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TECHMAG

Artificial intelligence in ventilation and drive technology

How much AI is in our fans already

PAGE 3

“Artificial intelligence: When visions become a reality”

Dr. Klaus Geißdörfer

CHIEF EXECUTIVE OFFICER
EBM-PAPST GROUP

Dear customers, partners and friends of ebm-papst,

When you open tech.mag, you expect concrete information from the world of ventilation and drive technology, new innovations, examples of best practices, numbers and facts. Not to worry: you will find all of that in this issue. For example, it includes intelligent cooling concepts for refrigeration technology and electromobility, quiet heat pumps and efficient air conditioning for vertical farming systems.

Yet you have probably noticed that this issue looks a little different somehow. The reason is that the title image and initial images for the articles have been generated using artificial intelligence. AI is a topic that is fundamentally changing our world in all areas of our life and work.

Therefore, it is playing an important role for us, too. Our engineers are already using AI and working on sustainable and digital solutions to protect the climate and to help our customers, and their customers, to reduce their carbon footprint and save on costs at the same time.

But this is only the beginning. Ever-quicker data processing is opening up entirely new opportunities. Generating photorealistic images within seconds is just a playful example, but it shows what is possible. We will definitely stay with it and derive the best benefits from AI for your applications.

I will let another AI tool have the final word: so, ChatGPT, what would you write for the concluding sentence of this introduction?

“We look forward to being by your side on the path to the future, which will be shaped by innovation and sustainability.”

Dr. Klaus Geißdörfer

By the way: The prompts – i.e. the text entered to get the images – are included below on the subject.

In supermarkets: Using data, reducing operating costs

The cold chain is getting smart

Continuous cooling or freezing of goods in supermarkets' sales and storage areas is essential for quality assurance. Fans play a central role here, both in supermarket cabinets for normal cooling and deep-freezing and in air conditioning systems in the supermarket building.

prompt:
a futuristic supermarket with a modern ventilation system, natural light, photorealistic


Fresh & Save

In addition to the lowest possible energy consumption, reliability is the key consideration when it comes to supermarket cooling. If a fan fails, it is important to locate and rectify the fault quickly to prevent the cold chain being interrupted and, in the worst case scenario, the food being spoiled. Fans with intelligent energy-saving motors with GreenTech EC technology provide important information about the MODBUS RTU serial communications interface. In this way, intelligent maintenance concepts based on the actual maintenance requirements can be implemented correctly. And, thanks to their high efficiency levels, the energy-saving fans make a significant contribution to reducing operating costs.

Continuous monitoring of all cooling operation components in supermarkets (Fig. 1) forms the basis for predictive maintenance, i.e. detecting faults before failure occurs and, in the worst case, the cold chain is interrupted. Facility managers and maintenance companies benefit from this equally, as it means that staff-intensive, regular maintenance is no longer necessary, or at least rarely. This reduces costs and is a decisive advantage even if there is a shortage of skilled workers. It is essential that the higher-level control system communicates with the components used in refrigeration and freezer units and the central air conditioning. For example, anomalies in the normal operating behavior can be identified at an early stage using fan data, and targeted countermeasures can be introduced.

To do this, the data supplied by the fan drives via MODBUS RTU must be evaluated and interpreted in real time as far as possible, taking into account the specific fan properties and the specific operating conditions. With the Computation Cloud (Fig. 2, p. 8) from ebm-papst neo, motor and fan specialist ebm-papst now offers a practical solution that is not only suitable for monitoring its own fans but also for other components used in the application, such as sensors, lighting units or similar. The specialists are happy to advise here and adapt the options to the individual supermarket control system.

Fans with intelligent energy-saving motors with GreenTech EC technology provide important information about MODBUS RTU.

Continuously monitoring fan operation

The latest fan generations from ebm-papst can transfer up to 200 data points to the higher-level control system, which can then be evaluated in the Computation Cloud. This provides meaningful information about every single fan (Fig. 3, p. 8) in real time, from compact fans in refrigerated cabinets to large fans in the chiller on the roof of the supermarket. Based on the data transmitted about the actual operating conditions, this can be used to calculate the expected remaining service life, for example. The key characteristic values here include the ambient temperature, shifts at the operating point, air flow, speed and vibrations that indicate abnormal loads. If the outage date approaches, the maintenance staff can order the appropriate replacement in good time using the part number, which is then replaced one-for-one before the expected failure occurs. The right replacement unit is then at your fingertips.

The cloud analysis also makes it possible to plan a wide range of maintenance measures, for example if the rotor blades of the axial fans used here begin to freeze on the chiller (Fig. 4, p. 9), which can be expected in particular in winter when the temperatures outside are low. Before the resulting imbalance leads to bearing damage, service staff can check the fans and remove the ice formation. In turn, air flow, speed and current draw allow conclusions to be drawn as to whether and when filters need to be cleaned or replaced. When planning maintenance for chillers, the cooling water quantity can also be included in the calculations.

Efficiency in focus

The targeted deployment of maintenance staff saves the service team's time and the operator's money. The latter also benefits from avoiding outages in advance and the cold chain is not at risk. In addition, the intelligent EC fans are

FIGURE 1: **Continuous cooling or freezing of goods in supermarkets' sales and storage areas is essential for quality assurance. Fans play a key role here.**

FIGURE 2: **The fan data transferred to the higher-level control system can be evaluated in the Computation Cloud.**

FIGURE 3: **The analysis data provides the basis for intelligent maintenance concepts that relieve service staff.**

energy-efficient, which noticeably reduces electricity costs. For example, EC motors from the ESM series (Fig. 5), which are typically used in refrigerated display cases, operate at efficiency levels of over 70% at just 10% of the power consumption of comparable shaded-pole motors. The speed control system enables demand-based operation. The display case is cooled accordingly depending on how often the display case is opened.

The compact EC motors are available as a complete plug-and-play system in which the individual components are perfectly coordinated with one another. Examples include the energy-saving fans W1G 250 and K1G 250. The W1G axial product range is intended for installation beneath the shelves of refrigerated and freezer cabinets. By contrast, the K1G product range with diagonal fan impeller was specially designed for the rear wall of refrigerated display cases, where there is often limited installation space. Thanks to their extremely shallow design, these fans fit in confined spaces and the diagonal fan design makes them well equipped to deal with the higher back pressure found in these spaces.

The high-performance EC motors in the large axial fans for chillers work at efficiency levels of over 90%. The aerodynamic optimization of the fan blades also makes the EC fans extremely quiet. This ensures that noise protection regulations are easily fulfilled, avoiding trouble with the neighbors. The efficiency levels can be checked at any time using the computation cloud by calling up the operating points and analyzing them in real time. ○

AUTHORS ARE PATRICK STERN, PRODUCT AND MARKET MANAGER, AT EBM-PAPST MULFINGEN AND WALDEMAR WAGNER, PRODUCT MANAGER AT EBM-PAPST NEO.

YOU WOULD LIKE MORE INFORMATION ON THIS TOPIC? PLEASE ADDRESS YOUR QUESTION TO:

Patrick.Stern@de.ebmpapst.com

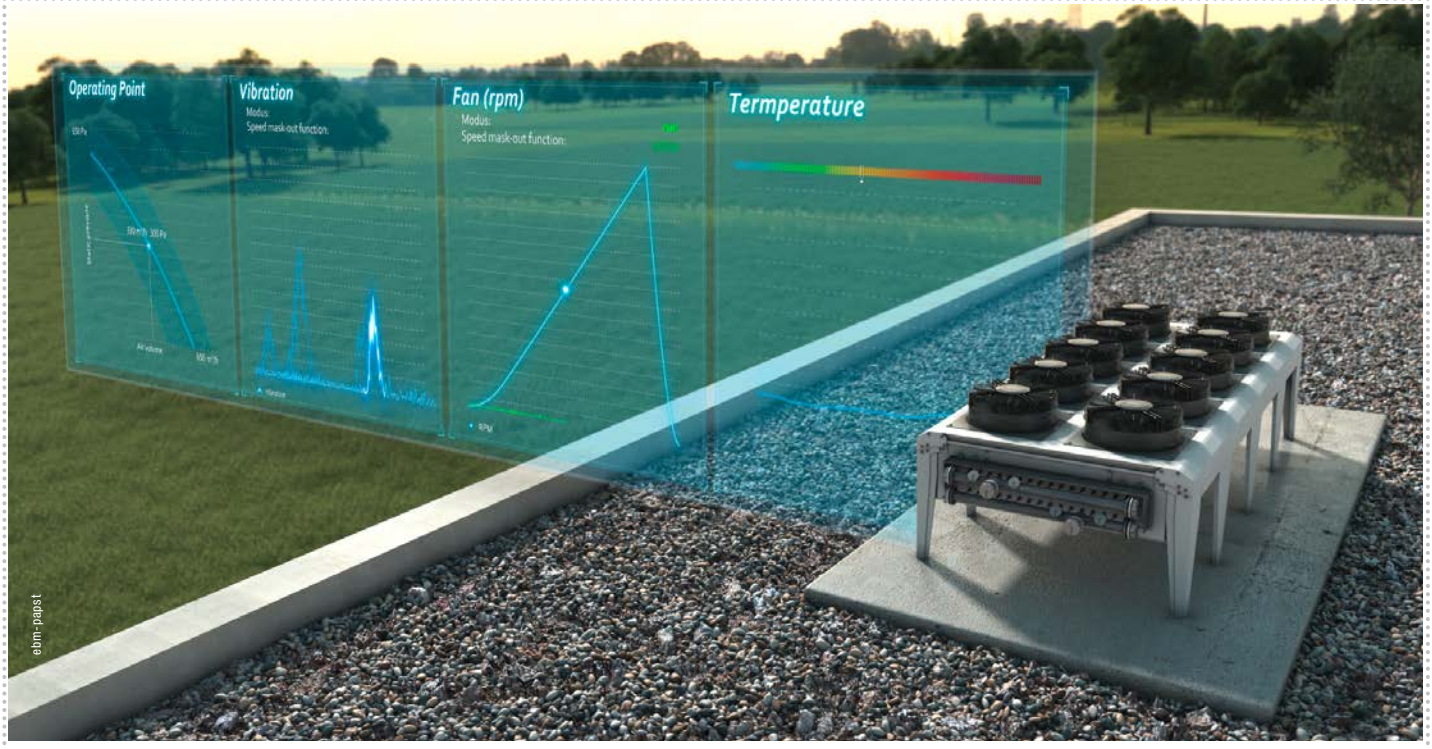


FIGURE 4: **Thanks to cloud analysis, a wide range of maintenance measures can be planned in advance, such as when the axial fans used in chillers begin to freeze.**

FIGURE 5: **The intelligent EC motors in the fans in refrigerated display cases also supply data for cloud analysis.**


LOADING THE FUTURE
TOGETHER

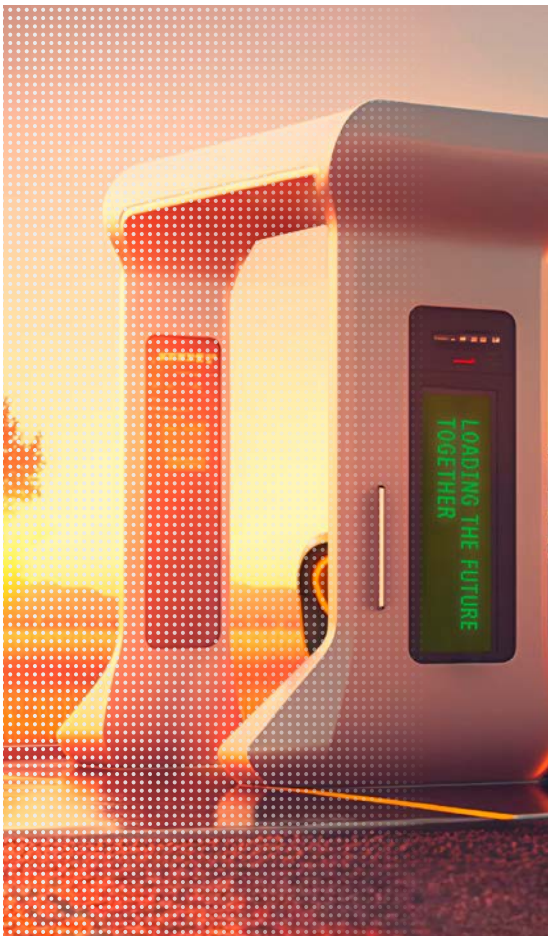
Efficient, adaptable and robust solutions are in demand

Cooling for the future of electromobility

Range and charging times are important parameters for electric vehicles. This is why fast charging processes are becoming increasingly popular. High-performance cooling concepts are required to dissipate the resulting waste heat. They need to be well integrated and work reliably for a long time, even under harsh conditions. This is the only way that the full charging capacity can be utilized and the cross-section of the charging cables reduced, making them far more flexible and more convenient.

prompt:
a futuristic e-mobility loading scene, contrast between technique
a sustainable surrounding, natural light, photorealistic

Electric mobility that relies on renewable energies is environmentally friendly: Wind, water, photovoltaics and even green hydrogen are possible sustainable sources. Charging stations and terminals of various sizes and capacities are the interface to the vehicles, i.e. cars, trucks and buses, and are often combined with battery storage systems to compensate for fluctuations and stabilize the grid (Fig. 1). As the interest in electric vehicles steadily increases, the availability of quick-charge stations is a challenge. To reduce charging time, the charging connection power must be increased to several hundred kilowatts depending on the application. As a result, the thermal load on the electrical components in the systems increases significantly.



Efficient heat dissipation

To efficiently dissipate the heat loss and enable fast charging, controlled thermal management incorporating different cooling solutions is required. The motor and fan specialists at ebm-papst have taken a close look at this issue and can now offer

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FIGURE 1: **Electric mobility that relies on renewable energies is environmentally friendly. Charging stations and terminals of various sizes and capacities are the interface to the vehicles, i.e. cars, trucks and buses.**

suitable solutions for the various cooling solutions related to electric mobility. Compact fans in various designs for efficient and low-noise electronics and switch cabinet cooling are just as much a part of this as powerful and intelligent drives with integrated K4 control electronics for the pumps, which are necessary for supplying the cooling circuits. One example of this is the ECI-63.20-K4 internal rotor motor, which, thanks to its high power density, is typically used as an efficient pump drive for cooling charging cables in the level 3 range with charging currents of up to 500 A (Fig. 2). With variants in the 180 to 370 W power range, the compact drive covers a wide range of applications. However, speed-torque controlled external rotor motors from the VDC-49.15-K4 series are also ideal for cooling solutions, and additionally enable users to make inferences about pressure and coolant flow, for example. This means that additional sensors are not required in the application, which has a positive effect on the system control of the charging station.

Fans for every application

The interior of a quick-charge station, its power electronics and cooling circuits are usually cooled with air (Fig. 3). Several fans are generally used for this, with axial, centrifugal, and diagonal compact fans as possible options, depending on the requirements. With sizes from 25 to 910 mm diameter and power ranges from 0.2 W to 4.6 kW, a suitable solution can be found for practically any application in electric mobility (Fig. 4, p. 14). Durable DC and GreenTech EC motors are the driving force behind the fans. They operate at high efficiency levels, thereby making an active contribution to saving resources. At the same time, their high efficiency keeps operating costs low. Thanks to the motor technologies used and aerodynamic optimizations, the fans also run extremely quietly, which helps prevent the quick-charge stations from becoming a disruptive factor and allows them to blend in well with their surroundings. The drives' excellent control characteristics ensure that demand-based operation can be easily implemented. The high efficiency of the EC fans is maintained, especially in the partial load range – a clear advantage over conventional AC fans.

FIGURE 2: **Efficient ECI-63 pump drive for cooling charging cables. With variants in the 180 to 370 W power range, the compact drive covers a wide range of applications.**

FIGURE 3: **Efficient solutions for quick-charge stations.**

FIGURE 4: **Centrifugal, axial and diagonal compact fans for a wide variety of cooling solutions relating to electromobility.**

An important factor for cooling in quick-charge stations is their outdoor suitability. Even under harsh ambient conditions such as rain, fog, dust and salty sea air, temperature fluctuations and other weather-related influences, the reliable functioning of the fans must be guaranteed. This is why they are subjected to rigorous testing by the manufacturer. Shock, vibration and corrosion tests are mandatory, as are the Highly Accelerated Life (HAL) test, temperature change control test, and EMC checks. In addition, all fans have electrical overvoltage protection.

Powerful cooling solutions for quick-charge stations

AxiEco and AxiForce series fans and have now been proven in a variety of electric mobility applications. The AxiEco offers high performance and efficiency in a compact footprint, allowing users to optimize the design of the final system. With a diameter of 200 mm, this fan delivers an air flow rate of 1,820 m^3/h (Fig. 5). The speed can be adapted to the required cooling capacity via a PWM or analog signal, and this also allows operating noise to be reduced to a minimum. Application-specific modifications can also be made easily, for example with regard to the strand length for the electrical hookup or the plugs.

The AxiForce series fans are well suited for applications with high back pressure. They are available in sizes 80, 120 and 172 mm and achieve pressures of up to 1,200 Pa. These fans have a steep air performance curve such as is required for cooling in densely packed quick-charge stations. Despite the high back pressures, air flow rates of up to

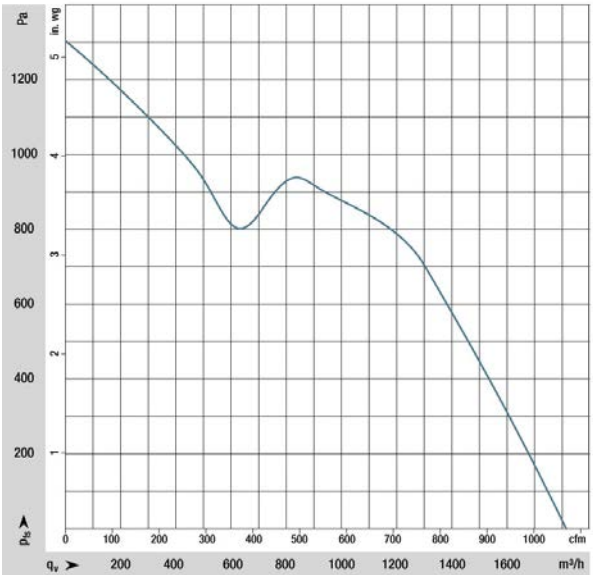

FIGURE 5: **Air performance curve of the AxiEco axial fan in size 200: Depending on the operating point, it can achieve an air flow rate of up to 1,820 m³/h.**

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FIGURE 6: **Fans often have to withstand harsh ambient conditions and therefore pass through various test stations beforehand, such as the salt spray test at ebm-papst.**

650 m^3/h can be achieved, which can mean a significant increase in performance for the application. There is also a particularly environmentally resistant version with encapsulated electronics that meets the requirements of protection class IP68 – in other words, it is dustproof and protected against powerful water jets, and has also successfully completed a thirty-day salt spray test. The fans are optionally available with ATEX certification. There are many other applications for these and similar compact fans – not only including the quick-charge stations themselves, but also battery storage systems and switch cabinet cooling.

AUTHORS ARE GERHARD GAUß, HEAD OF SALES INDUSTRIAL AT EBM-PAPST MULFINGEN AND CHRISTIAN STERN, PRODUCT MANAGER AT EBM-PAPST ST. GEORGEN.

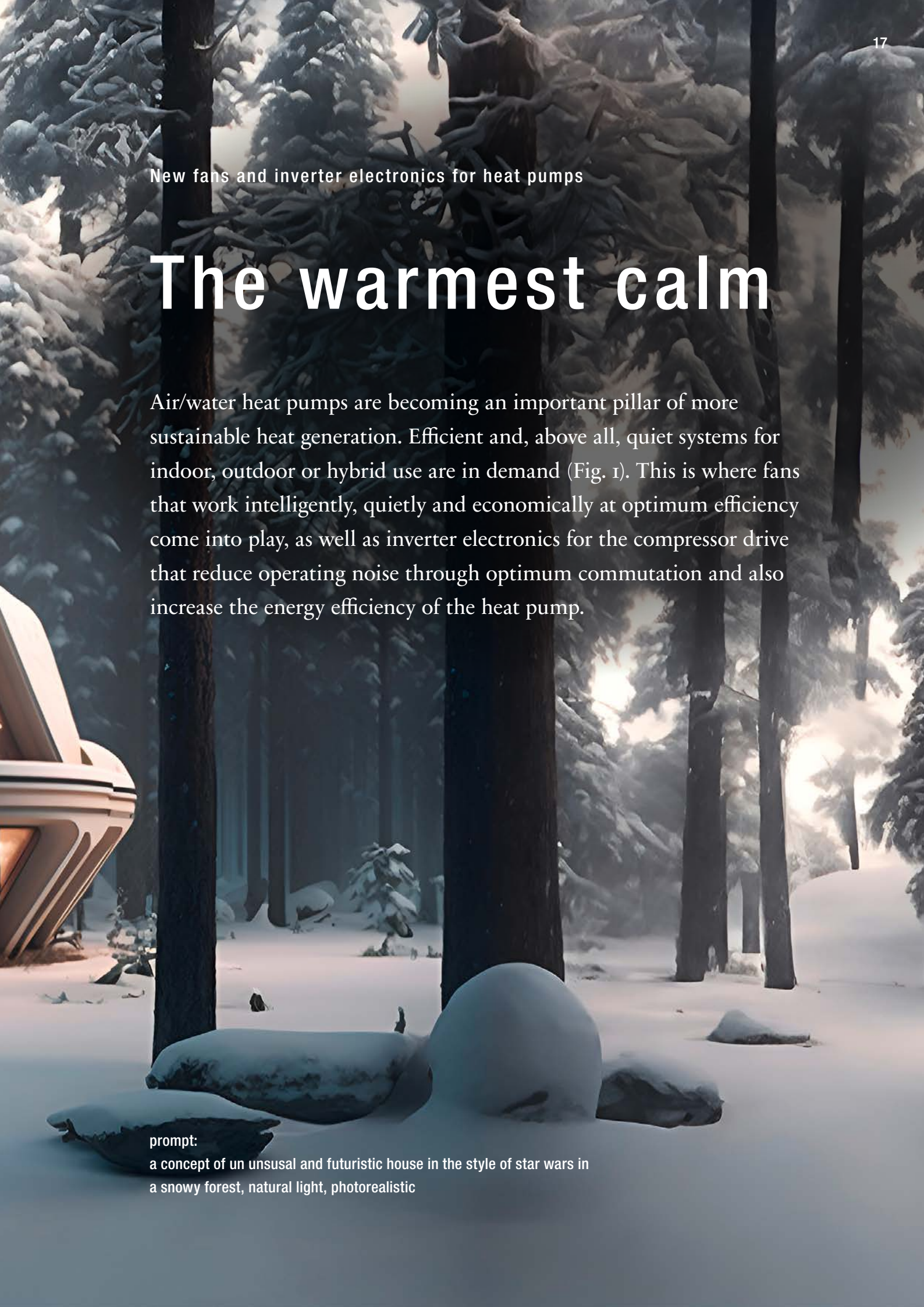
YOU WOULD LIKE MORE INFORMATION ON THIS TOPIC? PLEASE ADDRESS YOUR QUESTION TO:

Gerhard.Gauss@de.ebmpapst.com

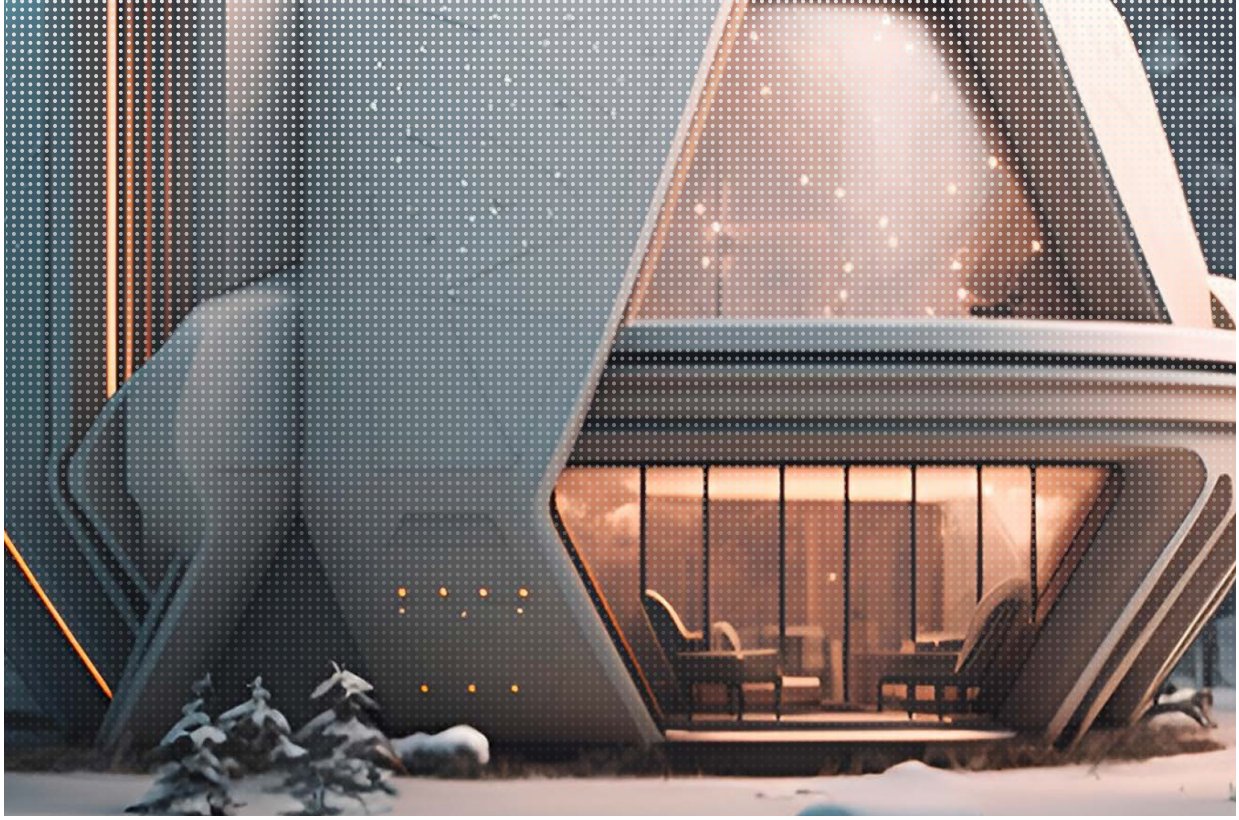
New fans and inverter electronics for heat pumps

The warmest calm

Air/water heat pumps are becoming an important pillar of more sustainable heat generation. Efficient and, above all, quiet systems for indoor, outdoor or hybrid use are in demand (Fig. 1). This is where fans that work intelligently, quietly and economically at optimum efficiency come into play, as well as inverter electronics for the compressor drive that reduce operating noise through optimum commutation and also increase the energy efficiency of the heat pump.



prompt:
a concept of un unsusal and futuristic house in the style of star wars in a snowy forest, natural light, photorealistic



The demands placed on the components installed in heat pumps are high, with durability, low noise, robustness and efficiency at the forefront. Although the compressor requires the largest amount of energy of the individual components, the fans should also be scrutinized carefully when considering efficiency. Various aerodynamic adjustments, such as an integrated diffuser and winglets, can further increase efficiency while simultaneously reducing noise. Given the high efficiencies, the use of state-of-the-art EC technology in the fan's motor has become a no-brainer, and also allows great flexibility thanks to individual speed adjustment. Development is continuing at a steady pace. Motor and fan specialist ebm-papst, which offers both centrifugal and axial fans in various designs for air/water heat pumps operating indoors or outdoors, has now developed two new fan series for particularly noise-sensitive outdoor areas. Both are suitable for use with natural and flammable refrigerants and are particularly quiet thanks to their special design, which helps prevent the heat pumps from becoming a disruptive factor and allows them to blend in well with their surroundings. While the AxiEco plug-in is suitable for heat pumps requiring a large pressure reserve for the evaporator, the AxiTone is geared more towards delivering higher air flow at low back pressure when the heat pump design requires this.

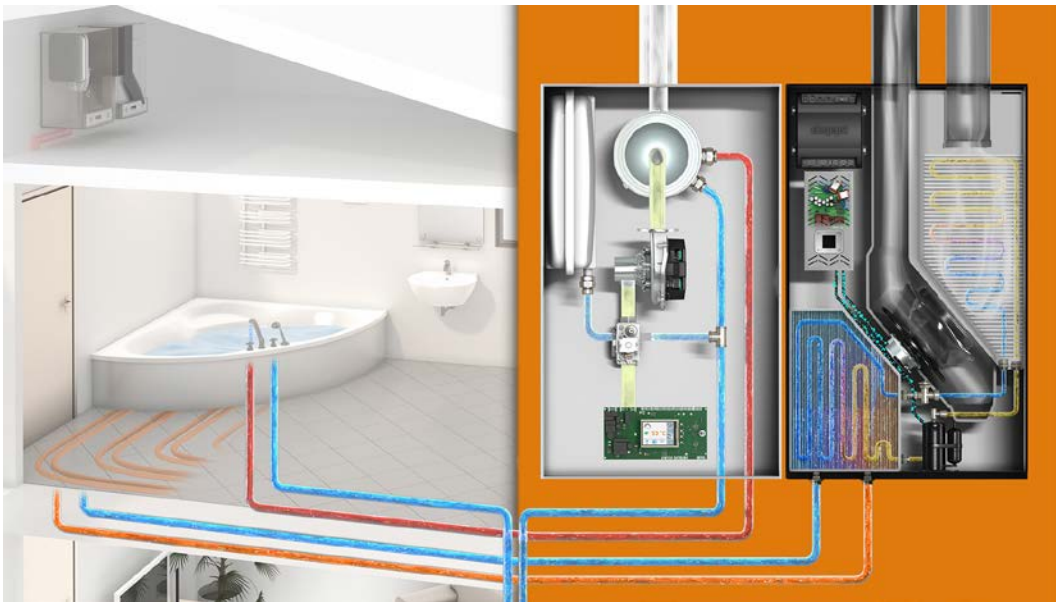


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FIGURE 1:
Functional principle of a heat pump in a single-family home in hybrid use.

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FIGURE 2: **AxiEco plug-in: as the pressure increases, the air flow changes only very slightly. The FlowGrid, which acts as a rectifier for air flow, drastically reduces noise-generating disturbances in the air flow.**

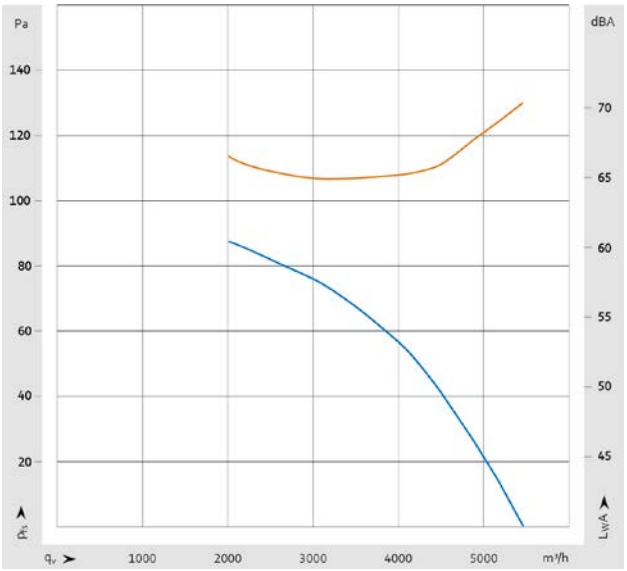

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FIGURE 3: **Characteristic map of the size 500 AxiEco plug-in in terms of air performance (blue characteristic curve) and noise (orange characteristic curve).**

Axial fan with high pressure reserve

Ice formation particularly affects evaporators when humidity precipitates as ice on the heat exchanger at cold ambient temperatures. This reduces the air routes and the drag, and so too the back pressure. The fans then have to offer significantly greater pressure reserves. This is where the new AxiEco Plug-in comes in (Fig. 2). Studies have shown that its flow technology reduces ice formation and its air flow only reduces very slightly as the pressure increases. This is also an advantage for heat pumps, which heat in winter and cool in summer, as the operating points then vary depending on operation.

The fan, which is available from summer 2023 in sizes 450, 500 and 630, typical of heat pumps for single- or two-family homes, has also been fitted with an air inlet grille. This FlowGrid, which acts as a rectifier for air flow, drastically reduces noise-generating disturbances in the air flow. This reduces the sound pressure over the entire frequency range, in particular the disruptive blade passing noise, i.e. unpleasant "humming" in the low frequency range (Fig. 3). At the same time, the air inlet grille serves as a motor suspension and, if necessary, the equipment manufacturer can insert heating tape. The new axial fan weighs 30% less than the comparable HyBlade version with steel wall ring. This means that less weight has to be handled during the installation and the compact dimensions often make it possible to optimize the design of the end device. The AxiEco Plug-in fans are supplied as a ready-to-install plug & play solution, including nozzle plate and FlowGrid.

Quiet fan with three blades

For air/water heat pumps, where high back pressure tends to be the exception due to their design, the three-blade AxiTone – initially available in size 450 mm and later in sizes 500 and 630 mm (Fig. 4, p. 20) – is the obvious choice. Its characteristic curve is flatter, it supplies large volumes of air, and, as the name suggests, it makes very little noise during operation (Fig. 5, p. 20). The blade geometry plays a key role

FIGURE 4: **The AxiTone delivers large air volumes and operates particularly quietly in noise-sensitive applications.**

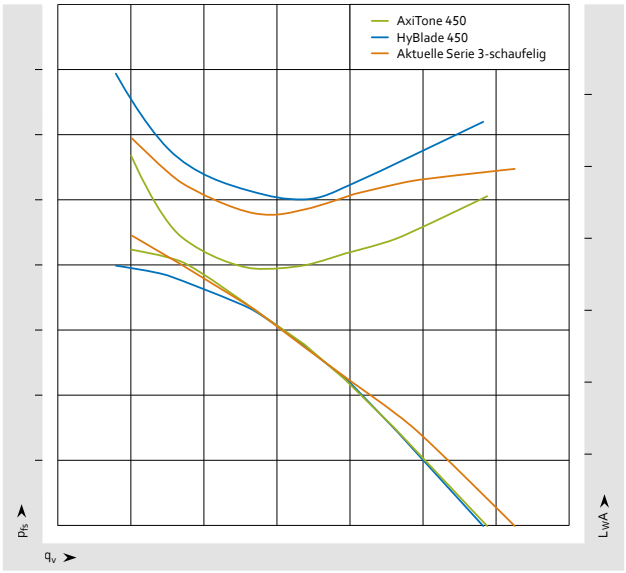

FIGURE 5: **Characteristic curve of size 450 AxiTone compared to the previous three-blade axial fan and HyBlade in terms of air performance and noise characteristics.**

in both respects, as it has been optimized to aerodynamic criteria. The large area and steep inclination ensure high air flow, and the sickle-like shape reduces turbulence and hence noise generation. Other new features include the serrations at the front edge of the blade. They also have a positive effect on the noise characteristics, as they minimize the tonal components of noise. Condensers in residential areas, where particular attention must be paid to minimum noise emissions, therefore also benefit from this quiet axial fan. The AxiTone is available as a ready-to-install motor-impeller combination in both airflow directions, i.e., intake or blowing, and optionally with a guard grill and support ring. It is also suitable for applications with flammable refrigerants.

Inverter electronics for efficient and low-noise compressor drives

Meanwhile, ebm-papst is not only focusing on offering efficient and quiet fans. Based on many years of experience with EC motors, their commutation electronics, and heat pump applications, the company has now developed inverter electronics that are suitable, among other things, for speed-controlled permanent magnet synchronous machines (PSM), as typically used in compressors (Fig. 6). The new electronics, the samples of which will be available from Q3/2023 and which will be available with output powers of up to 3.5 kW, 7.5 kW and 12 kW, offer several advantages here.

The ebm-papst commutation method, which has been optimized over decades, considerably reduces noise development; at the same time, efficiency is increased. For example, in a heat pump with a 7.5 kW compressor drive, the COP value (Coefficient of Performance) could be increased by 3.5 %. For users, this means an annual saving of 70 euros at an assumed electricity price of 35 cents per kilowatt hour. Depending on the variant, the controls also "detect" whether they are operated in one or three phases, and switch over automatically depending on the type of voltage available in the heat pump. The electronics are also flexible in terms of their cooling. Thanks to their modular

design, it is possible to use water or air cooling, or use a cold plate for cooling.

The active three-phase PFC level integrated into the inverter electronics (power factor correction filter) ensures good EMC properties. No additional measures are required to comply with the standards with regard to current harmonics. Given that, depending on the size of the heat pump, conventional expansion valve assemblies can easily weigh up to 20 kg, the weight saving and the reduced wiring effort required by active PFC are considerable. The low weight of the heat pump simplifies its entire handling, from production to transport and installation by the end user. As a competent partner for heat pump manufacturers, ebm-papst is already planning the next steps to become a system provider. In the future, further components will be integrated into the inverter electronics, for example commutation for the fan drive and the control of a heating rod. ○

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FIGURE 6: **Inverter electronics in output powers 3.5 kW and 12 kW for efficient and low-noise compressor drives.**

AUTHORS ARE MARCEL RÖSSLER, SALES ENGINEER HEAT PUMP APPLICATIONS & ELECTRONICS AND PATRICK STERN, PRODUCT & MARKET MANAGER, BOTH AT EBM-PAPST MULFINGEN.

YOU WOULD LIKE MORE INFORMATION ON THIS TOPIC? PLEASE ADDRESS YOUR QUESTION TO:

Marcel.Roessler@de.ebmpapst.com

Vertical farming in response to climate change

Vertical indoor farming is considered a promising future concept with numerous advantages. In particular, the yield per unit of area is significantly higher than in conventional agriculture, as the systems are operated all year round. Efficient and intelligent ventilation and air conditioning are essential for this. Fans, drives and automation solutions from ebm-papst play an important role in ensuring that the plants always have ideal conditions for growth.

prompt:
a vertical indoor farming concept in blue and red light, photorealistic

For years, many experts have been trying to work out how humanity will feed itself in the future. It is certain that existing resources must be used more efficiently to provide people with the same standard of living, or to improve the supply situation for people in developing countries in a sustainable way. In vertical indoor farming, plants are produced above one another in buildings, containers or in air-conditioned supermarket cabinets (Fig. 1). It is seen as a future-oriented technology for ensuring a food supply, as this allows urban spaces to be used sustainably for agriculture, saving additional transportation time and costs.

Economical solutions are in demand

In addition to lighting, it is essential that these vertical "farms" have appropriate air conditioning, regardless of plant type and cultivation technology. The potential of this technology can be only exploited if the light, nutrients, ventilation, temperature and humidity are right. The basic prerequisite for this is economic systems that always operate according to the demand and very efficiently, not only for the air conditioning and nutrient supply, but also in automated product handling and transport. Only then can indoor farms operate economically and sustainably.

Fan and motor specialist ebm-papst has been working on this issue for quite some time now. There are a number of energy-efficient,

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FIGURE 1: **Vertical indoor farms are available in different shapes and sizes.**

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FIGURE 2: **A hose ventilation system supplies the plants with oxygen.**

FIGURE 3: **Powerful, space-saving axial fans, for example for tunnel ventilation systems in which the air is pushed through the building.**

FIGURE 4: **Centrifugal fans perform particularly well against high back pressures. They are available with forward or backward-curved blades and in a scroll housing or as freewheel fans as appropriate. They are typically implemented in central ventilation units.**

ebm-papst

This allows urban spaces to be used sustainably for agriculture, saving additional transportation time and costs as well.

"intelligent" fans and drives suitable for the many different concepts. Furthermore, the specialist is also available as a dedicated engineering partner and system provider and offers support right through to complete automation solutions. All the products are robust and operate reliably over the long term, even in adverse conditions. ebm-papst designs and supplies sophisticated software and hardware solutions that make vertical indoor farming as sustainable, economical and profitable as possible.

Optimum air supply and air conditioning for every system size

There are different concepts for ventilation and air conditioning. Tunnel ventilation pushes the air through the building. However, central ventilation units installed on roofs are also common as is providing individual plants or floors with a targeted air supply via pipe and tube systems (Fig. 2), which must also be supplied accordingly. Different fans are required here: Compact axial fans move high air flows of up to 65,000 m^3/h and operate reliably even at back pressures of up to 1,500 Pa (Fig. 3). They are therefore particularly suitable for the tunnel supply. A comprehensive range of accessories enables further modifications to be made, such as guard grills. It is possible for the power supply to be 5 to 110 VDC or 11 to 480 VAC.

Centrifugal fans are particularly impressive at high back pressures up to 5,200 Pa (Fig. 4). Their air flow rates are up to 30,000 m^3/h. They are available with forward or backward-curved blades and in a scroll housing or as freewheel fans as appropriate. Versions with external rotor motor in the impeller are also very compact and therefore require little installation space in the ventilation units usually installed on the roof. The power supply provided is 6 to 72 VDC or 85 to 480 VAC. Compact fans have proven their worth for air conditioning in supermarket cabinets, for ventilation of individual shelves and for cooling LEDs. They also operate at a high level of energy efficiency and contribute towards economical operation in this indoor farming concept.

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FIGURE 5: **Efficient automation of logistics processes offers great potential for savings when handling products.**

ebm-papst

FIGURE 6: **Automated product handling: With the ArgoDrive, ebm-papst has developed a compact and easy-to-integrate drive system for automated guided vehicles.**

The right drive for every goal

New farming concepts also depend on high-performance drive systems. The many different work processes, for example in vertical indoor farming, increase the complexity of product handling (Fig. 5). Efficient automation of logistics processes offers great potential for savings here. In this way, decentralized drive solutions reduce costs for transport or handling systems. This ranges from automated product handling with autonomous driving vehicles (Fig. 6) to conveyor belts and access control systems, all of which rely on good control characteristics and precise positioning. Reliable, compact and highly dynamic drive systems that withstand strong loads are required to open and close barriers, gates and windows, for example. System solutions play a crucial role here and flexible, reliable drive systems with a high degree of networking are indispensable. Thanks to its many years of experience, ebm-papst offers a modular drive system

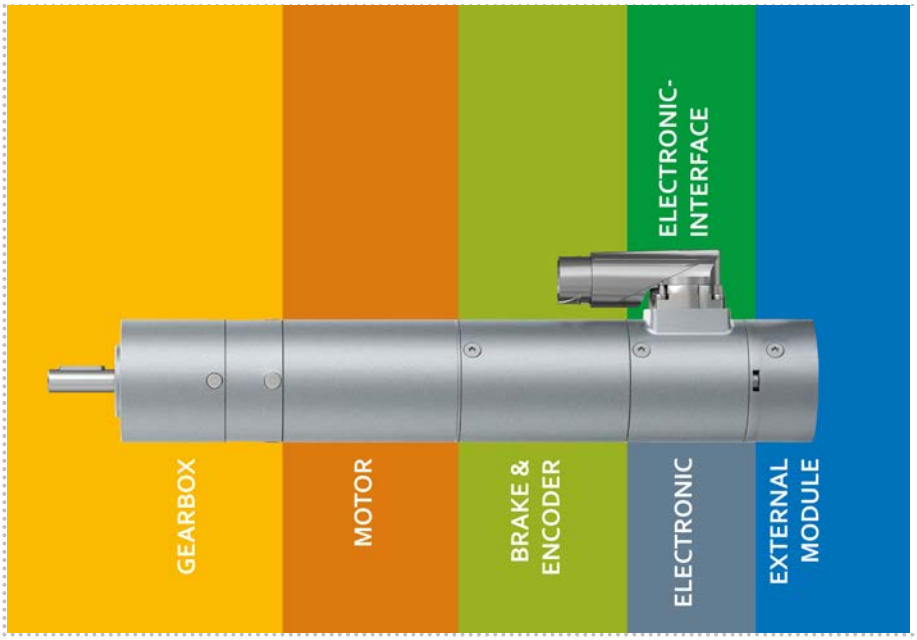

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FIGURE 7: **The modular drive system enables standard solutions to be implemented for many applications.**

for this field, consisting of motor, transmission and electronics for system solutions. In the field of transmissions, it offers both planetary and angular gearboxes.

The electronically commutated ECI motors, for example, cover a continuous power range from 30 to 750 watts in sizes 42, 63 and 80 mm. Then, different transmissions matched to the drives ensure the necessary reduction ratio of the high-speed internal rotor motors. The transmissions can also be combined with the external rotor motors in the VDC series. The latter cover a power range of 5 to 125 watts in the smallest installation space and also boast a long service life and good control properties. The modular drive system enables standard solutions to be implemented for many applications (Fig. 7). For example, the ECI internal rotor motors are ideal for use as shuttle traction drives, depending on the required power either in size 63 or 80. They require little installation space, achieve high torques at 24 or 48 V, and are able to deliver three times the nominal power for a short time. Combined with the Optimax transmissions, which already have overload capacity, compact, robust drive systems are created, which can also be controlled based on the application through the motor electronics chosen.

Real-time production monitoring

For a high-yield harvest, the conditions for growth must be continually monitored to initiate targeted changes or quickly eliminate problems if required. ebm-papst helps with this using its digital services. Sensors and hubs ensure that all necessary and meaningful data is digitized (Fig. 8), whether it is the status of technical systems or monitoring air and water quality. This enables all data on air conditioning, nutrient supply or lighting to be visualized in real time. For example, using an app, it is also possible to test settings or automatically receive current messages on a cell phone. The specially developed cloud applications provide the appropriate information and control options to optimize production and make it economical and sustainable. ○

AUTHORS ARE JOCHEN SCHERER, SALES ENGINEER VENTILATION, AT EBM-PAPST MULFINGEN AND CHRISTIAN STERN, PRODUCT MANAGER AT EBM-PAPST ST. GEORGEN.

YOU WOULD LIKE MORE INFORMATION ON THIS TOPIC? PLEASE ADDRESS YOUR QUESTION TO:

Jochen.Scherer@de.ebmpapst.com

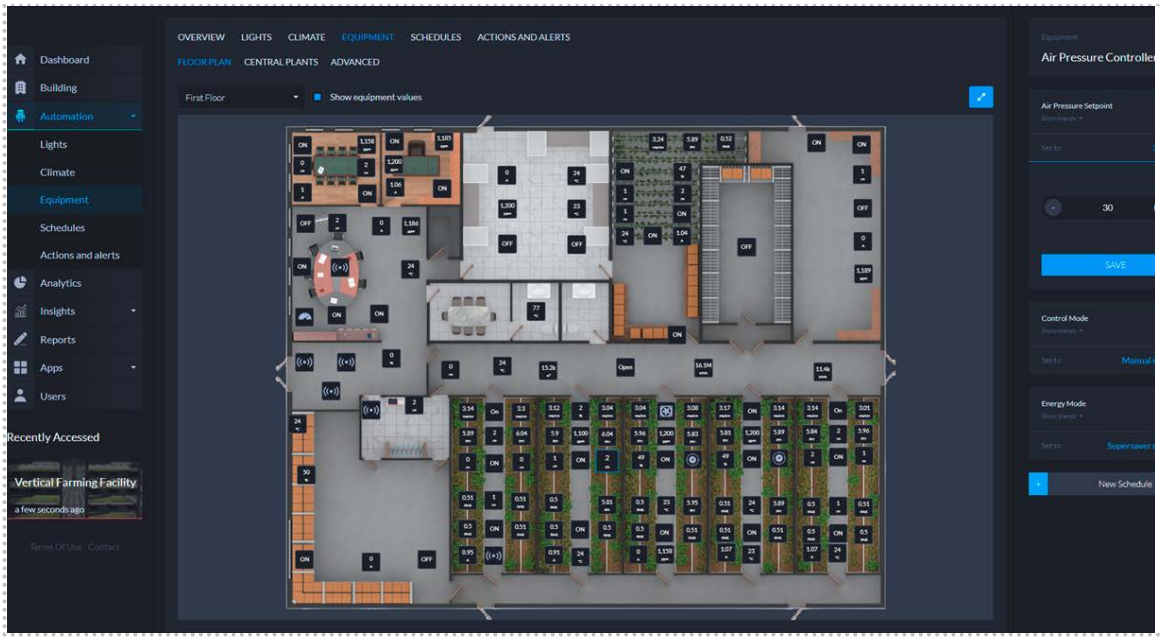

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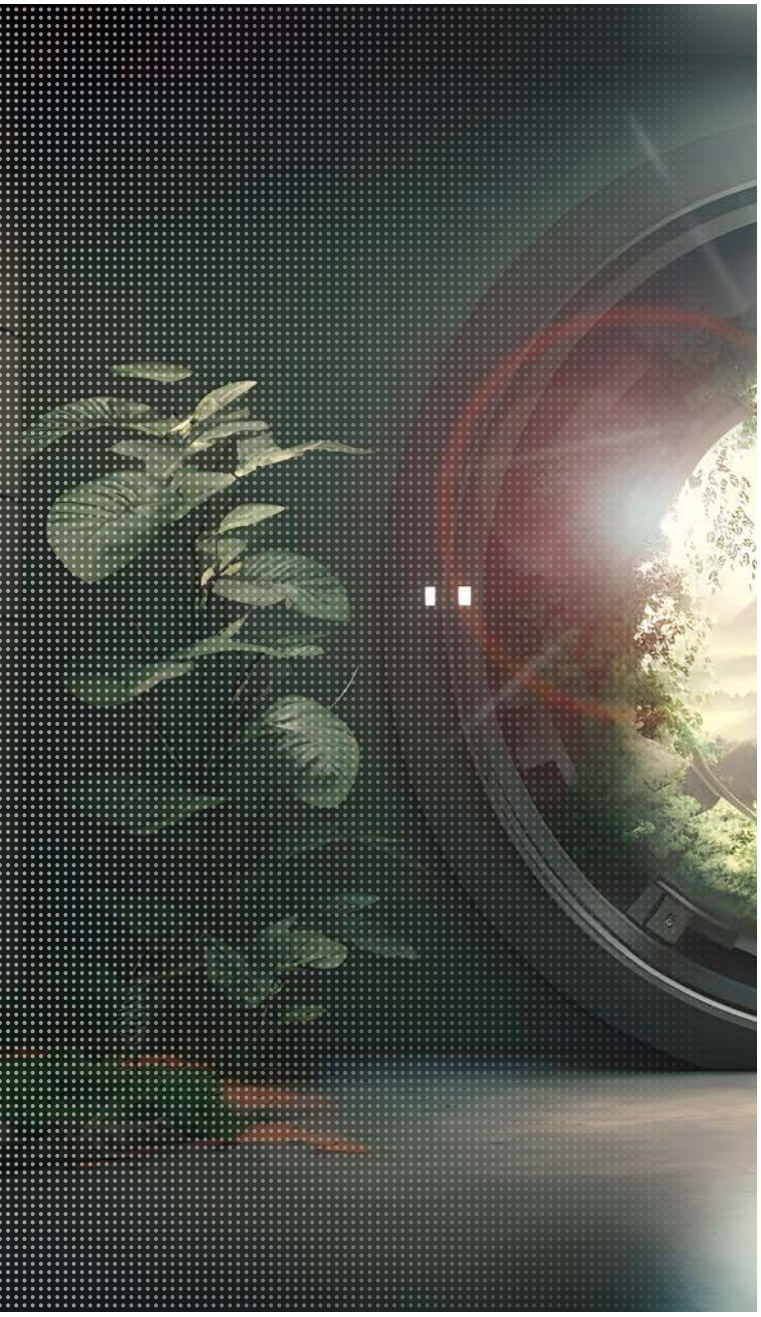
FIGURE 8: **For a high-yield harvest, the conditions for growth must be continually monitored to initiate targeted changes or quickly eliminate problems if required. ebm-papst helps with this using its digital services.**

Smart retrofit of a ventilation system with sensors

Celebrating better – thanks to good air

Until now, the event rooms in the monastery cellar in Beutelsbach were ventilated by old, belt-driven fans, but, at some point, they reached their limits. After a retrofit, the air is not only distributed more efficiently, the ventilation system also focuses on air quality using sensors.

prompt:
a view into a sustainable future out of a dark club room, natural light, photorealistic



The monastery cellar is located in the middle of the old city center in Beutelsbach, Germany. It includes a gym with showers and changing rooms, which are used by the nearby school, a small cinema, and a large vaulted cellar where events take place. These four rooms were supplied with fresh air by a ventilation system located in a narrow cellar room, using belt-driven fans. They could be controlled in just two stages. However, as the rooms were often used to varying extents, for example the cinema room often went from empty to full of people, this is a key area where more efficiency can be gained. Therefore, the city of Weinstadt commissioned an engineering firm and Pfänder GmbH to find an energy-saving and economical solution (Fig. 1).

The city's wish was initially only to modernize the control system. "That wouldn't have been a problem either – the system's control cabinet was in very good condition. However, the energy-saving potential would have been limited due to the old belt-driven fans," says Lukas Pfänder, Managing Director of Pfänder GmbH. As Lukas Pfänder had already implemented several successful retrofit projects in cooperation with the ebm-papst Breuell & Hilgenfeldt service center, he also suggested a retrofit for the monastery cellar. The lack of space meant that a plug-and-play solution was the only way to modernize the ventilation system's intake and exhaust air economically and to reduce the power consumption of the fans.

Retrofit with a focus on air quality

Dieter Hildebrandt, Sales Manager at Breuell & Hilgenfeldt, calculated the required performance and suggested eight RadiFit EC centrifugal fans as a replacement. However, the monastery cellar's special requirements – the fast change in the level of utilization of the space and the resulting changing demand for fresh air – gave Hildebrandt and Pfänder the idea of equipping the ventilation system with sensors and gateways in order to

ebm-papst neo offers intelligent solutions for data-based buildings.

FIGURE 1: **Lukas Pfänder, Managing Director Pfänder GmbH and Ralf Braun, Sales Director Germany, inspect the ventilation system in Beutelsbach monastery cellar.**

constantly monitor the requirements and regulate the system to them accordingly (Fig. 2, p. 32). They approached Ralf Braun, Sales Director Germany and contact person for ebm-papst neo, with this suggestion. The start-up of the fan specialist ebm-papst offers intelligent solutions for data-based buildings. Braun was immediately convinced by the idea, as demand-based, sensor-based closed-loop control would open up more energy-saving potential, alongside the efficient fans.

The RadiFit – the compact solution for ventilation technology

The main aim of the retrofit was to save energy, which is why the RadiFit EC centrifugal fan was chosen, the new system solution for ventilation technology from ebm-papst. Due to its compact dimensions, it was suitable for the installation dimensions of the old fans, enabling space to be saved and the installation to be quick and easy. As it was supplied as a plug-and-play design, it was also easy to connect the electronics. The RadiFit features a scroll housing and backward-curved blades, which enables a high pressure increase and ensures a high level of efficiency. The RadiFit is also maintenance-free and durable, which further reduces the operational and life cycle costs. The maintenance supervisor and the city benefit from this equally. Thanks to their high efficiency, the retrofit also pays for itself very quickly. Dieter Hildebrandt and Lukas Pfänder estimated energy savings of 60 percent with the eight new RadiFit.

Energy saving thanks to EC motor

This value comes primarily from the RadiFit's GreenTech EC motor. Such high savings are possible thanks to the efficiency level of over 90 percent alone. Because the old belt-driven AC fans could only be switched on or off, regardless of the actual capacity utilization of the different rooms, the system always ran at too high a power, even if a lower air flow would have been sufficient for the actual fresh

air requirement. By contrast, the new EC fan can communicate and can be continuously controlled between 0 and 100 percent. The new RadiFit can take on every speed as required and work with the lowest possible power consumption at every operating point. This results in significant potential for savings, as the power consumption increases or falls in line with the speed to the power of three ($P \sim n^3$). So if the speed is reduced by half com-pared to the nominal speed, the power consumption is reduced by a factor of 8 and is therefore only 12.5 percent of the rated output, saving over 80 percent. To compare, if, on the contrary, half of the old AC fans are switched off and the other half are still operated at full load, only 50 percent of the power consumption can be saved.

Demand-based control with sensors

The second part of the retrofit involved reworking the control system. After all, it becomes even more efficient if the demand for fresh air is precisely determined and controlled automatically accordingly. The changing conditions of the monastery cellar provided the perfect case for this. "The gym is not used for half of the day. However, if a school class has a sports class, the CO_2 content rises and the ventilation system has to supply more fresh air. After the lesson, the showers and changing rooms are used, which suddenly increases the temperature and humidity there," explains Pfänder. For this reason, sensors for CO_2 content, humidity, temperature and fine dust concentration have been installed in the monastery cellar. The measured values are sent to the IntelliGate Air Gateways from ebm-papst neo, which forward them to the ventilation system's control system. The closed-loop control has been individually adapted and programmed for the monastery cellar. Specially defined limit values now specify when the system increases its power by how much and when it reduces the power once again, with infinite variations and efficiently. Individual functions such as a warning e-mail to the caretaker, have also been set up if a certain value is exceeded.

FIGURE 2: **The system's control cabinet was still well maintained and could therefore be supplemented with sensors and ebm-papst neo gateway without great effort.**

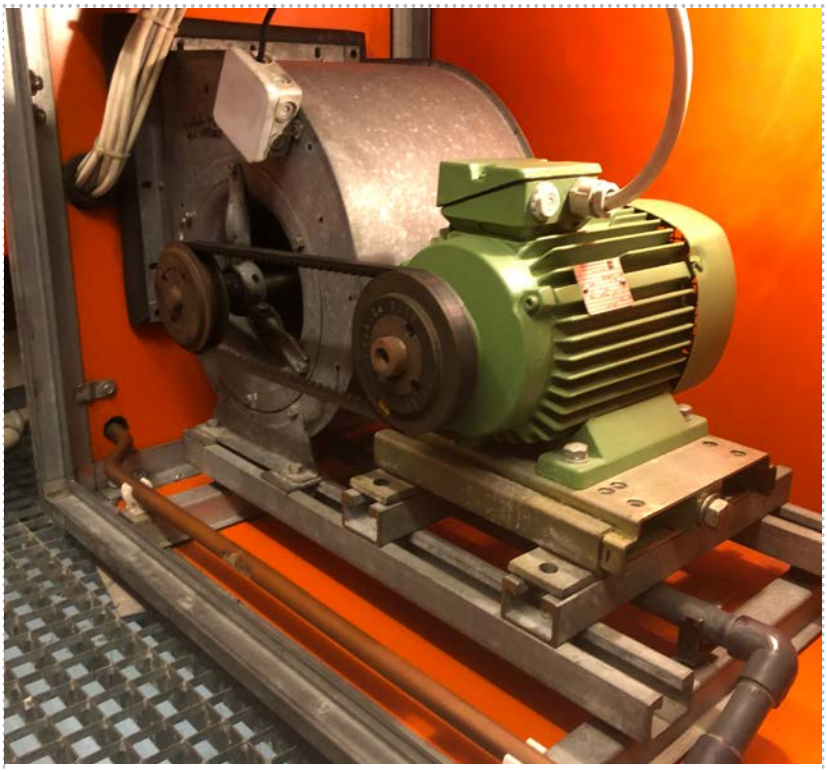


FIGURE 3: **The old, belt-driven fans used too much electricity and could only be controlled in two stages.**

FIGURE 4: **Thanks to EC motors, the new RadiFit is much more economical and could be replaced quickly and easily.**

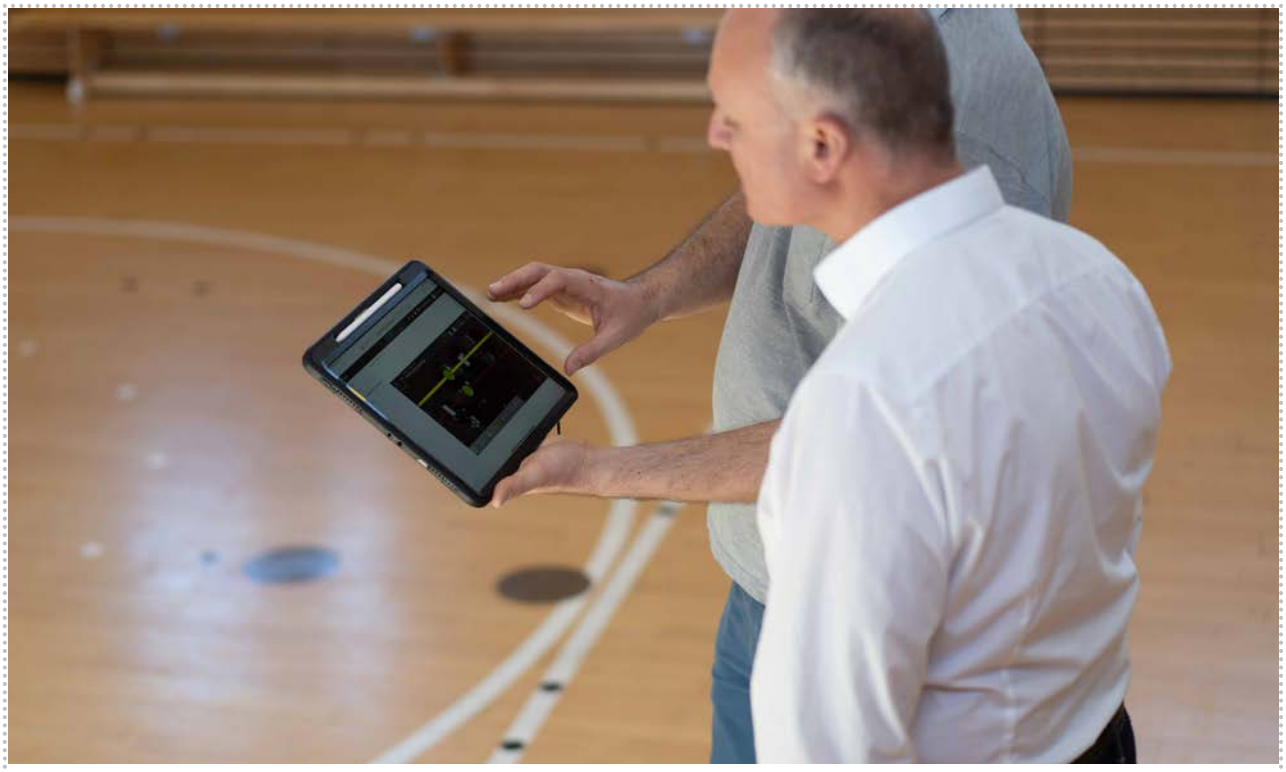


FIGURE 5: **Thanks to ebm-papst neo gateway, the ventilation system data can be displayed in real time and adjusted manually if required.**

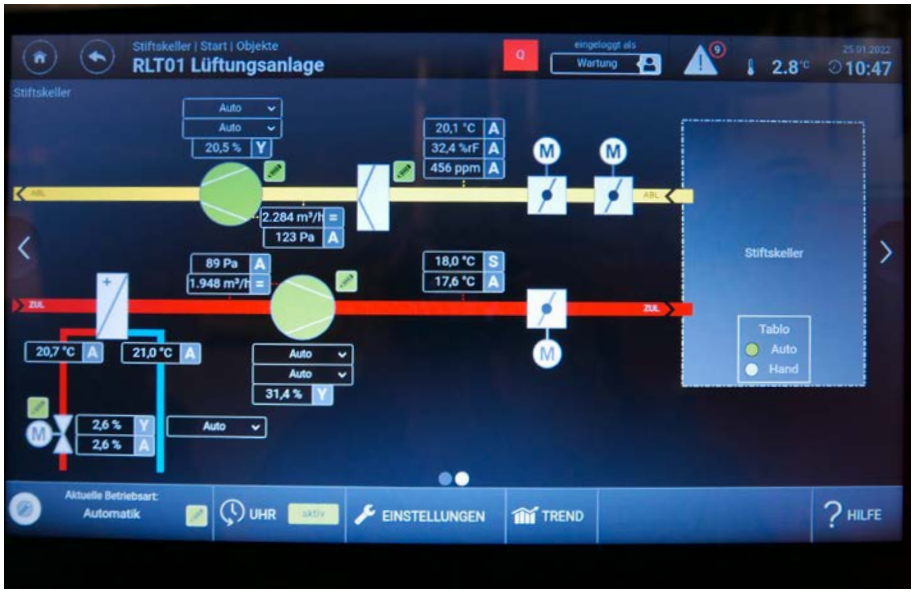


FIGURE 6a,b: **The maintenance supervisor can use an operating panel to read out the data from the ventilation system at any time and adjust it manually if necessary.**

Goal achieved – the city saves money

The interaction between sensors and systems is reliable and economical. This will enable more than the planned and achieved energy savings of 60 percent. The city not only saves on costs but can also guarantee high air quality for all visitors at large events, festivals or concerts (Fig. 6a, b). ○

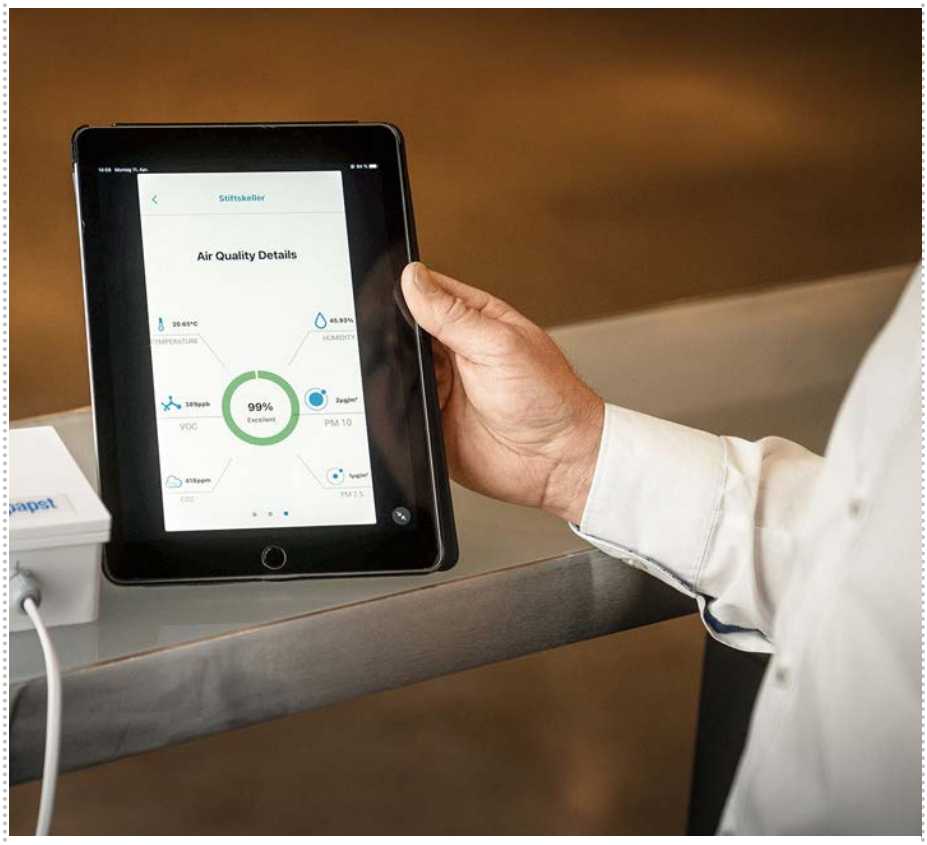
AUTHORS ARE RALF BRAUN, SALES DIRECTOR GERMANY AT EBM-PAPST MULFINGEN AND WALDEMAR WAGNER, PRODUCT MANAGER AT EBM-PAPST NEO.

YOU WOULD LIKE MORE INFORMATION ON THIS TOPIC? PLEASE ADDRESS YOUR QUESTION TO:

Ralf.Braun@de.ebmpapst.com

Ensuring air quality with the multi-IAQ sensor

With the Multi-IAQ sensor from ebm-papst neo, there is a simple and efficient way of ensuring consistently high air quality in event rooms. The sensor measures a total of five values, namely temperature, humidity, VOC (volatile, organic compounds that are harmful to health), CO_2 and fine dust in the air. The viral index is calculated using the five measured values and a complex mathematical equation. This indicates the quality of the air and the risk of virus transmission and can be read off from the freely accessible IAQ Connect app. The multi-IAQ sensor can be installed in flush-mounted sockets similar to a light switch.



The Multi-IAQ sensor can be used to read out detailed air quality data.

Imprint

ebm-papst Mulfingen
GmbH & Co. KG
Bachmühle 2
74673 Mulfingen
Phone +49 (0) 7938 81-0
Telefax +49 (0) 7938 81-110
info1@de.ebmpapst.com

ebm-papst St. Georgen
GmbH & Co. KG
Hermann-Papst-Straße 1
78112 St. Georgen
Phone +49 (0) 7724 81-0
Telefax +49 (0) 7724 81-1309
info2@de.ebmpapst.com

ebm-papst
Landshut GmbH
Hofmark-Aich-Straße 25
84030 Landshut
Phone +49 (0) 871 707-0
Telefax +49 (0) 871 707-465
info3@de.ebmpapst.com

www.ebmpapst.com

Responsible for content:
Kai Halter

Editor:
Corinna Schittenhelm

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