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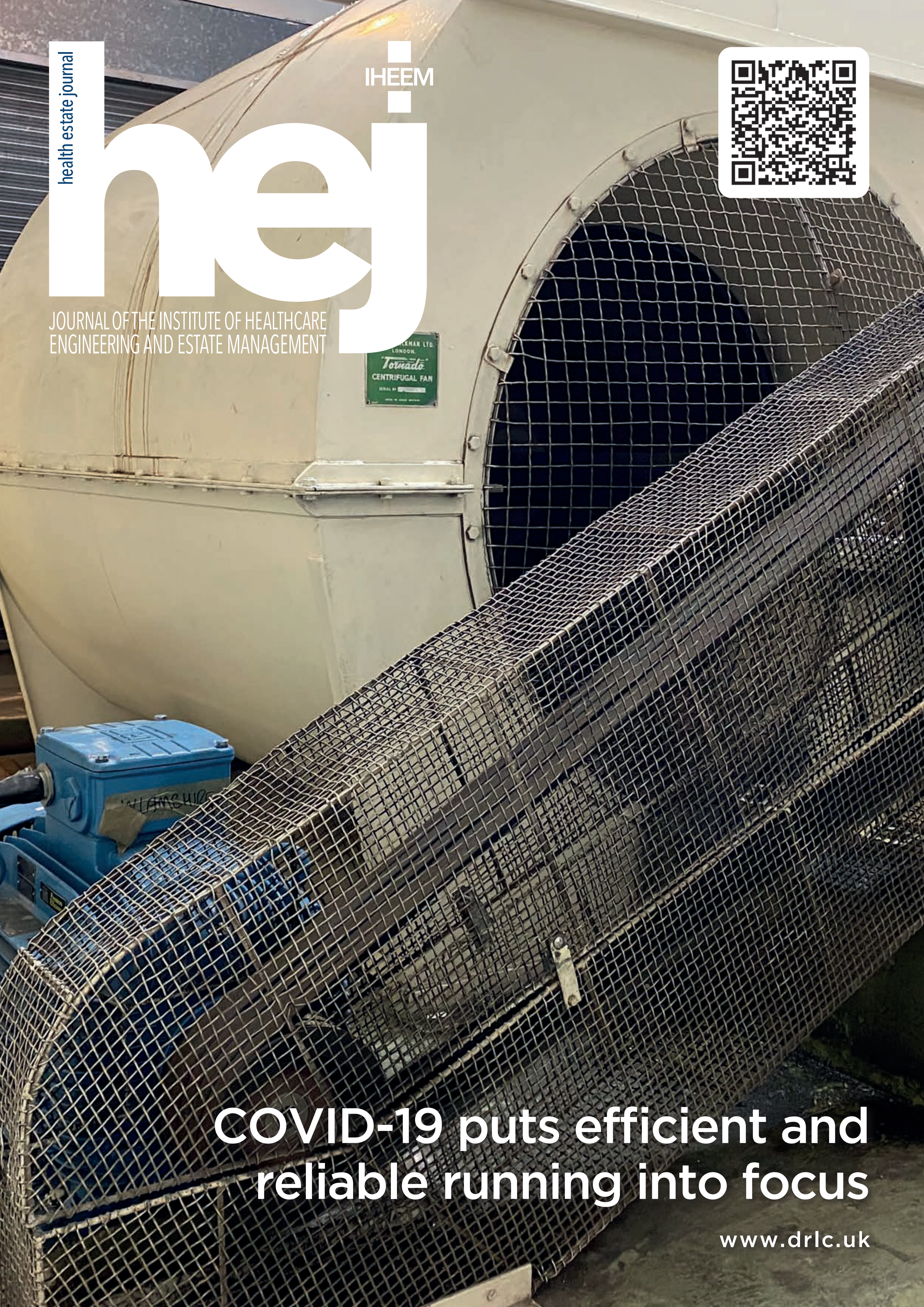


# COVID-19 puts efficient and reliable running into focus

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**With input from her colleague and MD, Authorising Engineer (Ventilation), David Livingstone, Dr Louise Webb, Project director at DRLC – a provider of authorising and regulatory compliance consultancy services for the healthcare estates and healthcare engineering sector, considers the key steps for keeping air-handling and other vital ventilation plant in healthcare facilities running both reliably, and – with the drive towards Net Zero – as efficiently and sustainably as possible.**

The COVID-19 pandemic has focussed attention on how buildings, and particularly those within the healthcare estate, are ventilated. Ventilation, both natural and mechanical, uses energy, especially in UK winter months, and of course NHS Trusts are simultaneously under increasing pressure to reduce their energy consumption and carton emissions in the drive towards Net Zero Carbon. Nick Evans, Energy Environment Sustainability manager for Lincolnshire Partnership NHS Foundation Trust (LPFT) and Lincolnshire Community Health Service NHS Trust (LCHS), says of the issues he faces in moving a mental healthcare Trust and supporting a community healthcare Trust in Lincolnshire towards Net Zero Carbon: "Our building stock at LPFT and LCHS ranges from Victorian buildings to premises currently under construction, with the majority of the buildings constructed from the mid-1970s to the early 1990s. With the ever-increasing need to move away from fossil fuel heating systems, and to utilise renewable, more sustainable technology, there will be an increased demand on the amount of electricity consumed. We therefore need to explore every opportunity to increase the energy efficiency of our buildings, and reduce our energy consumption.

## AHUs' greater energy efficiency

"One area we are currently looking into," Nick Evans explains, "is replacing existing old belt-driven ventilation plant with more energy-efficient air-handling units (AHUs) through the use of direct drive fan technology. With such units offering potential energy efficiency of up to 98%, compared with efficiency as low as 50% from belt-driven electric motors, there are significant energy savings to be made. To enable us to move away from our reliance on fossil fuel heating systems, I have been researching and investigating how we can use air and ground source heat pumps for our standalone mental health units and health clinics. Lincolnshire has a lot

Image courtesy of Air Sentry Ltd

Figure 1: An Air Sentry air purifier.

of sunshine hours, and this makes it very advantageous to use solar power, so to further help compensate for increased electricity consumption, we are currently looking to install photovoltaic cells on a number of our south/south-west-facing properties. I am also looking at small wind turbines for some of the remote buildings, which are in exposed locations. Net Zero Carbon is a challenge, and we are being proactive in addressing the issues early on."

## Running '24/7'

The COVID pandemic has resulted in air-handling units being run 24/7. Units in healthcare premises that previously were switched off when the area was not in use are now being left to run continuously. Treatment rooms are recommended to have 10 air changes / hour, and where there is no mechanical ventilation, this is being achieved by opening windows, which in winter adds to the heating bills.

Authorising Engineer, David Livingstone, explains his experience of advising on increasing ventilation while keeping energy usage down. He says: "The basic principle is to provide the necessary ventilation utilising the minimum amount of energy. In the past the air-handling units in operating theatres were put in 'set-back', which meant they were running at half fan speed. In the past few years it has been recommended to turn operating theatre plant 'off' 15 minutes after finishing the last procedure – a step which can be automated via sensing of the last movement in the theatre or on a time schedule on the Building Management System (BMS), or via a connection to the theatre lights. The plant is then reactivated 30 minutes before starting an operation. Modern plant put on 'Night Set Back' sees the plant switched off. Of course some emergency operating theatres have to be left running '24/7', but these are the exception. These standards are now in the new HTM 03-01, which has as one if its main drivers the Net Zero Carbon agenda.

"Many ventilation systems," David Livingstone continues, "completely shut down when the facility is not in active use. If the system needs to be 'on' outside of normal occupancy hours to maintain minimum conditions – for example to run relative sensor or dew point sensors in the environment to prevent excessive humidity – the plant should run at a predetermined minimum speed, which in the past was half speed, during unoccupied periods."

## HTM guidance

Areas that prior to COVID-19 were not deemed to require measured rates of ventilation have now come under the guidance of the HTM03-01. For example, suites used for the administration of Electro Convulsive Therapy (ECT) in

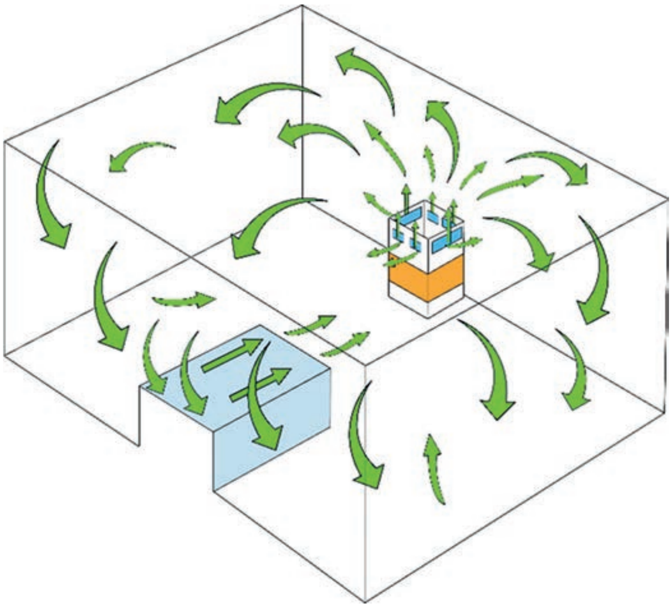

Diagram courtesy of Air Sentry Ltd

Diagram 1: Clean air flowing from an Air Sentry air purifier.

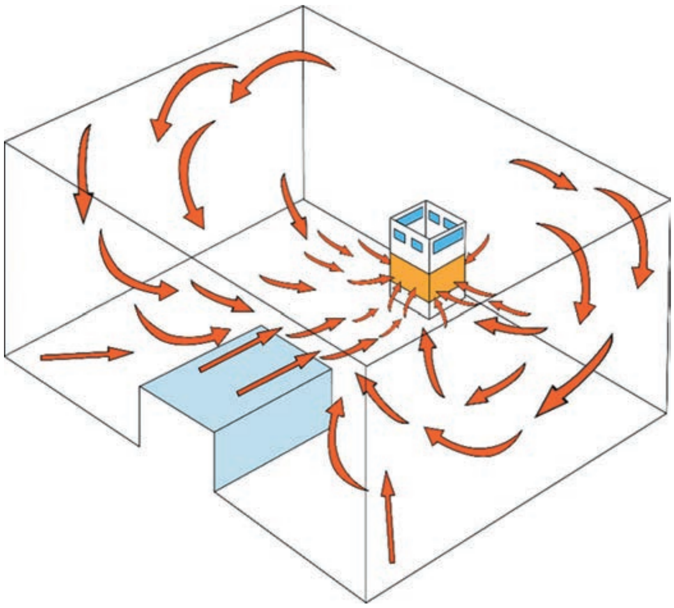

Diagram courtesy of Air Sentry Ltd

Diagram 2: Input air being drawn into an Air Sentry air purifier.

mental health settings now require 10 air changes / hour and the patient discharge rooms require 6 air changes / hour. General wards and waiting areas in hospitals are also being considered as areas where increased ventilation is being provided, with a minimum of 6 air changes / hour becoming the accepted norm, which is significantly greater than the CIBSE occupancy guidance levels. Where air-handling units are not supplying enough air, the room ventilation rate can be supplemented by opening windows and/or the provision of air scrubbers.

## Air scrubbers/Air purifiers

These units are often portable, and are generally about the size of a small under counter fridge. They contain HEPA filters capable of trapping particles down to 0.01 micron in size, as discussed in the NASA research into these filters in 2016.[1] The deployment of these portable units can cause issues in large hospital Trusts, as many types need to be maintained every two weeks – a task which tends to be delegated to the end-users. This equipment also needs to be asset tracked for its location, so that the Estates Department can check the units at least every three months. Some air purifiers are fitted with additional UV light units, which have been shown to remove viruses. Over time the recirculated air pulls dust and debris through the filters, degrading the performance of the unit. It is thus important that the filters are changed periodically, typically every six months, or whenever the filter becomes blocked. There is usually an indicator on the unit that shows when the filters are becoming blocked.

## Potential air purifier issues

Potential issues with air purifiers include failure to change the filters in a timely fashion, and not using the correct process for changing them – problems that can be mitigated by showing end-users how to manage the units, and also putting information notices on the air purifiers to explain how to change the filters. The filter life is reduced if the unit is located in an area with high levels of airborne debris, for example near a busy entrance to an Accident and Emergency unit. As with any portable unit, there is a risk that the purifiers could be switched off by staff, and again this problem can be reduced by educating staff and possibly appointing air purifier 'champions' to monitor each unit and check it on a weekly basis.

Andrew Carnegie, inventor of the Air Sentry air purification system, and managing director of Air Sentry, shared his thoughts on his product (see Figure 1) and how it can be used in healthcare environments. He said: "Our products are well-thought-through systems, designed for clinical use. Air Sentry systems use an ULPA-based filter which is down certificated to H14. This means that it can trap particles down to 0.007 micron, much smaller than a conventional HEPA filter. The arrestance (a measure of the ability

Image courtesy DRLC Ltd

Figure 2: A large legacy belt-driven fan that could be replaced by a fan wall.

Image courtesy DRLC Ltd

Figure 4: A heavily loaded duct.

of a filter to remove dust from the air) of Air Sentry filters is between 99.9995% and 99.9999% at 0.3 microns. At a glance this doesn't seem very different to the 99.995% claimed for HEPA14 grade filters, but to a virus it is a huge difference. Air Sentry systems do not require to be constantly maintained in clinical use, with only an annual inspection required and a filter change every two years."

## Proud of units' robustness

Andrew Carnegie is proud of the robustness of his air purifiers, as he went on to explain: "Air Sentry has units within British Gypsum's mining operation where the particulate contamination is particularly high. Those systems will still meet their expected two-year filter life. We have never had a clinical client with a maintained system which hasn't met this two- year filter change criteria. Our systems are made to last at least 25 years or more. We even had an Air Sentry unit crushed by a CT scanner, a force of several tonnes, without any major effect. In my opinion a less well-made unit in the same situation would have required a bag for the pieces."

When asked about the effect the air scrubber has on air movements within a confined space such as a single isolation room, he takes a practical approach: "The ability to mix room air to achieve excellent dilution is essential. When discussing the effectiveness of air scrubbers we talk about equivalent air changes, and ours are achieved by moving air through the entire room area. This means that air in areas where air movement can be slow or even stagnant, such as around patient bed areas or lower room corners, it is also moved by our system. We can quantify the effect the unit is having using smoke machines and particle counters, ratifying performance so that the resultant air quality, including when it is patient occupied, is clearly able to be demonstrated. Diagrams 1 and 2 show how the air in a single occupancy room is dispersed and then drawn back into the unit to be cleaned through the filter. We believe this is essential if a practical approach to risk management is to be achieved in clinical settings which lack effective mechanical or natural ventilation."

**Figure 3: A fan wall *in situ*.**
Image courtesy of Axair Fans Ltd. www.axair-fans.co.uk

## Net Zero Carbon

Capital replacement programmes are now being based on sound principles of energy saving using low carbon modern technology. Consultant engineer, David Livingstone, agrees: "According to the European Commission, buildings are responsible for 40% of energy and $CO_2$ emissions, and it is estimated that 39% of this is related to the heating, ventilation, and air-conditioning (HVAC) systems. Improvements in the efficiency of the HVAC system, and replacing such plant with low carbon new technology solutions such as Electronically Commutated (EC) fans, are the way forward." What are EC fans, however, and what makes them so special? EC technology refers to a mains electricity-fed, brushless, permanent magnet motor with inbuilt electronic commutation for speed control. These fans have no need for inverters to provide speed control, as the motor can take a direct control voltage from the building management system. They maintain a high efficiency, typically of 90%, when running at half speed.

> Filters that are blocked with dust increase the resistance, and therefore the power required, to push air through the ducts. Units that are supplying too many air changes are also increasing the costs of hospital ventilation
>
> Shaun Sutton, managing director, Air Projects

## Drawbacks of 'traditional' fans

Traditional fans used for the movement of air are usually powered by asynchronous AC motors that drive a pulley and fan via a belt. Belt-driven fans take up space, the belt drive systems require considerable maintenance, and if the electrical motors are incorrectly sized, may be running at 5 % efficiency when not running at full duty. These AC motors require inverter drives for speed control, introducing further complexities and the chance of component failure.

Plug fans are the replacement for centrifugal fans. They are more reliable, and provide optimum efficiency, moving the same amount of air as a traditional centrifugal fan. The HTM 03-01 (2021) guidance on healthcare ventilation references European Directives on Energy Efficiency for commercial buildings, which mandate eco-design requirements for mechanical ventilation systems, and this includes the use of plug fans. The cost savings from replacing belt-driven fans with EC plug fans are quantifiable. Legacy air-handling units (AHUs), if completely replaced with all new components such as

EC plug fans, better-insulated AHU casing, and an improved heat recovery unit with better control parameters, could pay back the capital costs in 3-5 years, and not need replacing for a further 25 years.

For example, typically the electrical running costs for a traditional belt-driven fan and older technology electric motor servicing an operating theatre suite or other specialised healthcare facility, would be about 1.5 kW, with the fans in some cases running '24/7' and 365 days a year. If the healthcare organisation pays 15p for a kWhr, then the electrical cost to drive the motor for a year would be £2,064. Also, there would be a similar cost for the extract fan, nominally the same size, making £4,128 per year. Additional revenue savings with a new AHU plant would include lower maintenance costs associated with servicing belts and pulleys, plus higher reliability and improved availability.

## Retrofitting

Retrofitting just the new EC plug fans in place of the older technology, backward curved centrifugal fans would produce savings typically of around 47%-53% on electricity usage for the motors and fans alone. A typical payback for installing an EC fan as a retrofit into an existing AHU would be less than 21 months, and may be as little as 12 months. Units with large legacy fan units – see Figure 2 – that supply large amounts of air can be replaced by fan walls, which are an array of, for example, 3 x 3 fans – a total of 9 – see Figure 3.

Shaun Sutton, managing director of verification company, Air Projects, agrees with David Livingstone that – irrespective of the age of the air-handling plant – regular and thorough maintenance is essential to keep energy running costs down. He explained: "Filters that are blocked with dust increase the resistance, and therefore the power required, to push air through the ducts. Units that are supplying too many air changes are also increasing the costs of hospital ventilation.

"As verifiers, we look at hundreds of critical ventilation systems in healthcare settings every year. Energy savings are a significant factor in the thinking of most Trusts, and keeping their air-handling unit plant properly maintained, and planning to replace ageing plant, are, in my opinion, the best way to reduce energy wastage in this area." hej

## References

1 Perry JL, Agui JH, Vijayakumar R. NASA Research: *Submicron and Nanoparticulate Matter: Removal by HEPA-Rated Media Filters and Packed Beds of Granular Materials*. Glenn Research Center, Cleveland, Ohio Space Administration, Marshall Space Flight Center Huntsville, Alabama, May 2016.

## David Livingstone

**David Livingstone B.Eng (Hons), C.Eng, FIHEEM, MCIBSE, MBCS, Authorising Engineer and consultant engineer, is a Chartered Engineer and the MD of DRLC, Consulting Engineers. In addition to supplying NHS Trusts and other healthcare providers with technical expertise and Authorising Engineers, DRLC provides design review services for engineering design for healthcare, Premises Assurance Model (PAM) assessments, and CQC assurance inspections to NHS Trusts.**

**Starting his engineering career as a time-served Marine Engineer in the Merchant Navy, David Livingstone worked his way up to achieving qualifications as a Second Engineer and obtaining his steam ticket. He worked on a variety of ocean-going ships, including container carriers and oil tankers. On coming shoreside he got his first post in the NHS as an engineer in the Estates Department of the Northern General Hospital in Sheffield, one of England's largest hospital sites.**

**Seeking varied engineering experience, he moved from NHS estates maintenance to delivering engineering projects for Sheffield Hallam University, and then to becoming head of Estates for Nottingham University Trust. His NHS career culminated in him being a director of Estates and Facilities. He launched DRLC Ltd in 2016 with a view to providing Authorising Engineering Services to healthcare providers. Having since grown, the company now provides Authorising Engineers for Ventilation, Fire Safety, and Pressure Systems, and engineering design review.**

Thanks are also due for their contribution to this article to Shaun Sutton, managing director and Ventilation verifier, Air Projects; Nick Evans, Energy Environment Sustainability manager for Lincolnshire Partnership NHS Foundation Trust (LPFT) and Lincolnshire Community Health Service NHS Trust (LCHS), and Andrew Carnegie, MD, Air Sentry.

## Louise Webb

**Louise Webb MBChB, MSc Computer Studies, PGCert, Fellow of the British Computer Society, and Association of Project Management Professional, is a Chartered IT Professional and Project director at DRLC, Consulting Engineers. DRLC works with NHS Trusts and other healthcare providers supplying technical expertise and Authorising Engineers to them in the areas of Ventilation, Fire Safety, and Pressure Systems.**

**Louise Webb started her career as a Medical student at Edinburgh University. She went on to gain a MSc in Computer Studies at Sheffield Hallam University, before spending five years at Sheffield heavy engineering company, Davy McKee, where she automated the process of sending engineering drawing details to the factory floor. She also created a search engine for engineering estimate production.**

**After a break to have children, she returned to work for BT as a senior project manager, where she gained an NVQ Level 4 in Project Management, and helped Google get its first servers installed in the UK. She also managed the implementation of firewalls for FTSE100 financial services companies, and was instrumental in rolling out broadband to schools in Yorkshire and Humberside.**

**Looking for a variety of project management experience, she set up her own company, and won work from a variety of clients, including Leeds City Council and the Department of Health. Having been asked to create an online training module by Sheffield Hallam University, she realised she enjoyed teaching, and went on to teach Master's level students at Hallam and the University of Bedfordshire and Anglia Ruskin.**

**As Project director, Louise Webb has helped DRLC to grow over the past six years, and has just embarked upon a MSc in Building Services Engineering at Heriot Watt University.**

# DRLC Ltd.

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## Reducing Covid-19 transmission by Ventilation Systems

- ✓ Check ventilation ductwork from intake to pre-filter annually and clean if required
- ✓ Air Scrubbers play a part in clean air systems however ensure a maintenance policy is agreed and that they are on the Asset Register
- ✓ Wall mounted Air Conditioning Units are prone to throw the air across rooms. Restrict their use in Healthcare premises to the minimum
- ✓ HTM03-01 (2021) guidance is to inspect Critical Ventilation Quarterly and carry out Annual maintenance
- ✓ Treatment and waiting rooms with opening windows can use natural ventilation to dilute any airborne virus
- ✓ Ensure AHU filters are checked regularly and when they are changed check they are fitted correctly. A filter with an air gap will not deliver clean air.

## Net Zero Carbon and Ventilation

- ✓ AHU being newly installed or refurbished should be fitted with EC plug fans
- ✓ Large belt driven fans which use a lot of energy can be effectively replaced by fan walls
- ✓ Plan to upgrade old AHU units – the cost of replacement can be recouped by the energy savings from new plant
- ✓ Ensure filters are kept clean as this reduces the power required to drive the fans
- ✓ Inspect ventilation ducts and repair any leaks
- ✓ Switch off ventilation that is not required
- ✓ Ensure all new and refurbished plant has an energy recovery unit

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