPa
- ☐ D 2,000-2,500kPa
- ☐ E 2,500-3,000kPa

5. Which of these is least likely to be true regarding pressure vessels?

- ☐ A Expansion vessels fitted to fixed speed pump sets are typically smaller than on variable speed pump sets
- ☐ B System impulse forces are reduced
- ☐ C The vessels recharge when the pumps are not otherwise fully used
- ☐ D They act as buffers to reduce frequency of start/stop cycling
- ☐ E They provide opportunity for expansion

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Further Reading:

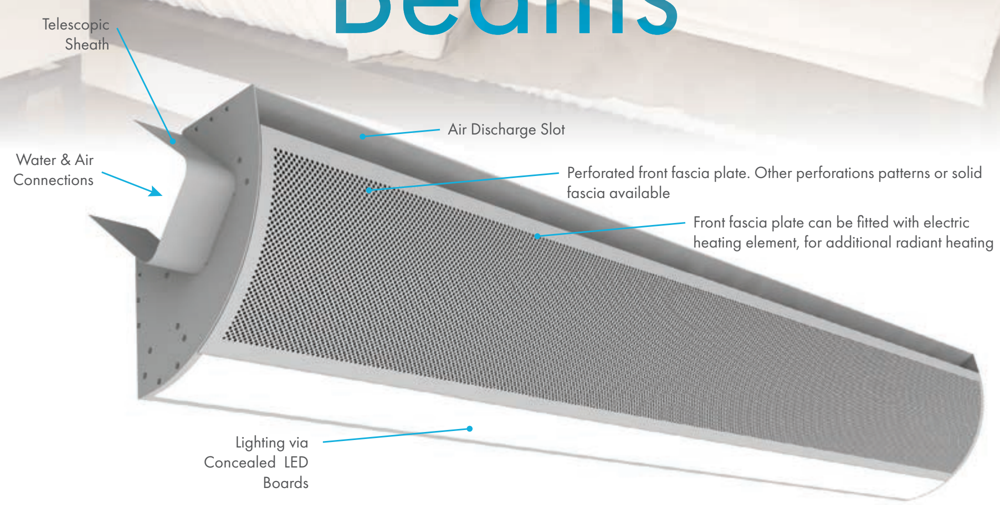
CIBSE Guide G: 2014 (2017 revision) *Public health and plumbing engineering*, chapter 6, sections 1 to 5.

BS 6558:2015 *Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Complementary guidance to BS EN 806* provides very useful system information and layout schematics.

References:

1 *The guaranteed standards scheme (GSS): summary of standards and conditions*, OfWat 2017.
2 *Water storage tanks and cisterns*, UK Drinking Water Inspectorate, 2013.
3 The Building Regulations 2010, Approved Document G, *Sanitation, hot water safety and water efficiency*, Appendix B.
4 *Plumbing Engineering Services Design Guide*, The Institute of Plumbing (CIPHE) (2002).
5 *An assessment of the validity of the loading units method for sizing domestic hot and cold water services*, CIPHE/CIBSE/Heriot Watt Uni/SoPHE 2017.
6 CIBSE Guide G, *Public health and plumbing engineering*, CIBSE 2014 rev. 2017.
7 **www.bpma.org.uk/news-article/5996faef4f837/EU-Compliance-for-Booster-Sets-is-a-Legal-Requirement** – accessed 3 September 2019.

Cornice™ Hotel Chilled Beams



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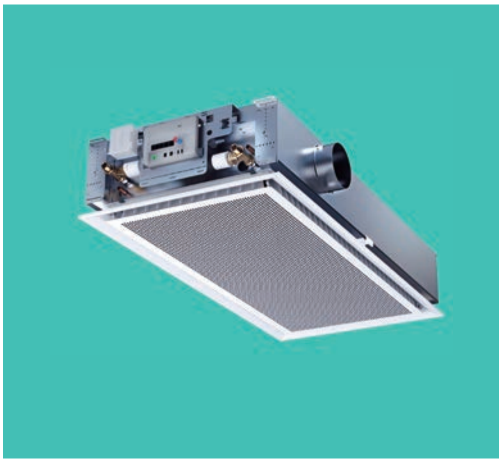

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