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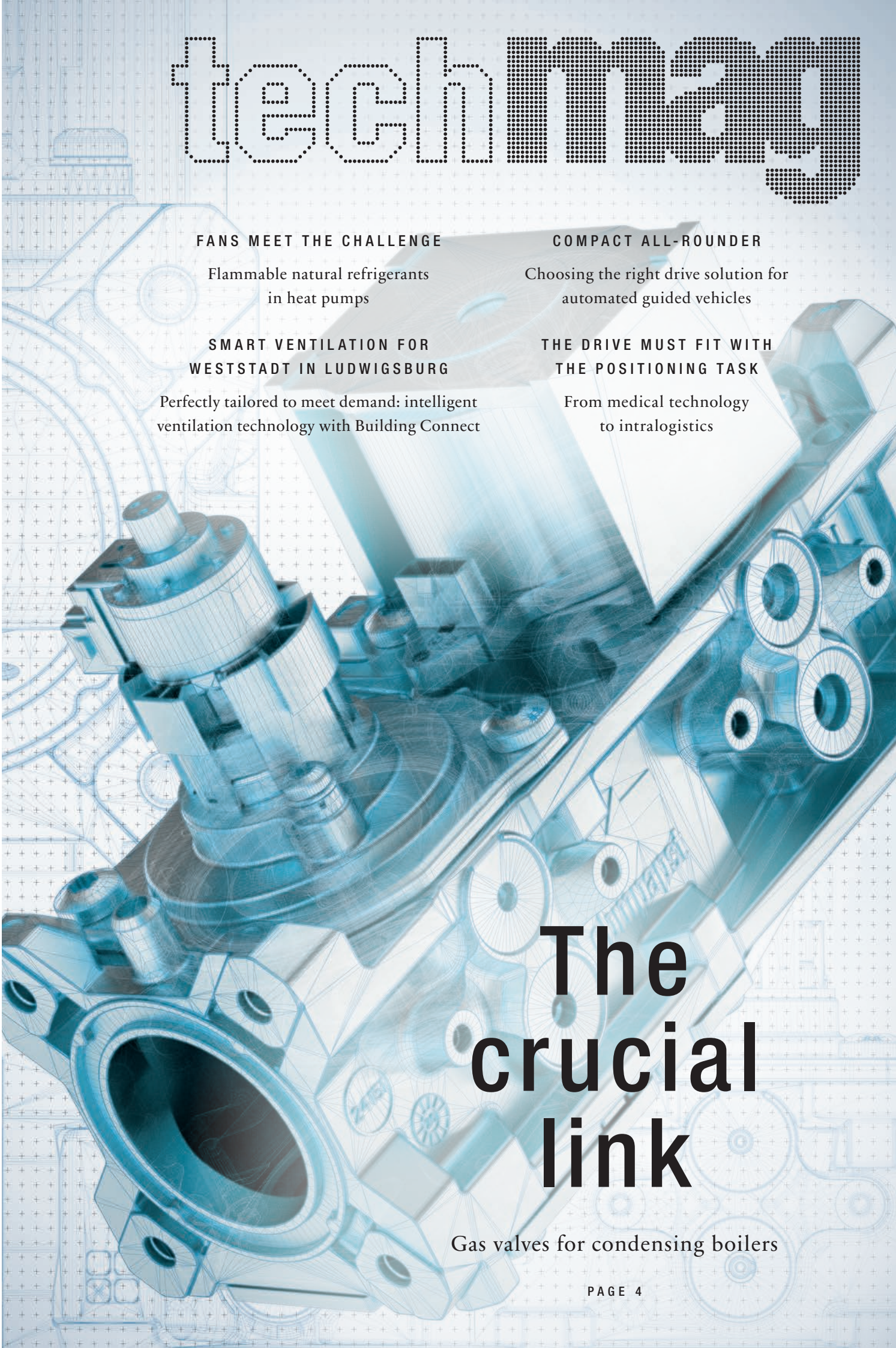

The crucial link

Gas valves for condensing boilers

PAGE 4

“Perfectly coordinated components create future-proof systems”

Stefan Obermaier

HEAD OF PRODUCTMANAGEMENT
AND MARKETING
AT EBM-PAPST LANDSHUT

Dear Customers, Partners and Friends of ebm-papst,

The future is to become more sustainable, more efficient and greener. Through interdisciplinary and diverse teams, we generate the necessary creativity and inspiration to develop the best, most sustainable solutions for our customers. With solutions for heat pumps, efficient system components for gas condensing boilers and hybrid solutions, we are going full steam ahead with environmentally friendly heating. Green hydrogen also provides an alternative to fossil fuels. Many of our gas/air composite systems are already able to operate with up to 20 percent hydrogen admixture, helping to reduce CO_2 emissions. We also invest in H_2-ready technologies. Like our new gas laboratory, for example.

System solutions from ebm-papst meet the highest efficiency standards for state-of-the-art heating applications, which supports optimum operation. It is crucial that all individual components interact with each other perfectly. This also includes regularly developing these further, which is how our wide range of gas valves for pneumatic and electrical systems with a wide range of performance classes was developed. Regulating the incoming gas is crucial for achieving the perfect gas/air mixture ratio. In conjunction with the right blower, Venturi and control unit, a system is created that is already future-proof – and tailored to every customer's needs.

Would you like to find out more about tomorrow's heating technology? Then read the lead article about our gas valve range and the other exciting topics in this issue!

Gas valves for condensing boilers

The crucial link

In condensing boilers, the gas valve is a key component for combustion control. It ensures safe, reliable operation and is crucial for providing the optimum combustion mixture. The gas valve range from ebm-papst offers the ideal solution for both pneumatic and electronic networks (Fig. 1, p. 6).

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If there were only one type of gas in the world, life would be much easier for heater manufacturers. They would need to configure their combustion system just once to provide the optimum gas and air mixture ratio, after which the condensing boiler would provide heat equally efficiently in all parts of the world – leaving aside ambient parameters such as temperature or air pressure for now.

However, natural gas is produced by a natural process, and it has a different heating value depending on where it comes from. In the Netherlands and Germany, for example, L-gas is traditionally used. Its name reflects the fact that it is low-calorific (L = low). This contrasts with H-gas from Russia, which has a higher methane and thus energy content, making it high-calorific (H = high). Since sources are running dry and the market is changing, there are also new fuels such as liquefied gas from the USA, as well as synthetic gas or hydrogen from power-to-gas plants. Therefore, finely balanced systems are required to set the optimum combustion mixture.

Key role within the network

In practice, pneumatic combustion control has proven its worth in this regard for many years. As a result of fluctuations in gas quality, electronic combustion control is gaining in importance as an alternative. ebm-papst offers both variants as a complete solution under the names CleanEco (pneumatic) and CleanVario (electronic) (Fig. 2). Within these systems, the gas valve plays a key role. Firstly, it prevents the gas from flowing out in an uncontrolled manner, and secondly, it only allows the exact quantity that needs to be mixed with the air

The gas valve range from ebm-papst offers solutions for pneumatic and electronic combustion systems.

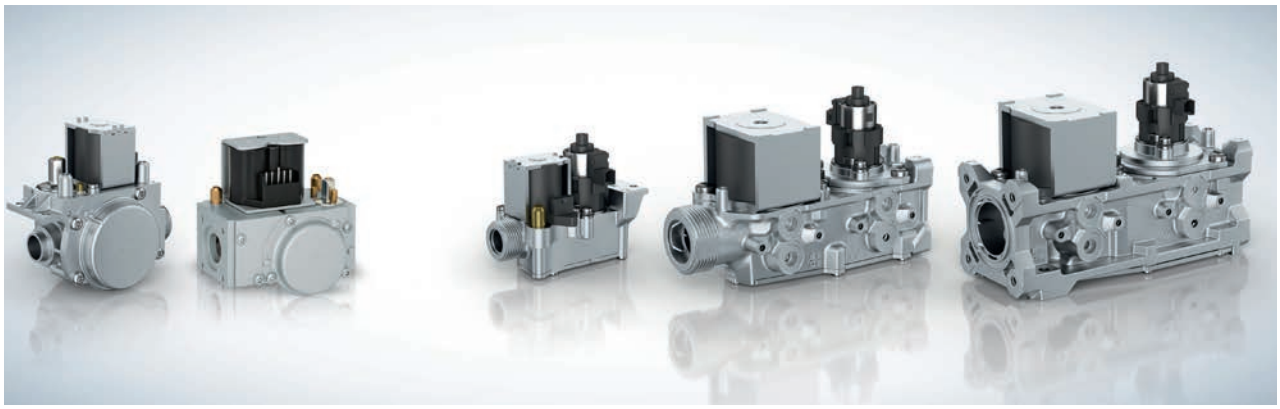

FIGURE 1: **Gas valve range from ebm-papst.**

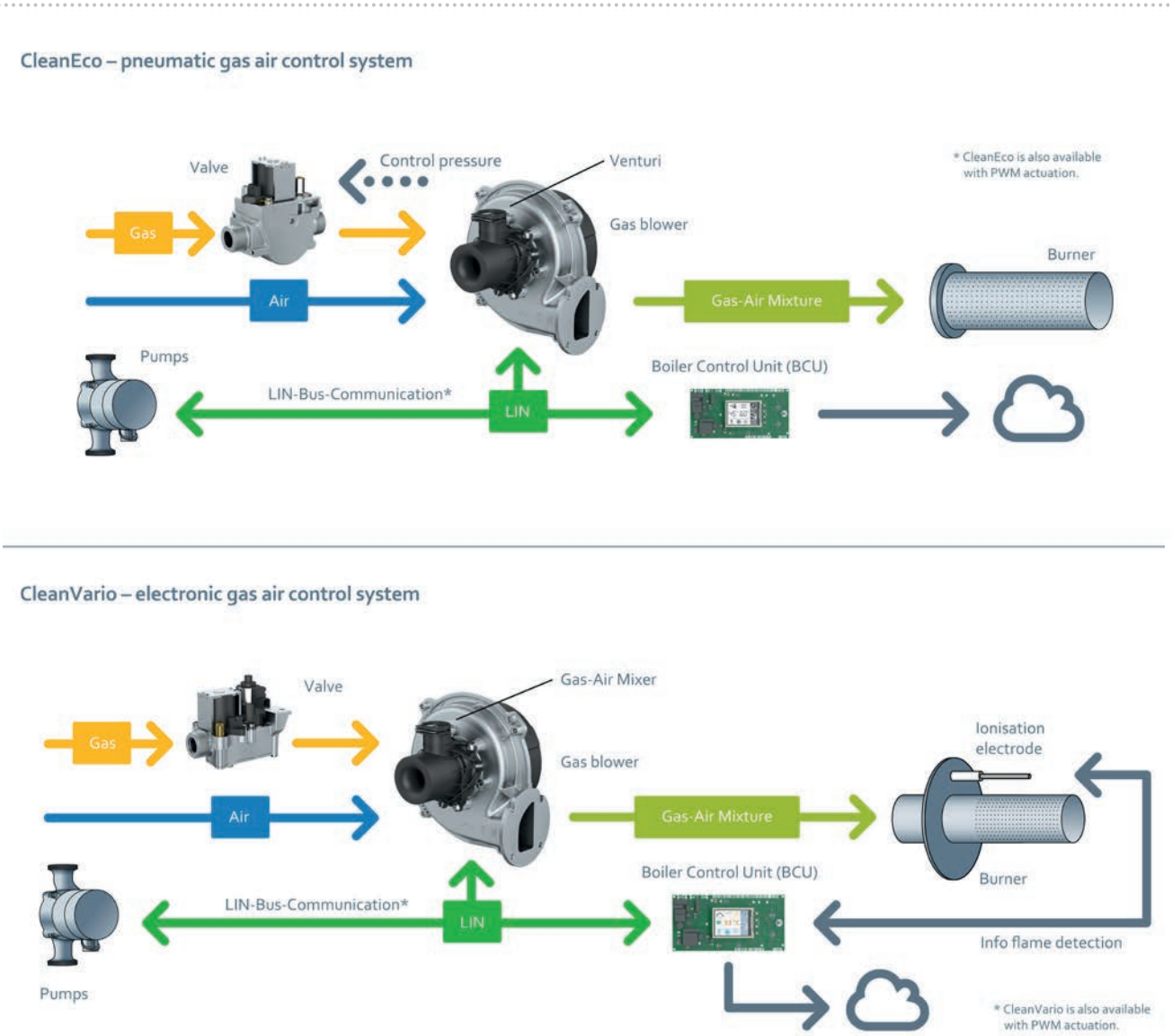

FIGURE 2: **The interaction between all components is a decisive factor for both electronic and pneumatic networks. The gas valve plays an important role here in ensuring the correct combustion mixture.**

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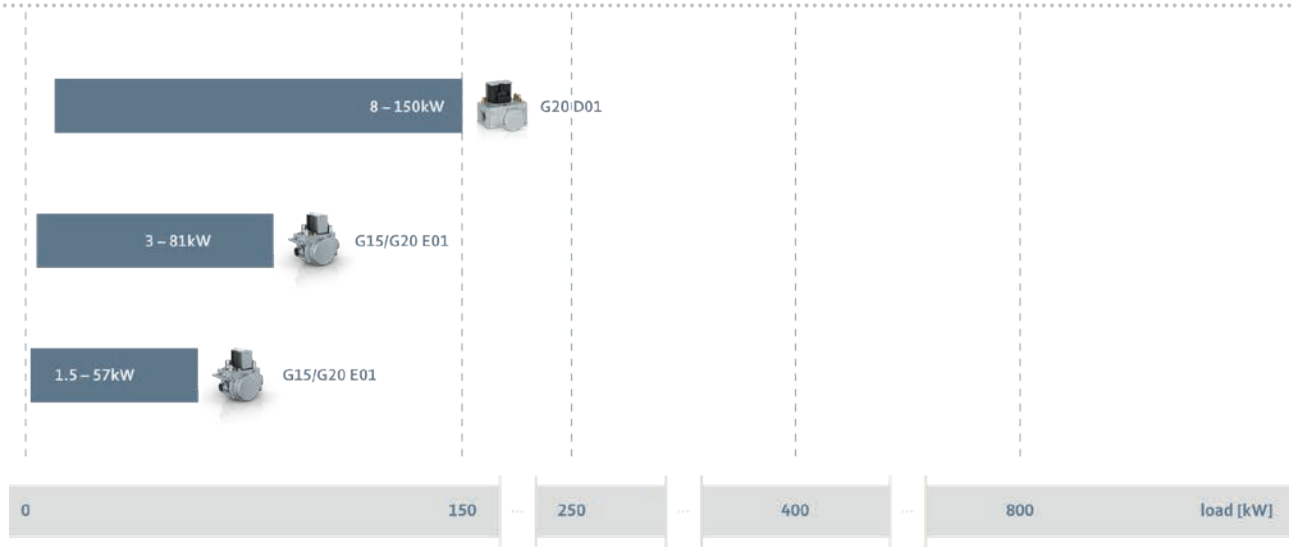

FIGURE 3: **The gas valve range from ebm-papst for pneumatic networks.**

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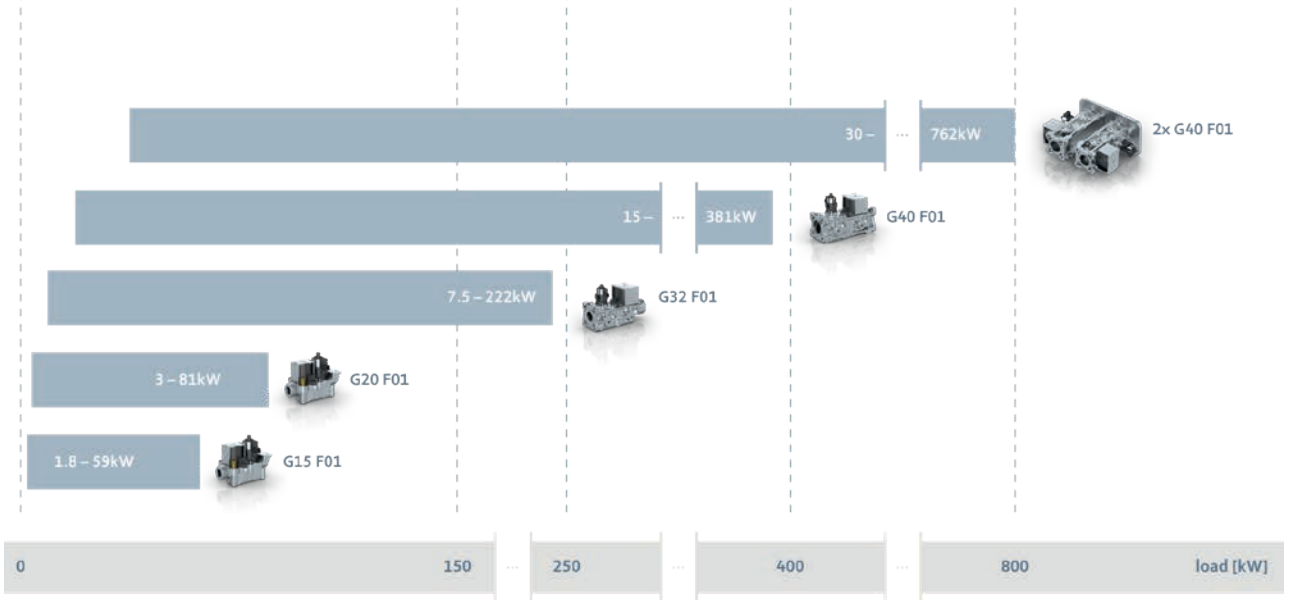

FIGURE 4: **The gas valve range from ebm-papst for electronic networks.**

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All components from a single source: gas valves from ebm-papst are continuously being expanded and refined.

to flow through. The important thing is to ensure a coordinated approach with the blower, venturi, and control unit. That works best when all components come from a single source. This is why ebm-papst has also included gas valves in its range since 2011 and is continuously expanding and refining the range, such that power ranges (Fig. 3 and 4) from 1.5 - 762 kW can now be offered.

The classic solution: the D01 valve

Mechanical valves are used in pneumatic networks. Their operating principle is that if the thermostat in the home switches on or if someone turns on the hot water faucet, the boiler starts working. The blower rotates as per the required power, the gas valve is opened, and the taper in the venturi causes a vacuum that draws in the gas. In simple terms, the faster the blower rotates, the more gas is taken in. This must not happen in an uncontrolled manner. Therefore, the valve should only open until it allows the exact quantity for the combustion mixture to pass through.

How does this work? A look at the interior of valve D01 from ebm-papst provides the answer (Fig. 5 p. 11). There are two safety valves on the gas inlet side. If one fails, the other can still prevent an uncontrolled supply of gas. The safety valves are lifted by way of electromagnetic coils and the gas can flow in. The operating valve is located on the outlet side, which is connected to the venturi. The vacuum generated by the blower exerts a force via a working diaphragm. This force mechanically lifts the operating valve.

Two adjusting screws can be used to regulate the extent of this action: the offset and main flow throttle setting. The offset (shifting the zero point) can be set on the servo controller. The offset pressure is always regulated to zero, regardless of the suction pressure generated by the premixing blower. This also enables pressure fluctuations in the supply network to be compensated. The throttle element adjusts the quantity of gas required based on the gas quality. For example, with L-gas a larger quantity flows through than with H-gas. This means that both settings are crucial for ensuring a correct gas-air mixture ratio over the entire modulation range.

The D01 valve is the first one that ebm-papst included in its product range and is suitable for a very wide power range of 8 to 150 kW. Thanks to its compact dimensions, the D01 is a space-saving solution for integration into the boiler.

Low power, big impact: the E01 valves

For lower power classes of up to 81 kW, the engineers at ebm-papst have further refined the D01 principle and pro-

vided an even more compact solution: the E01 valve. The crucial difference lies in the design of the safety valves. Instead of being distributed across two coils, they are combined in a single module. This uses less material and also saves more energy as there is only one coil that has to be energized. The E01 is available in two versions: for power ranges from 1.5 to 57 kW and 3 to 81 kW.

More flexibility: the F01 valve

The gas valve is becoming much more important in electronic networks. Here, the mixing ratio is not controlled by the vacuum but by the electronic actuation of the gas valve. Instead of reacting passively, it thus actively controls the gas supply. This means that, in contrast to pneumatic networks, the valve does not have to be manually set in advance to suit the respective gas type and quality, as the system adapts to the gas. The valve needs a parameter to ensure it knows how much gas it should provide for mixing with the air. ebm-papst relies on what is known as ionization technology for this, which uses the electrical conductivity of the flame. If a voltage is applied, the so-called ionization current can be measured directly in the flame using an electrode. This can be used to draw conclusions about the combustion quality: If the current is too weak, the valve receives the signal to supply more gas; if it is too high, it restricts it.

To ensure that the gas valve can actively control the gas supply, it has to be designed differently than in a pneumatic network. With the F01 series, ebm-papst offers the ideal valves for all power classes between 1.8 and 762 kW (see Fig. 4, p. 8). In terms of the safety technology, the developers relied on the same system as for the E01. However, a stepper motor with integrated pressure regulator is used on the outlet side. This motor can precisely vary the flow rate and, in turn, the amount of gas. If the flame sends the signal that combustion is not optimal, this patented solution can take the appropriate countermeasures flexibly. This means that, in an electronic network,

THREE VALVES WITH A WHOLE HOST OF BENEFITS

THE D01 VALVE

- Tried and tested in everyday operations for many years
- Compact dimensions mean greater flexibility for manufacturers
- Easy access to electrical connections and settings
- Precise adjustment of the gas-air ratio using the offset and main flow throttle setting

THE E01 VALVE

- Gas valve with one coil with coaxial double safety valve and a die-cast housing
- This makes it even smaller and allows for low electrical power
- Produced in ever-increasing volumes since 2014
- Easy access to the connections
- High offset accuracy and thus optimum compensation of pressure fluctuations in the supply network

THE F01 VALVE

- Electronic control system means that manual settings are no longer required
- Patented solution comprising stepper motor and integrated pressure regulator
- Optimized design enables fully automatic mounting
- Very precise control in a power range of 1.8-762 kW
- Modular design enables the valve to be optimally combined with other system components

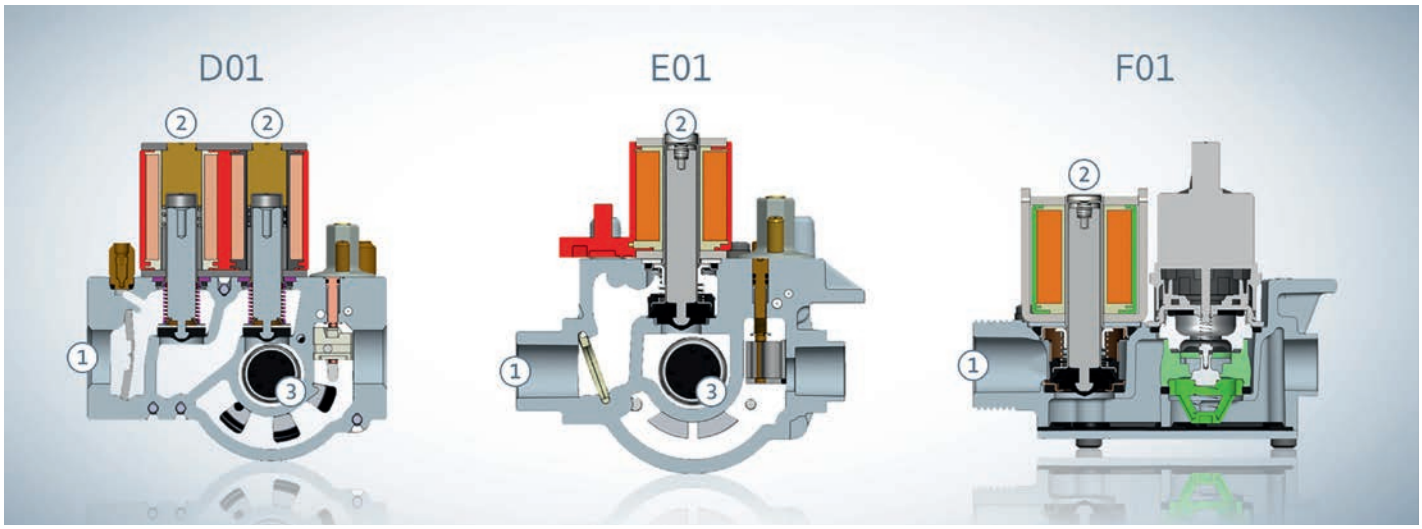

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FIGURE 5: **All three gas valve types from ebm-papst shown as sectional views. The gas flows in from the left (1). The two safety valves (2) are opened by one (E01, F01) or two (D01) electromagnetic coil(s). In the D01 and E01, the operating valve (3) is used to regulate the pressure and quantity.**

it almost doesn't matter which fuel is flowing through the pipes. What's more, the manufacturers have to worry much less about the different gas types and qualities – the combustion is always optimal, efficient, and environmentally friendly. ○

AUTHOR IS ENNO VROLIJK, HEAD OF GAS VALVES AT EBM-PAPST LANDSHUT.
YOU WOULD LIKE MORE INFORMATION ON THIS TOPIC? PLEASE ADDRESS YOUR QUESTION TO:

Enno.Vrolijk@de.ebmpapst.com

THE PERFECT COMBINATION

Whether it's a pneumatic or electronic network, it is crucial that all components in a combustion system are perfectly coordinated with one another. This means that the blower and valve have to be a good match. ebm-papst offers the following possible combinations:

Blower	Gas valve
RadiMix VG 71 & VG 100	E01 and G15 F01
RadiMix VG 108	G20 D01 and G32 F01
VG 145	G20 D01 and G32 F01
RG 175	G32 F01 and G40 F01
G1G 170	G40 F01
G3G 200	G40 F01

Fans meet the challenge

Climate protection is the global challenge of our time, which needs to be tackled by climate protection agreements, laws and regulations on decarbonization. This includes the F-gas Regulation, which has been in force since January 1, 2015. By 2030, fluorinated greenhouse gas (F-gas) emissions in the EU must be reduced by 70 million metric tons to 35 million metric tons of CO_2 equivalent in steps. It is therefore essential to switch to natural refrigerants with a low global warming potential (GWP). However, these are often flammable. This means that all components installed in heat pumps, for example, must meet the standards for flammable refrigerants. This also applies to the fans used, but these also need to be as quiet and energy-efficient as possible.

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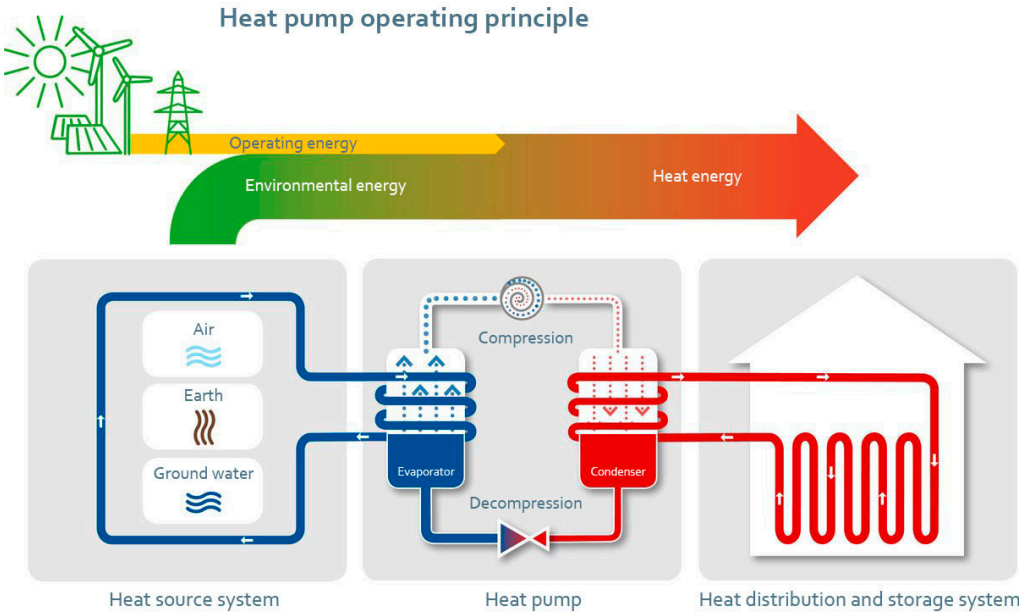
Today's heating systems demand concepts based on renewable energies. Therefore, heat pumps are becoming ever more popular in both new buildings and renovations and are subsidized by funding in many cases. They are becoming an important pillar in creating more sustainable heat generation. Today more than half of new construction projects are equipped with this. Air-to-water heat pumps are widely used here due to their efficiency and their simple installation and set-up. They use heat energy from the ambient air and transfer it to the hot water circuit via an intermediate circuit with refrigerant (Fig. 1).



Bundesverband Wärmepumpe e.V.

FIGURE 1: **Air-to-water heat pumps use the heat potential from the ambient air and transfer this to the hot water circuit via an intermediate circuit with refrigerant.**

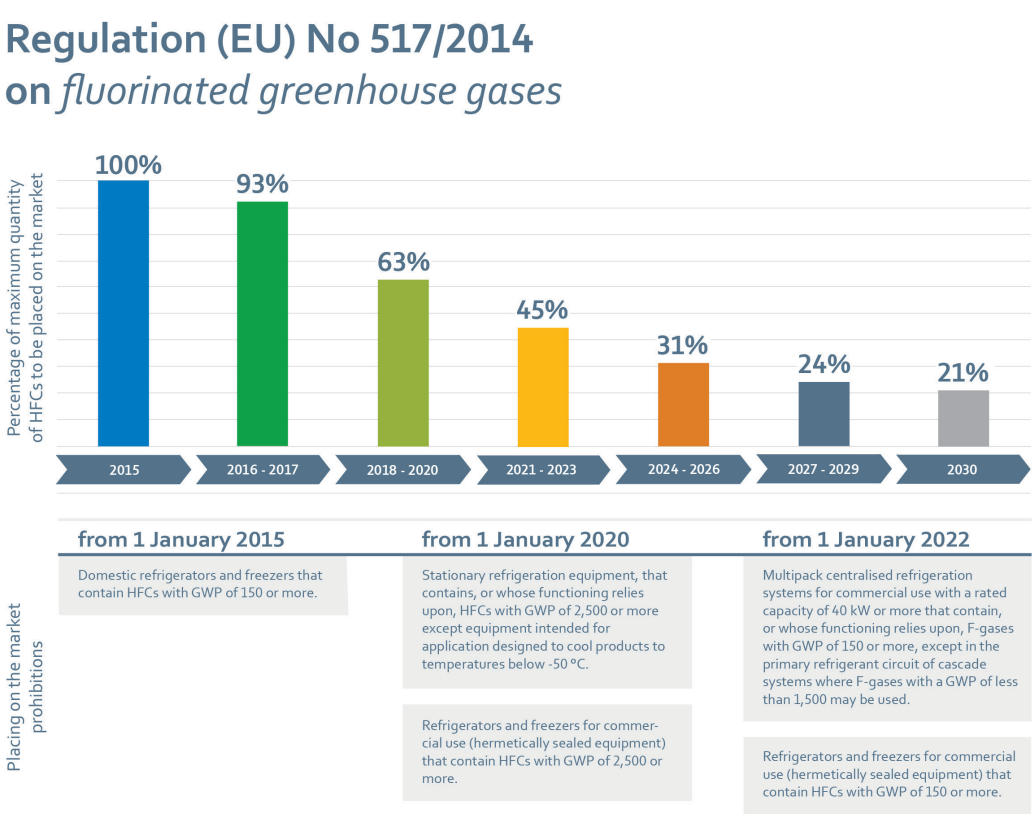


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FIGURE 2: **The step-by-step plan of the F-Gas Regulation (Regulation (EU) No. 517/2014) governs the use of partially halogenated hydrofluorocarbons (HFCs).**

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FIGURE 3: **The fans approved for use with A3 refrigerants in accordance with EN 60335-2-40 are available in various axial and centrifugal versions.**

What fan options are there?

However, the step-by-step plan of the F-Gas Regulation (Regulation (EU) No. 517/2014) governs the use of partially halogenated hydrofluorocarbons (HFCs) (Fig. 2). So in the long term, there is no way around the natural alternatives. However, these are flammable in most cases. The reason for this is simple: a low GWP value requires a rapid decomposition of the refrigerant when it enters the atmosphere. This can only be assured if it is chemically reactive, but high reactivity typically goes hand in hand with a high level of flammability. When developing refrigerating systems and air conditioners, household refrigerators and heat pumps, manufacturers must therefore ensure that they only use components that meet the applicable standards for handling flammable refrigerants.

For fans that provide the necessary air flow in heat pumps through the evaporator, this means that their electronics must not become an ignition source, even if a fault occurs. In principle, this can be achieved in various ways. One method, which is very time-consuming, is using restricted-breathing housings that prevent electronics and flammable atmospheres from coming into contact with one another. Another option is using an additional, smaller ATEX fan, which ensures reliable ventilation of the unit. However, this principle of continuous ventilation is only rarely used, e.g. in chillers. Most manufacturers of air-to-water heat pumps prefer to use components that are approved for use with flammable refrigerants.

Drive design in accordance with EN 60335-2-40

Using ATEX-approved fan motors is always possible but they are often oversized and expensive. Motor and fan specialist ebm-papst therefore offers an alternative specially designed for use in air-to-water heat pumps. For fan drives in sizes 55, 74 and 84, the electronics circuits have been modified to comply with EN 60335-2-40 for heat pumps with flammable refrigerants, i.e. the maximum surface temperature must be at least 100 kelvin below the ignition temperature of the refrigerant used in the event of a fault. Propane, which is very well suited to new buildings and building renovations due to its good heat transfer capacity and its low GWP value, has an ignition temperature of 470 °C. The electronic assemblies, which have been tested and certified accordingly, ensure that their maximum surface temperature always remains below 370 °C, even if a fault occurs, and as a result they do not become an ignition source.

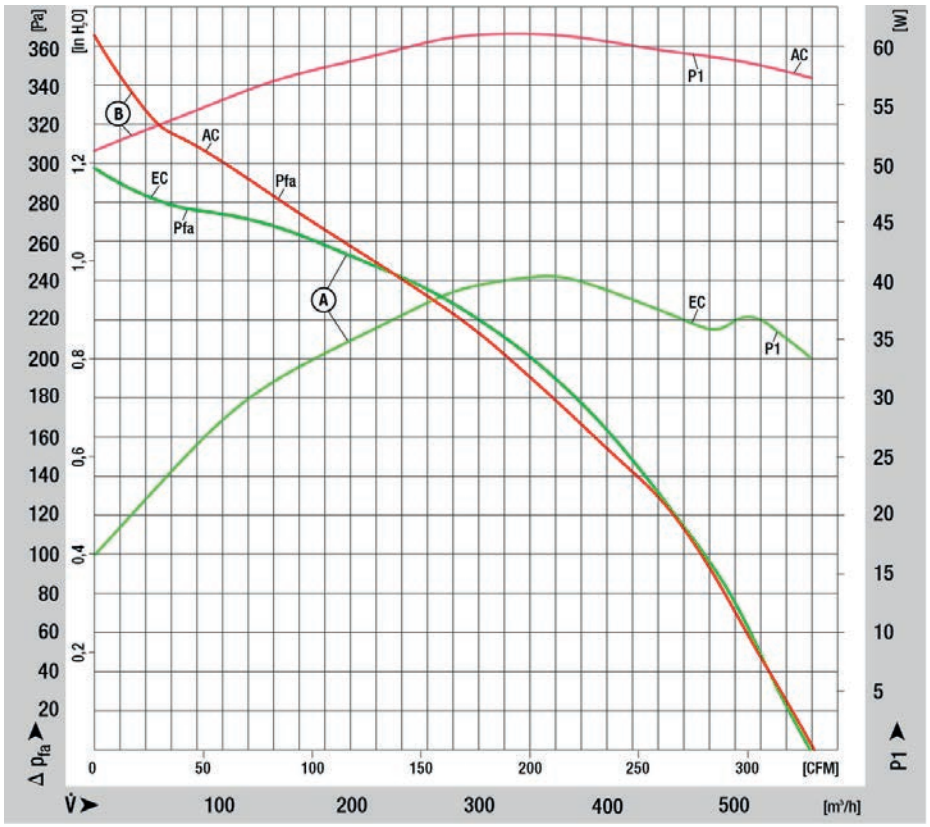

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FIGURE 4: **When providing the desired heat output, heat pumps should consume as little primary energy as possible. It pays off if the fan operates at the highest possible efficiency (green characteristic curve 'RadiCal' with GreenTech EC technology, red characteristic curve for conventional centrifugal fan with AC technology: P1=Power consumption, Pfa=Air performance curve).**

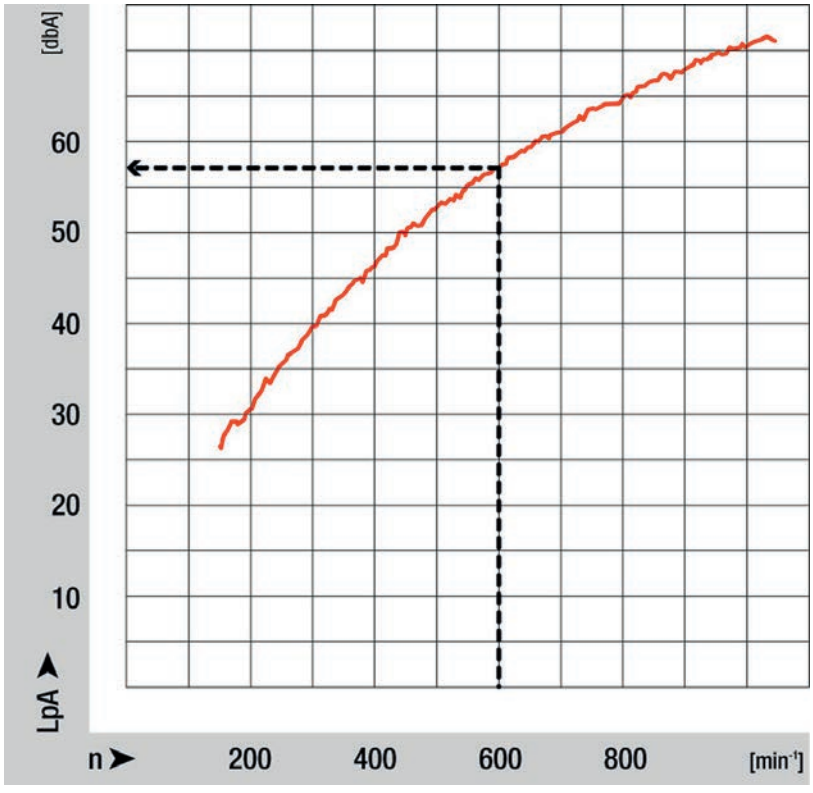

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FIGURE 5: **Dependency of sound pressure on the speed with a centrifugal fan. If the speed of the example fan is reduced by just 100 rpm, the noise can be reduced by more than half.**

The fans approved for use with A3 refrigerants in accordance with EN 60335-2-40 with maximum fill quantities of up to 1 kg or 5 kg (depending on the installation site) are available in many axial and centrifugal variants, covering the widest variety of applications for air-to-water heat pumps for outdoor use and for indoor use (Fig. 3).

High energy efficiency and low noise emissions

Energy efficiency and noise characteristics are also important aspects when selecting fans for heat pumps. Modern EC motors are the driving force behind the fans. Users benefit from GreenTech EC technology in several ways: One of them is thanks to its energy efficiency. When generating the desired heat output, heat pumps should consume as little primary energy as possible. The compressor consumes much more power than the fan, but it still pays to have the fan work at the highest possible efficiency. That is why there is no alternative to EC technology here too (Fig. 4).

Another advantage, the noise characteristics of the EC fans, becomes particularly important at night when the limit values of the applicable legal regulations must be observed inside and, most importantly, outside the building. To keep noise emissions low, large fans should operate in the low speed range as far as possible. It goes without saying that the EC motors used in the fans are easy to control, as the speed can be further reduced at night without a problem. This means that switching off the heat pump to avoid trouble with the neighbors is not necessary. If the speed of the example fan is reduced by just 100 rpm, the noise can be reduced by more than half (Fig. 5). Good interplay between fan impellers or blades with the motor and electronics is another key element for quiet fan operation. ebm-papst has optimized its blade and impeller geometry to achieve considerable improvements in aerodynamic efficiency and noise emission. Psychoacoustic aspects were also taken into account to ensure that fan noise comes across as pleasantly as possible. For quiet operation, the fans can usually be combined with guide vanes. This FlowGrid reduces noise resulting from the conditions of installation. This ensures that the heat pumps operate quietly at all times. The range of fans that meet the applicable standards for flammable refrigerants is being continuously expanded so that a suitable design can be found for each performance class. ○

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

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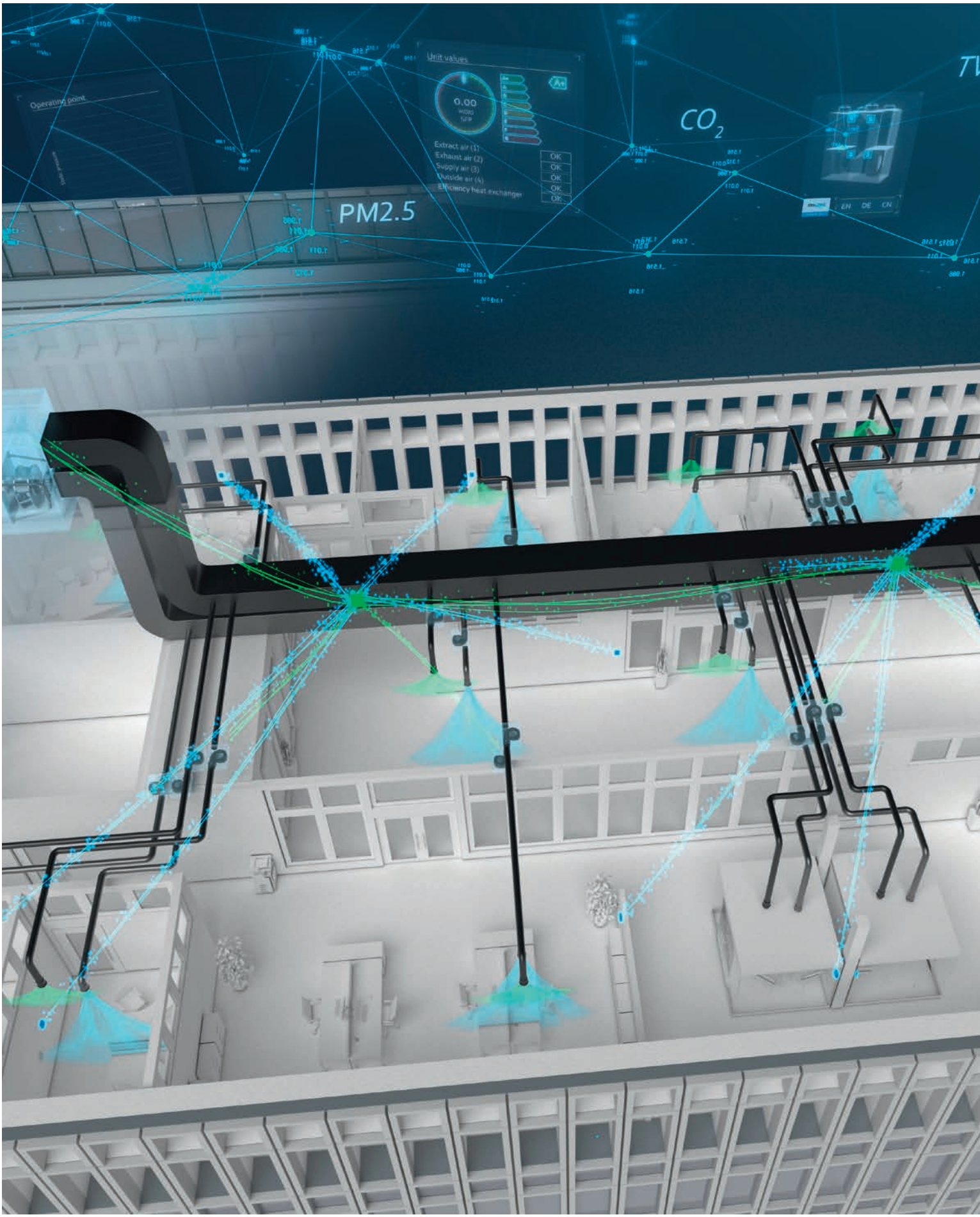
Marcel.Roessler@de.ebmpapst.com


Unit values
Operating point
0.00
Extract air (1)
Exhaust air (2)
Supply air (3)
Outside air (4)
Efficiency heat exchanger
OK
OK
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PM2.5
CO_2
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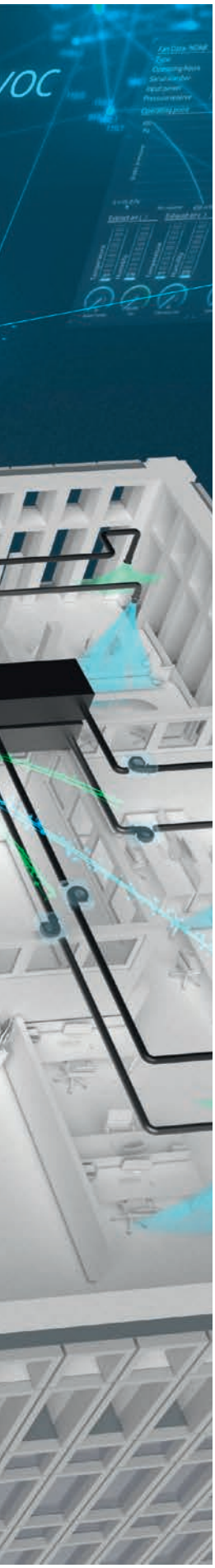

Perfectly tailored to meet demand: intelligent ventilation technology with Building Connect

Smart ventilation for Weststadt in Ludwigsburg

Sustainable construction is becoming increasingly important in the fight against climate change and to protect our environment. Architectural design should conserve resources and buildings should be constructed using renewable or reusable raw materials, and aim to reduce water and energy consumption during operation. In the Weststadt district of Ludwigsburg, this is now a reality. This is where Europe's first climate-neutral urban district, urbanharbor, is being developed. Instead of constructing new buildings, old manufacturing facilities are being transformed into new offices for local start-ups. Energy is only provided to where it is being consumed, in real time – including to the ventilation system. Behind the industrial façade, data from state-of-the-art sensor technology and extremely intelligent ventilation technology runs on ebm-papst's cloud-based Building Connect platform. This approach ensures that the focus is always on meeting demand. This ventilation concept is not only good for our environment, it also benefits the employees' well-being.

maxmaier urbandevelopment

FIGURE 1: **The urbanharbor in Ludwigsburg covers an area of more than 200,000 m². It is an ecosystem of gastronomy, retail, and entertainment, as well as start-ups from the region, and has set itself the goal of operating completely climate neutrally by 2030.**

Looking across the roofs of Weststadt in Ludwigsburg, it looks as though nothing has changed for years. All across the 200,000 square meters, you can see one industrial hall after the other (Fig. 1). But take a look inside, and you can see that there has been a complete transformation: the facilities' usage and energy consumption are state-of-the-art. The manufacturing facilities that were once used to manufacture refrigerators and similar goods have been transformed into state-of-the-art offices for start-ups from the region working to bring their pioneering ideas to life. The conversion into this "building within a building" concept requires 75 percent less CO_2, as it saves a lot of embodied energy – all of the energy that would otherwise have been required in terms of raw materials and transportation for the new building. The air cushion between the external and internal façades provides an additional level of insulation – like in a thermos flask. "Our vision is for urbanharbor to be the first productive urban district in Europe to operate in a climate neutral way by 2030," says Max Maier, partner at and successor to the max maier businessgroup & urbandevelopment. "To achieve this, we make sure the energy is supplied exactly where it is needed in order to optimize the processes within the district's ecosystem. We use the cloud to organize this demand-based control system."

This vision is demonstrated most impressively in Hall 8, which, at some 10,000 square meters, is the largest hall. All energy-relevant areas such as the photovoltaic system, quick-charging stations for electric cars, reusable containers for supplying food, and heat pumps are linked together via the cloud. If employees want to charge their electric cars during their lunch break and the meeting rooms are empty, then the energy will be redirected from the ventilation system to the battery storage system. With this in mind, the owners, the Maier family, anticipate that in the worst-case scenario, Hall 8 will offset an additional 63 metric tons of CO_2 by producing excess solar power in addition to the 700 metric tons of carbon emissions offset to achieve climate neutrality. In the best-case scenario, they expect as much as 250 additional metric tons. These figures would not be possible if the individual areas, such as the ventilation and building technology, did not control their energy consumption as efficiently as possible using a demand-based system. "We were impressed by the semi-centralized solution including ebm-papst's cloud-based Building Connect platform," says Max Maier Jr. "The demand-based control system is exactly what we wanted."

Air – only where it's needed

Christoph Hornek, CEO of i-on Engineering GmbH and responsible for ventilation and building technology, normally uses air flow controllers in his air conditioners and ventilation systems to regulate the volume of air in each area of use. To adjust the air volume, a control flap is closed as far as necessary, until the desired air volume is reached. Restricting the air flow in this way wastes energy. However, the idea in Hall 8 was to make sure this energy is not consumed in the first place, and to design the Air Handling Unit (AHU) to have the lowest possible output. Another key factor was ensuring the best air quality. After all, the only fresh air available is the air that comes through the system.

Highly efficient heat recovery and a heat exchanger for heating or cooling bring fresh air to the appropriate tem-

perature. A near-surface concrete core activation system is responsible for controlling room temperature, and air humidifiers ensure a pleasant level of humidity during winter. The system filters out fine dust (PM10 and PM2.5) and organic compounds emitted by the materials inside (known as TVOCs) that could make employees feel unwell. This high-quality air, which is expensive to provide, is not wasted. Instead, air is viewed as a resource here, and indeed, is the most important one people need. After all, we all breathe up to 15,000 liters of air every day.

The fan for demand-based control – the RadiCal

The first semi-centralized ventilation system in Europe with an AHU in the technical center supplies air to the individual areas of use using around 300 peripheral fans (Fig. 2). Hornek opted to use the latest generation of EC centrifugal fans, the ebm-papst RadiCal with vane anemometer for integrated air flow measurement (Fig. 3). These highly efficient fans can measure the air flow precisely and maintain it independently, as required in each area. In and of itself, it offers very high efficiency thanks to its improved impeller technology and the latest EC motor. Its speed can be varied steplessly using the 0-10 V DC/PWM control signal or, as in this case, via a MODBUS RTU interface. When precisely regulated, the RadiCal can achieve a service life of over 100,000 operating hours.

The fans are now located in sound-insulated housings where the air flow controllers usually were. Due to this specific installation situation, they operate at a maximum air flow of 600 cubic meters per hour. Employees sitting one floor below cannot hear the operation because the centrifugal fan runs extremely quietly due to the optimized impeller. At 15 to 20 Pa, the pressure in the air distribution system is close to zero. Leaks via the air distribution network are therefore a thing of the past.

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FIGURE 3: **The latest generation of EC centrifugal fans, the RadiCal with vane anemometer for independent air flow measurement and regulation, backward-curved, single inlet with housing (flange).**

What's more, the RadiCal was ideally suited to the design challenges due to its unrivaled compact design. This was particularly relevant as the crane track in the old industrial hall restricted the available installation height under the roof to a minimum. Only 30 centimeters remained between the inner and outer façades for the supply and exhaust air. Thanks to GreenIntelligence, the fans emit

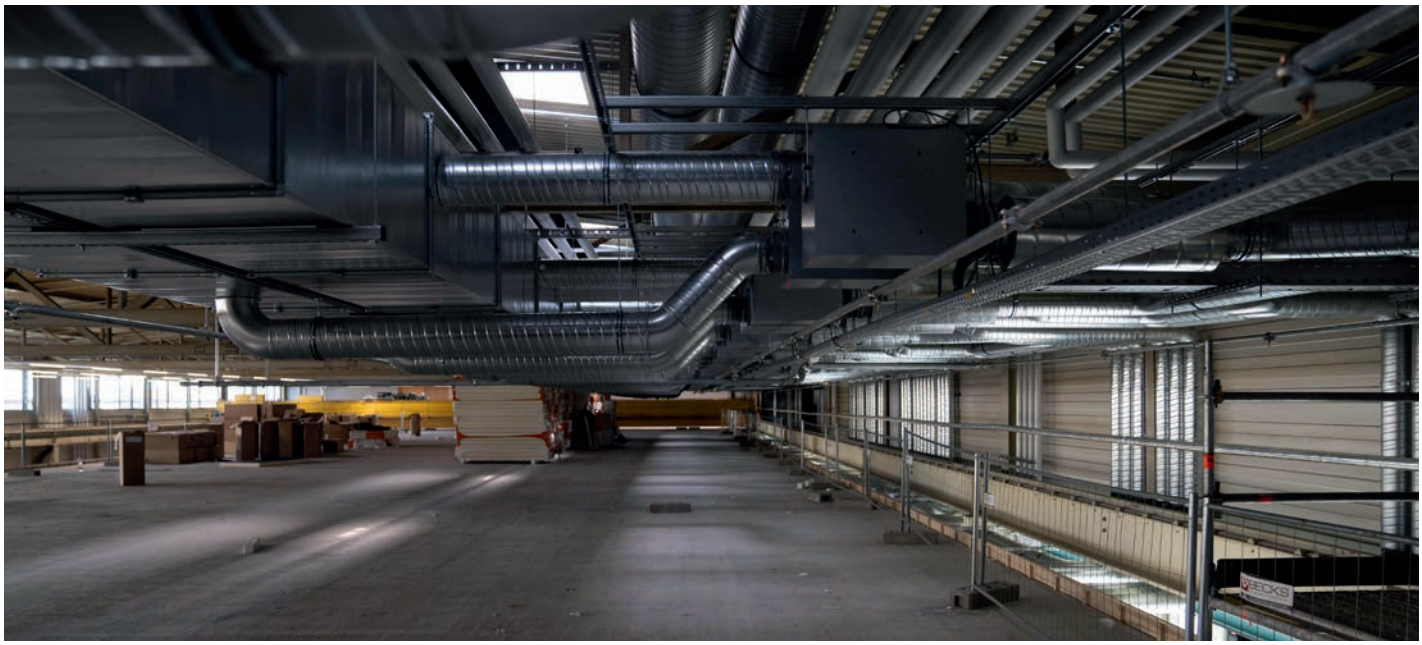

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FIGURE 2: **One of Europe's first semi-centralized ventilation systems, with almost 300 fans, runs between the roof of Hall 8, with its integrated crane track, and the roof of the double-story office space. It is installed in sound-insulated housings.**

The ebm-papst Building Connect platform controls where should be ventilated, and how strongly.

an error warning if their temperatures deviate too far from the target values. This level of reliability is also important if the supply of fresh air, as in this case, is only ensured by the fans. "This concept has enabled us to save around 50 percent of the air that would need to be treated, and 30 percent of the electricity that would be required to convey the air," says Christoph Hornek.

The brain of demand-based control: Building Connect

The ebm-papst Building Connect platform controls where should be ventilated, and how strongly. "ebm-papst neo developed software for this specific application at the time of planning. I knew immediately that Building Connect was what we were looking for," says Hornek, explaining his decision. The cloudbased real-time data platform obtains data from sensors in the office buildings, processes it in the ebm-papst cloud, and then issues commands to the fans. In addition to the temperature, humidity, TVOC, and fine dust levels, the sensors measure the CO2 content in the air – and it is this that determines how the ventilation system responds. 600 ppm or below is ideal. If the level reaches 1,000 ppm, employees begin to notice the poorer air quality and it affects their ability to concentrate. Once the value reaches 900 parts per million, the sensors start to inform the local fans that they need to increase their air performance accordingly. They ventilate until the value is back in the ideal range. As a result, people feel comfortable at work and can perform value-adding activities (Fig. 4).

To achieve this, the sensors constantly measure the air quality and continuously send the measured values to the gateway via the MODBUS line. The gateway processes the data internally and sends it to the cloud. Over 5,000 data points are monitored as part of this process. All of the sensors are RESET-certified (Fig. 5). RESET is the only real-time-based, internationally recognized air quality standard for indoor applications. The measured values are continuously checked by an independent third party. With Building Con-

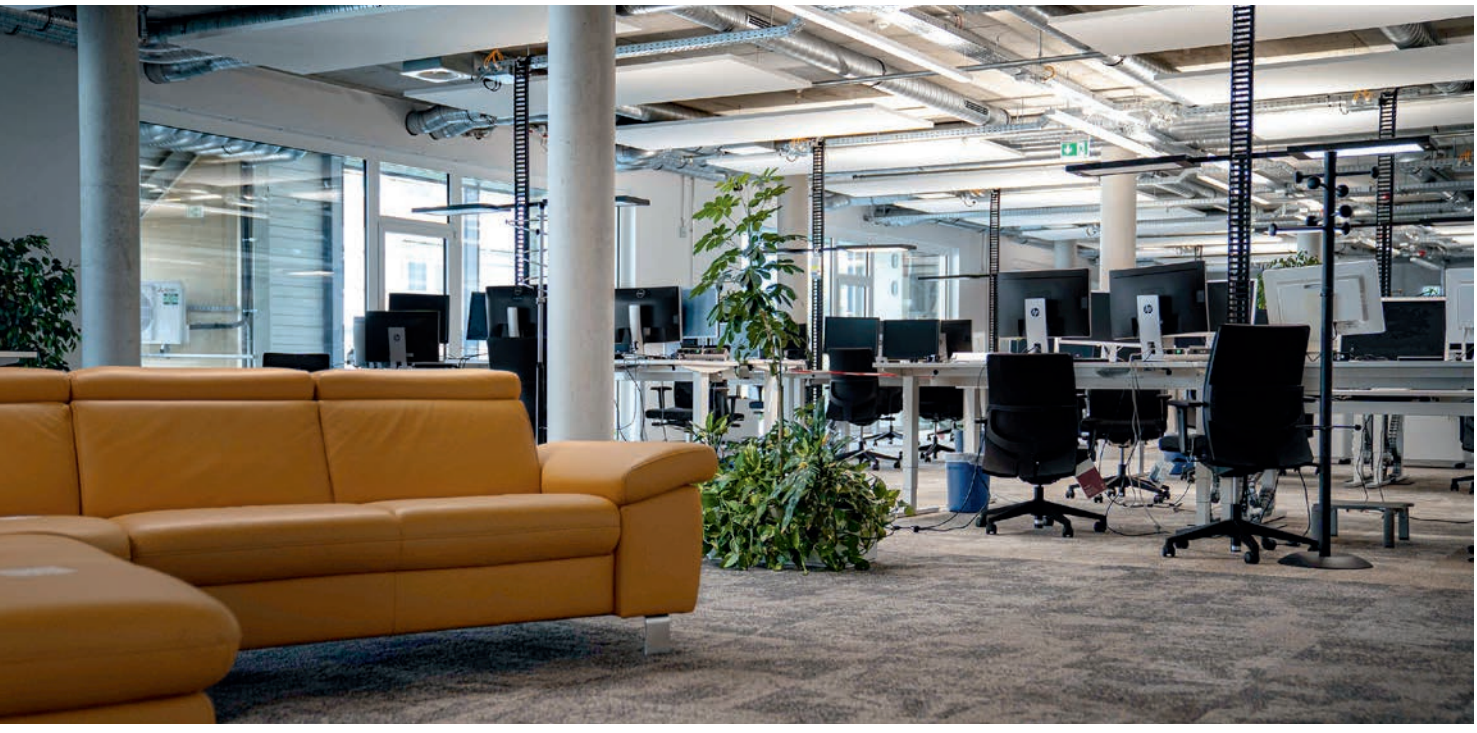

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FIGURE 4: **Productive work with top air quality – in addition to the temperature, humidity, TVOC, and fine dust levels, the sensors measure the CO_2 content in the air – and it is this that determines how the ventilation system responds. 600 ppm or below is ideal. As a result, people feel comfortable at work again and can perform value-adding activities.**

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FIGURE 5: **The sensors, which are certified according to the only real-time-based, internationally recognized air quality standard for indoor spaces, RESET, continuously measure the air quality and send their data to ebm-papst's cloud-based Building Connect platform, which processes it.**

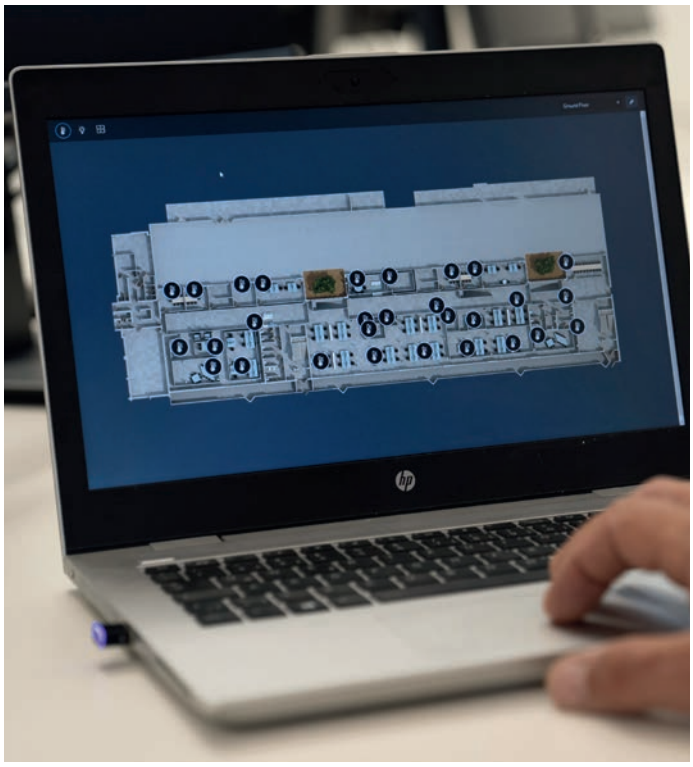

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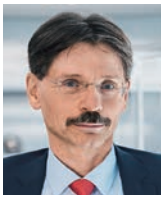
FIGURE 6: **The Building Connect platform collects the data from the sensors and fans and analyses it. Room plans are used to create the building's digital twin – in this case, Hall 8. The algorithms working in the background learn from user behavior, building characteristics, and environmental conditions so as to continuously improve the entire building ecosystem – intelligent real-time control.**

nect, the operators always have access to a precise mobile representation of the premises, and an overview of the data (Fig. 6). The algorithms working in the background learn from user behavior, building characteristics, and environmental conditions so as to continuously improve the entire building ecosystem. Any anomalies can be quickly identified and eliminated. In future, all data will be sent to the urbanharbor cloud so that the site can be managed holistically, taking into account all areas of the energy ecosystem. This is how the cooperation of today is creating the climate-neutral urban district of tomorrow. ○



AUTHOR IS THOMAS SAUER, MANAGING DIRECTOR AT EBM-PAPST NEO. YOU WOULD LIKE MORE INFORMATION ON THIS TOPIC? PLEASE ADDRESS YOUR QUESTION TO:

Thomas.Sauer@de.ebmpapst.com

Compact all-rounder

The drive solution is a central element in automated guided vehicles (AGVs). Omnidirectional mobility, transportation of a wide range of loads, a compact design and high vehicle reliability are only possible if the right concept is considered. A new driving/steering system meets all of these requirements, enabling a high level of flexibility using a scalable modular principle.

Hakahaka! This Polynesian term stands for freedom. Many automated guided vehicles (AGVs) require a lot of freedom because they take up a lot of space due to their limited free-range mobility and their height. Drive systems are usually the limiting factor here because maneuvering in tight spaces is difficult, or impossible, and low loading sills are difficult to achieve due to high drive units. But the term Hakahaka actually stands for freedom in a positive sense. And the right drive system for AGVs offers precisely this freedom: high free-range mobility in any environment, even tight ones, compact dimensions and flexible configurations enable a lot of freedom in the AGV design. In addition, the drive system's connectivity and safety functionality must provide freedom for smart integration into the AGV system.

The most important requirements for an AGV's drive system in typical use cases are explained in more detail below.

Maneuvering without restrictions

An essential requirement for all AGVs is as unrestricted maneuverability as possible. There is nothing in the way of navigating around spaces, even in the tightest of environments, if the AGV can rotate in a stationary position, move in the narrowest of radii, and perform parallel driving maneuvers. Many current drive solutions for

AGVs with the Heavy version are ideally suited for transporting heavy body shells or Euro pallets, designed for a weight of up to 2 metric tons.

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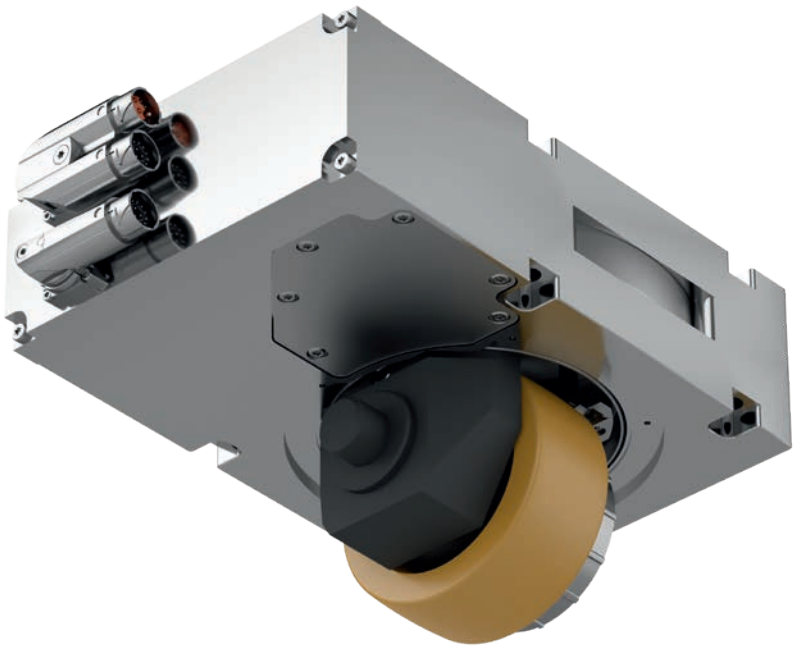

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FIGURE 1: **The ArgoDrive driving/steering system from ebm-papst for AGVs is a unit consisting of motors, special transmissions, sensors and all the necessary connections, and it allows for free-range navigation.**

ArgoDrive combines propulsion and steering functions in one module.

AGVs only allow maneuverability that is comparable with the principle of tanks, let alone track-guided solutions that do not allow any flexibility at all. Particularly in tight warehouses or flexible production environments with many work stations and machines, an AGV must be able to move freely in any direction. This means that they can drive up to material transfer points quickly and precisely without requiring a large amount of space. The AGV also has to be able to handle temporary obstacles easily.

To achieve omnidirectional mobility in an AGV, ebm-papst offers the new ArgoDrive drive solution. This driving/steering system combines propulsion and steering functions in one module (Fig. 1). This unit consists of motor, transmission, omnidirectional steering, sensors and all the necessary connections. Thanks to a superposition gear, its two integrated motors contribute to steering, acceleration, movement and braking, depending on requirements. The infinite steering angle enables space-saving, free-range vehicle movement – even from a stationary position.

Two driving/steering systems on the left and right side of the AGV guarantee full omnidirectionality (Fig. 2). Two additional freely moving support wheels on the front and rear ensure stability. Depending on the required size of AGV and the weight of the goods to be moved, three or four ArgoDrives can be installed. Smooth movement is one very important factor, regardless of the load being moved. Depending on the drive system installed, such as differential steering (differential drive), the vehicle often makes "rough" sequences of movement when cornering and maneuvering. Due to the design, the ArgoDrive can score points here, as rough movements are eliminated due to fluid and simultaneous driving and steering movements. Gentle and smooth movement sequences are very important, especially when the goods to be transported are delicate or when fine positioning the AGV at goods transfer stations.

Fit for different loads

The usage scenarios of AGVs are very multifaceted. They can be used to transport lighter and fragile goods, as well as heavy body shells in vehicle production. Accordingly, an AGV provider usually has to rely on completely different drive systems for its different solutions designed for these purposes. This not only increases the work involved in engineering and service but also the cost of individ-

ual solutions. Therefore, ideally, a scalable drive solution for AGVs should be designed in different sizes to meet various requirements with a single modular system.

ebm-papst addressed this problem when developing its ArgoDrive driving/steering system. Accordingly, the manufacturer offers its solution in Light, Standard and Heavy versions (Fig. 3, p. 28). All ArgoDrives are conceptually identical and so they have the same omnidirectionality. However, they differ in terms of which weight classes they can move. The Light version can move up to 100 kg per drive unit. If four ArgoDrive Light models are installed, the AGV can reach a total weight of up to 400 kg. The Standard model can transport up to 300 kg per driving/steering unit with full maneuverability. Therefore, with two ArgoDrives, one AGV can move a maximum of 600 kg. With four systems, it can move up to 1.2 metric tons. If the Heavy model is used, ebm-papst specifies a maximum weight of 500 kg per drive unit. Therefore, in the maximum configuration level with four ArgoDrive Heavy models, a load capacity of 2 metric tons is possible without issues. This means that transporting heavy body shells or Euro pallets, designed for a weight of up to 2 metric tons, is ideally suited to AGVs with the Heavy version.

Variable speed and ground clearance

Therefore, with this modular system, an AGV manufacturer can choose exactly which variant is ideal for their requirements. After all, in addition to weight classes, the Light, Standard and Heavy models also offer different driving speeds. Light drives allow up to 3 m/s, the Standard model moves at 2 m/s and the ArgoDrive Heavy enables a speed of 1.5 m/s. This offers fine scaling options based on

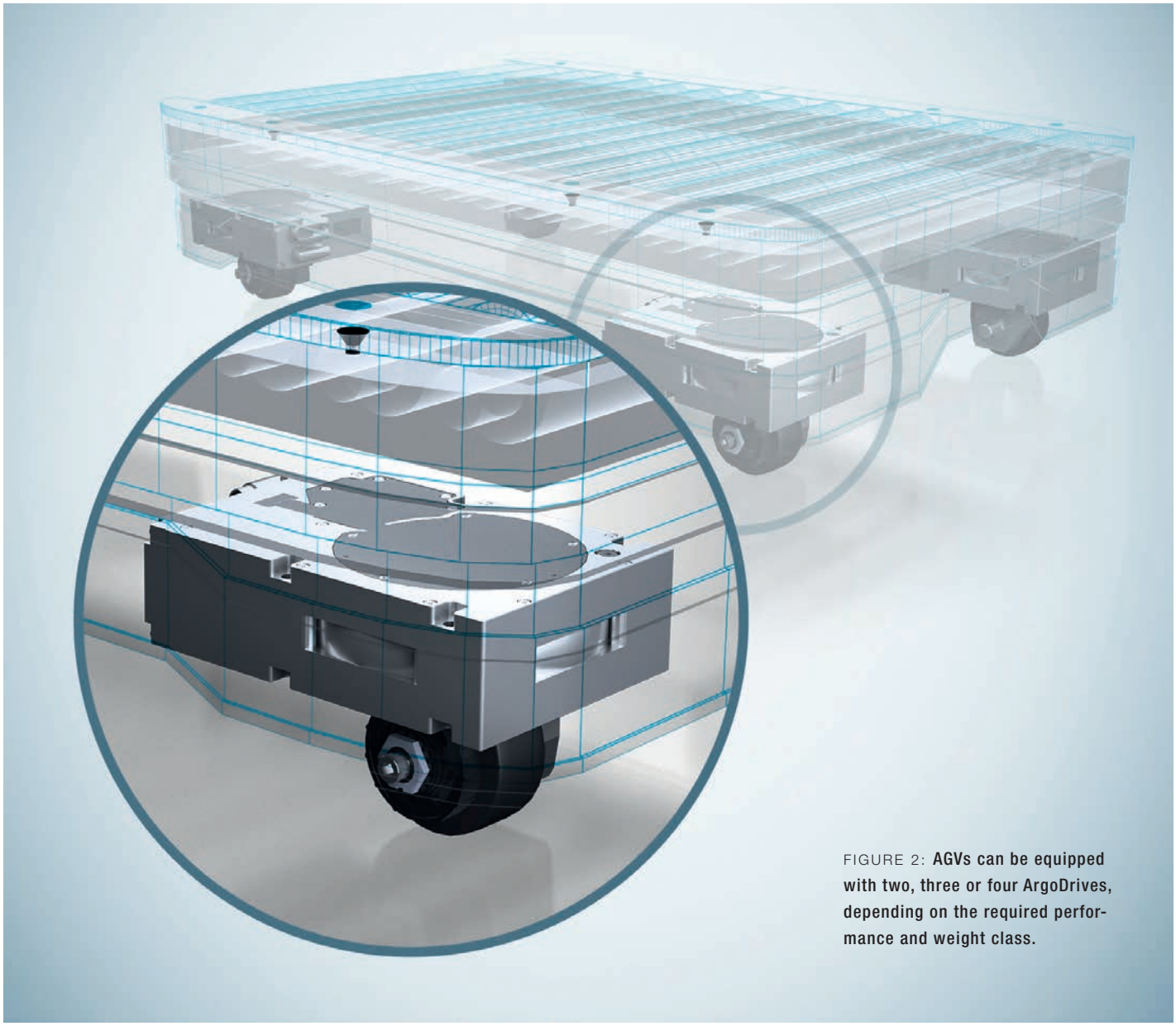

FIGURE 2: **AGVs can be equipped with two, three or four ArgoDrives, depending on the required performance and weight class.**

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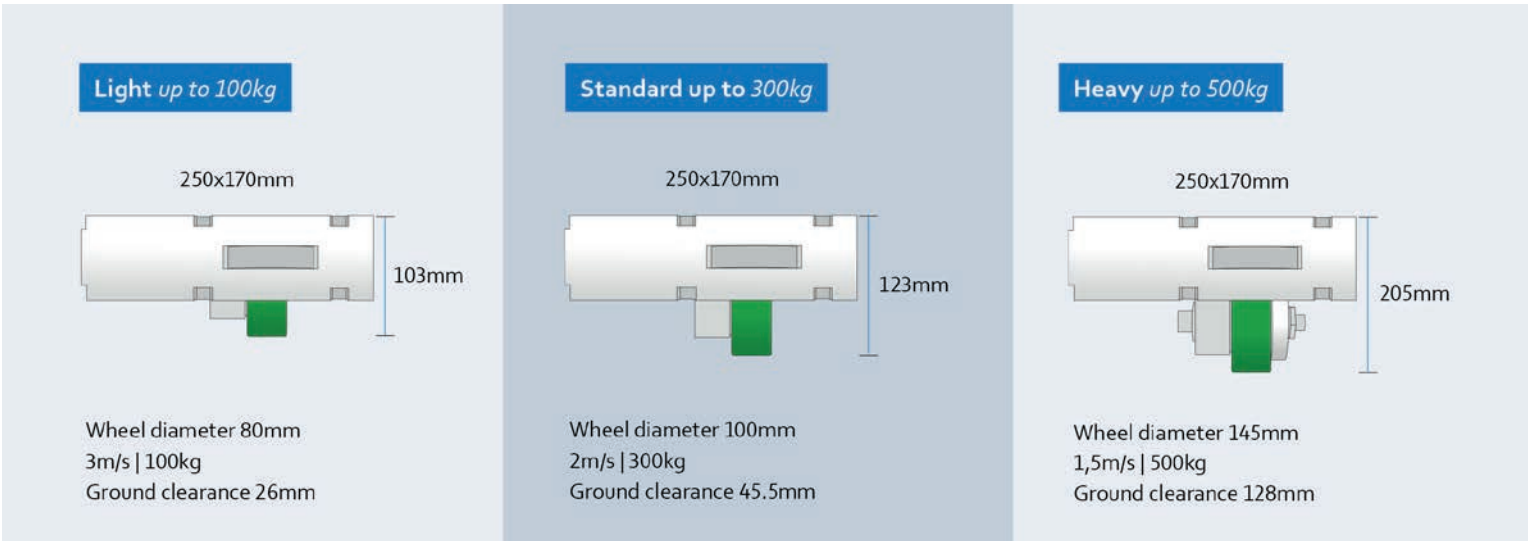

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FIGURE 3: **ebm-papst offers the ArgoDrive in Light, Standard and Heavy versions. All of them have the same omnidirectionality. "Heavy" allows a maximum weight of 500 kg per drive unit.**

the required transport weight and preferred speed. With an acceleration of up to 2.5 m/s², the ArgoDrive ensures that the vehicles arrive quickly. Another major advantage for AGV manufacturers is that all three versions of the ArgoDrive have identical installation dimensions and a standardized fastening, only the wheel diameter varies.

The Light version has a wheel diameter of 80 mm and enables the AGV to have a ground clearance of 26 mm. ebm-papst has given the ArgoDrive Standard a 100-mm-diameter wheel. The ground clearance is then 45.5 mm. Larger wheels are better suited to heavy loads. The Heavy model has a wheel diameter of 145 mm. The larger the wheel, the more insensitive the AGV is. Of course, that also applies to its sensitivity to unevenness on the floor. Contamination on the floor, such as chips, do not impair the function. Here, drive concepts with a Mecanum wheel in particular are at a clear disadvantage due to their mechanical vulnerability.

AGVs with larger wheels and high ground clearance are particularly in demand when needing to drive over transitions between halls. Grooves in the floor, seals or changing floor surfaces require insensitive systems. Managing gradients is also important. These often occur in hall transitions with level compensation or entrances to halls. Here, the AGV must not break down at full load. Transport solutions equipped with the ArgoDrive can handle inclines of up to 10 percent at full functionality.

Compact design despite high performance

In addition to free-range mobility with fine positioning for all transport tasks, the key criteria for AGVs are small dimensions and a low installation height. The level of the loading area for an AGV in particular must be very low in order to meet the requirements in intralogistics, at goods transfer stations or for structures with mobile robotics. Therefore, drive technology for AGVs should be very compact and offer as flat a design as possible. This is where many solutions fall down, because the performance suffers.

With the ArgoDrive from ebm-papst, this dilemma is solved by integrating two motors in one unit in a way that optimizes the installation space. The power of both motors can be used entirely for the drive and braking function. At the same time, a superposition gear ensures the required division of both motors' drive power during steering maneuvers. Therefore, ebm-papst makes it possible to have automated guided vehicles with extremely low loading areas. In the Light version, the entire height of the driving/steering system is only 103 mm from the wheel's contact with the floor. The Standard version requires 123 mm and the Heavy model needs 205 mm.

Thanks to the ArgoDrive's compact horizontal dimensions of 250 x 170 mm (all variants), the AGV manufacturer has sufficient space at one level to accommodate components, such as the control system, safety modules and, in particular, batteries and their associated electronics. The less space is required for the drive solution, the easier it is for AGV manufacturers to achieve a low installation height.

Low-maintenance and fail-safe

Reliable operation is an important aspect for AGVs. Unscheduled downtimes reduce availability, as does maintenance being required

at regular intervals. Of course, the drive system plays a significant role in the reliability of AGVs because of its moving components. This begins with sensitivity to harsh ambient conditions such as dirt on the ground or dusty air. The Mecanum drive concept is particularly disadvantageous here because the more complex mechanics are more sensitive to contamination, thus requiring regular maintenance. With the ArgoDrive from ebm-papst, the system is equipped with oil lubrication designed for the entire service life. Re-lubrication is not necessary here. If the wheel surface is naturally worn down after a long period of operation, it can be easily replaced without removing the drive unit. In the event of a defect, the entire unit can be replaced quickly in just a few steps.

Contact faults on the electrical interfaces of the drive systems are one frequent cause of AGV failures. For example, with pivot plates, cables and plugs are constantly rotating. The ArgoDrive scores points here as well, because the necessary cables and plugs of the driving/steering system are permanently installed in the vehicle, and the design means that moved cables are not required. Tried-and-tested industrial connectors also ensure a secure connection to the control system.

Safety first – and communicative

To protect people, the safety of AGVs is even more important than reliable operation. The AGV must be able to initiate emergency braking immediately in the event of danger, in order to prevent contact with people who appear on the travel route. This is ensured by continuously scanning the surroundings using appropriate safety sensors on the vehicle. In the event of danger, the drive system must give the safety control system the command for a safe stop. In this situation, high braking power is key. Using an integrated brake mechanism, the ArgoDrive can initiate immediate emergency braking here, as well as a controlled motorized deceleration of up to 2.5 m/s^2.

In an emergency braking process, an AGV with four ArgoDrive installed will of course stop even faster than one with two units plus support wheels, because all four wheels then brake at the same time. Even if the power supply on the transport system fails, the ArgoDrive is held securely to prevent uncontrolled movements. This means that the driving/steering system from ebm-papst supports all typical and necessary safety requirements.

A drive system for AGVs should also be communicative so that it can work with other systems in the AGV. ebm-papst already supports the most important common communication standards on the market. Taking remote controllers from several manufacturers into account, with the ArgoDrive ebm-papst offers the option of integration into CANopen networks and EtherCAT networks or integration into Siemens control environments with Profinet.

All advantages combined

With the ArgoDrive, ebm-papst offers AGV manufacturers a new drive solution that does not require compromises in terms of free-range mobility and compactness compared to familiar solutions. A Mecanum solution can keep up in terms of pure maneuverability, but not when it comes to speed, climbing ability and reliability. ○

AUTHOR IS PATRICK SCHUMACHER, HEAD OF PRODUCTION MANAGEMENT FOR INDUSTRIAL DRIVE TECHNOLOGY AT EBM-PAPST ST. GEORGEN. YOU WOULD LIKE MORE INFORMATION ON THIS TOPIC? PLEASE ADDRESS YOUR QUESTION TO:

Patrick.Schumacher@de.ebmpapst.com


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From medical technology to intralogistics

The drive must fit with the positioning task

Positioning drives are used in industrial automation, intralogistics, medical technology and access control systems. The different types of applications require the technology used to fulfill very different requirements. Should the drives be as compact as possible? Are high outputs or high dynamics required? What is the starting torque or overload capacity like? How much intelligence is required? Do the motors need to run as quietly as possible? How about EMC and fail-safe performance? And, finally, the cost usually plays no small role. Therefore, it is no surprise that positioning tasks can have very different drive solutions, but these always have specific advantages and disadvantages.

Various drive concepts have taken root, depending on the complexity and requirements of a positioning task. The most common include AC servos, DC motors – either with brushes or no brushes with electronic commutation (BLDC) – and stepper motors. All of them have typical fields of application in which they can offer their own functional advantages.

AC servomotor or stepper motor

AC servomotors are considered particularly powerful and responsive. Due to their high dynamics, they are used in rapid pick-and-place machines, for example. For many positioning tasks, their performance exceeds the requirements and the drives are therefore overpriced for these applications. Therefore, stepper motors are often used in 'more simple' applications. These work with either an open or closed control loop. When the control circuit is open, there is no position feedback. The motor then usually ends up being oversized to meet the torque requirements at all times and to ensure that no steps are lost. Although this saves on sensors, users cannot clearly identify whether the motor has actually been brought to the desired position, and the oversized motors require a lot of energy.

If stepper motors are in a closed control loop, i.e. with position feedback via an encoder, the torque margin can be reduced, less energy is required and the motors are able to be much smaller. However, stepper motors whose performance is adapted to the application cannot withstand overload. They cannot work with alternating loads, e.g. when packages of different weights are transported on a conveyor belt. These drives can be absolutely the right choice for a robot or swivel arm that always grabs parts of approximately the same weight. In some areas, however, the noise that stepper motors make – and that cannot be avoided – are intolerable from an occupational safety perspective.

DC servomotors from the modular drive system

DC servomotors are also frequently used in positioning applications. The electronically commutated variants experience almost no wear and are very durable. Due to the safety extra-low voltage (24 VDC or 48 VDC), there are much fewer training requirements for the personnel installing this type of drive and the user does not need to spend nearly as much effort on documentation as with the AC servomotors mentioned above. The drives are also smaller. Their positioning is much more precise than stepper motors, and they are more dynamic, extremely quiet and energy efficient. In addition, drive systems that are suitable for a wide range of positioning tasks can be found "off the shelf", which keeps the costs of the high-performance drives down. Motor specialist ebm-papst proves this with its modular ECI drive system.

The internal rotor motors are at the heart of the series with power outputs of 30 to 750 watts (Fig. 1). Depending on the application, they can be individually combined with con-

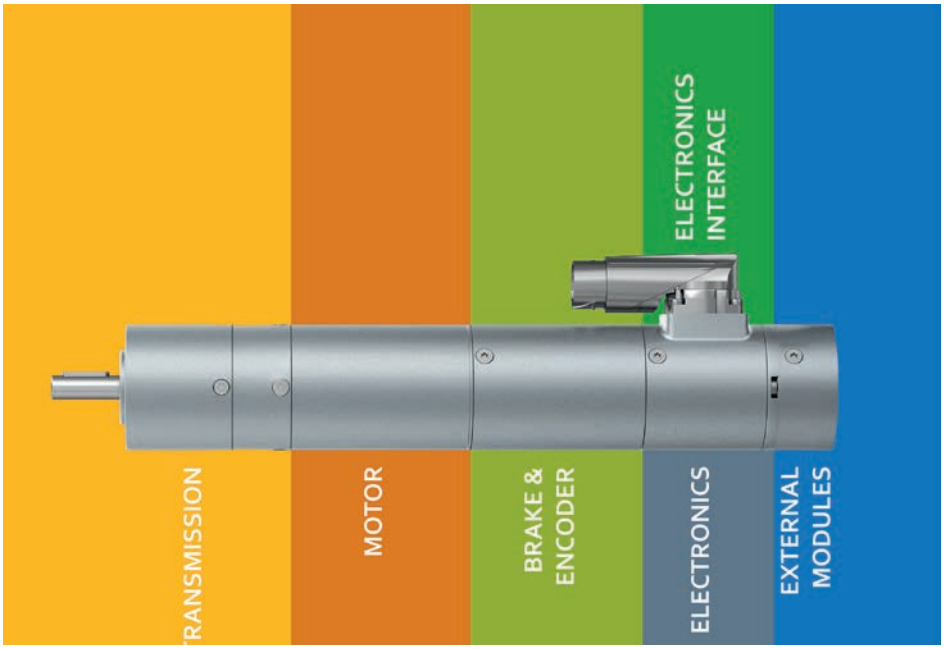

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FIGURE 1: **Positioning drives from the modular drive system: the internal rotor motors are at the heart of this with power outputs of 30 to 750 watts. Depending on the application, they can be individually combined with control electronics and various transmission, brake, and encoder modules.**

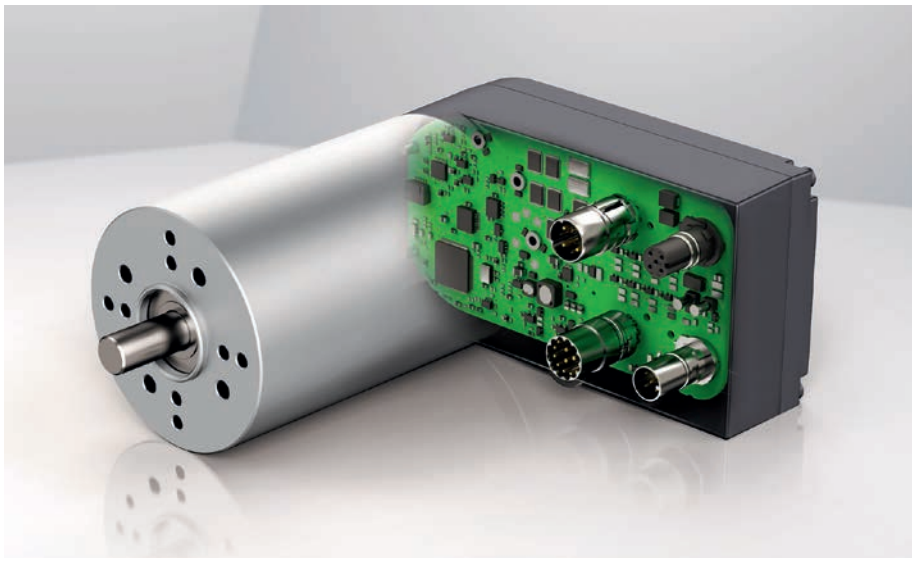

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FIGURE 2: **Equipped with an integrated electronics module, many intelligent functions can be implemented in the drive itself; the PLC required previously is freed up or, in an ideal scenario, can be completely omitted.**

trol electronics and various transmission, brake, and encoder modules. A lot of application expertise went into developing this modular system. The experts know what users in a wide range of sectors need, from automation technology and logistics right through to medical technology. This enables precise movements at low speeds as possible as a rapid change to a dynamic operation. The drives are highly efficient and can even be easily accommodated in confined installation conditions. The active components (wound stator and rotor equipped with magnets) are short at only 20, 40 or, in the most powerful variant, 60 mm. Equipped with an integrated electronics module, many intelligent functions can be implemented directly in the drive (Fig. 2). The PLC required previously is freed up or can, in an ideal scenario, be completely omitted. They can be controlled with digital and analog inputs and outputs. There is nothing standing in the way of them being integrated into Industry 4.0 concepts.

Wide range of applications

There are many typical positioning applications for ECI drives. One example is workpiece carrier transportation systems, which quickly

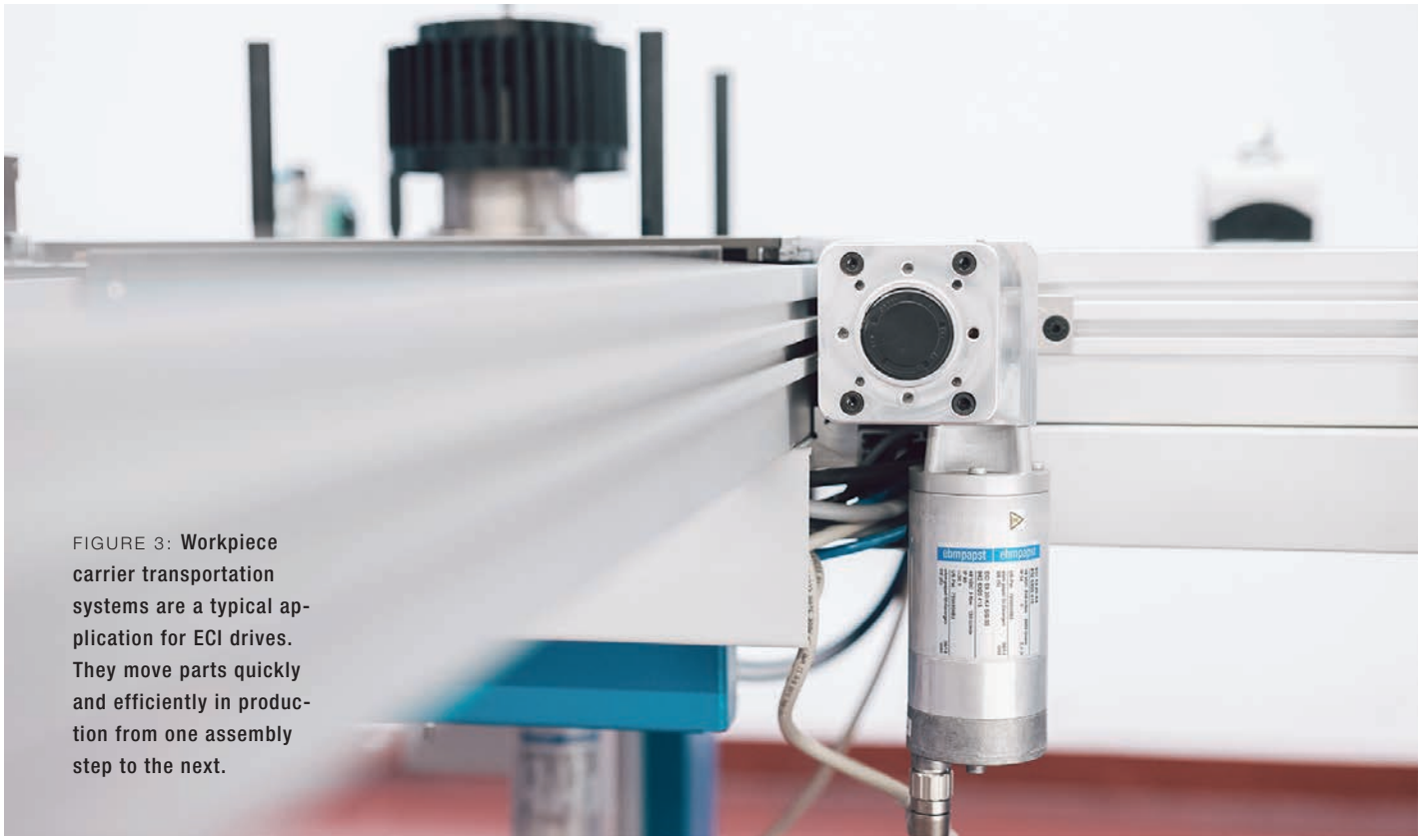

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FIGURE 3: **Workpiece carrier transportation systems are a typical application for ECI drives. They move parts quickly and efficiently in production from one assembly step to the next.**

The drives are highly efficient and can even be easily accommodated in confined installation conditions.

and efficiently move parts in production from one assembly step to the next. It is important that nothing jolts or wobbles to ensure that sensitive products do not get damaged. Fig. 3 shows an application in which ECI motors with integrated electronics and worm gears have replaced the AC gear motors used previously. As a result, users can save up to 80% of energy. ECI motors also feature torque control and high overload capacity. Since the motor regulates torque and current, workpieces of different weights can be transported at constant speed. For post-sorting in large logistics centers, the compact brushless DC drives on the belts, gates and diverts have also replaced the AC motors that used to be common with their large control cabinets for controllers. ECI drives can be installed easily and can save space (Fig. 4), and they can make complex pneumatic solutions at diverts or lifting equipment unnecessary.

The industrial-grade drives are suitable for countless other positioning applications, for example in medical technology: they meet the requirements for dental chairs, which include compact dimensions, high holding force, EMC, fail-safe operation and operation with as little noise as possible (Fig. 5). And the right drive can be found quickly. Thanks to

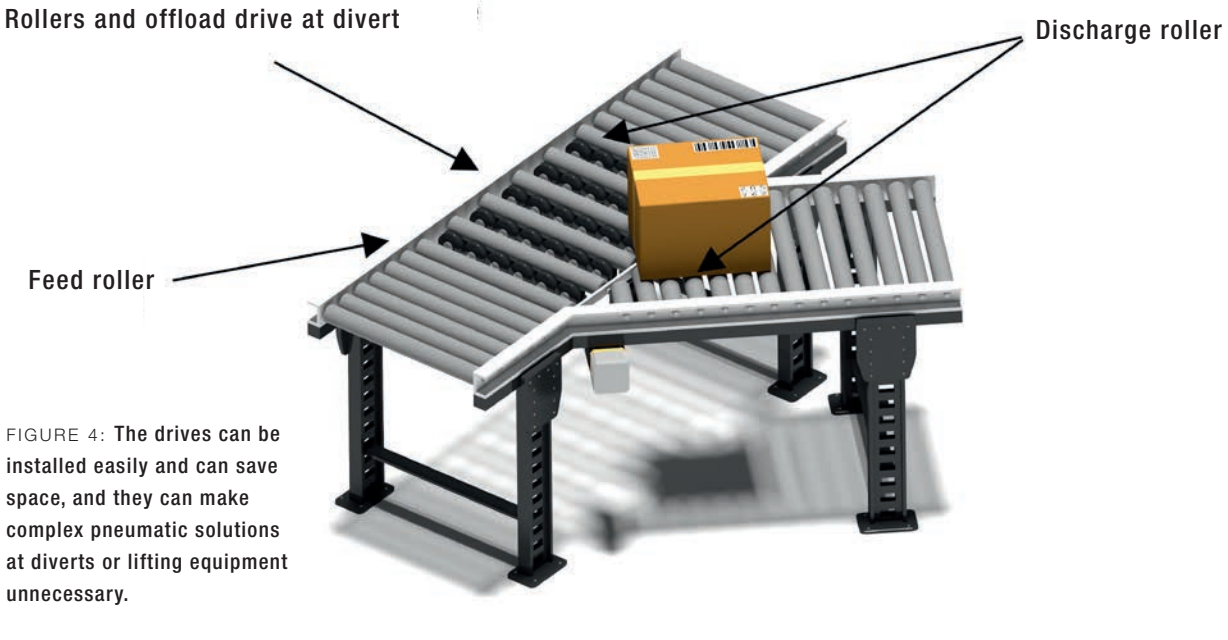

FIGURE 4: **The drives can be installed easily and can save space, and they can make complex pneumatic solutions at diverts or lifting equipment unnecessary.**

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FIGURE 5: **The ECI motors meet the requirements for dental chairs, including compact dimensions, a high holding force and an operation that is as quiet as possible.**

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defined preferred types, selected drive configurations can be delivered within 48 hours, which means that sampling, for example, can be done very quickly. The drives can be configured and ordered via the online portal https://idt-config.ebmpapst.com. ○

AUTHORS ARE ARMIN POKORNY, MARKT MANAGER IDT AT EBM-PAPST IN ST. GEORGEN, DR. ROBERT MICHEL, MARKT MANAGER IDT AT EBM-PAPST SERVICE CENTER AND PATRICK SCHUMACHER, HEAD OF PRODUCTION MANAGEMENT FOR INDUSTRIAL DRIVE TECHNOLOGY AT EBM-PAPST ST. GEORGEN. YOU WOULD LIKE MORE INFORMATION ON THIS TOPIC? PLEASE ADDRESS YOUR QUESTION TO:

Patrick.Schumacher@de.ebmpapst.com

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

Layout and production:
Scanner GmbH, Künzelsau

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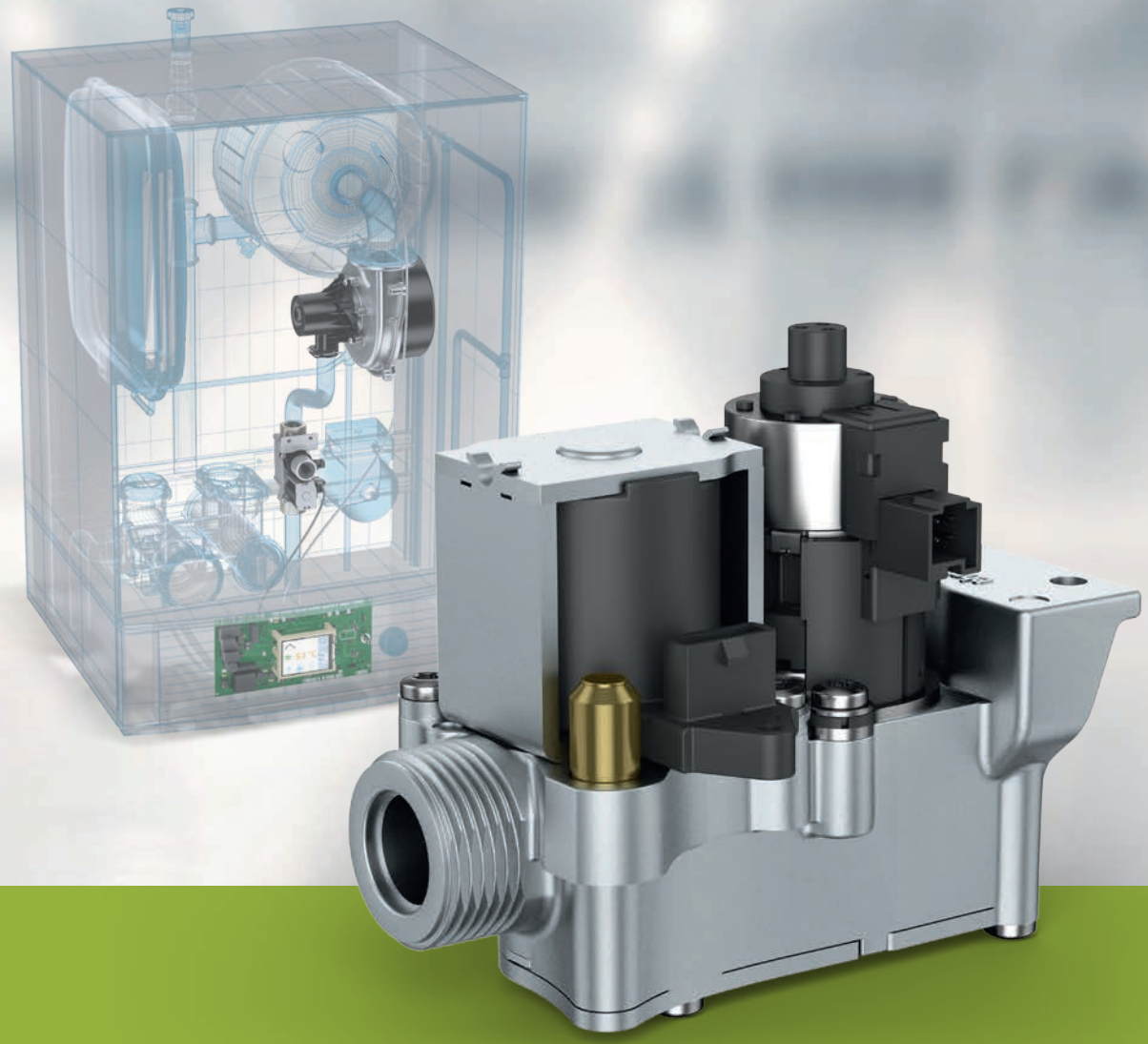
Druckerei Ziegler
GmbH + Co. KG



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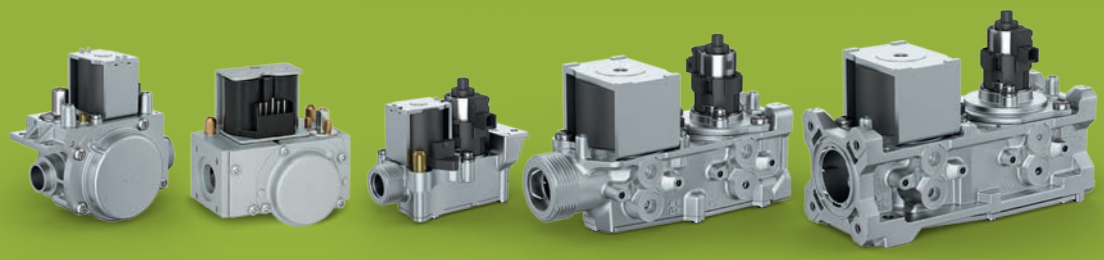

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