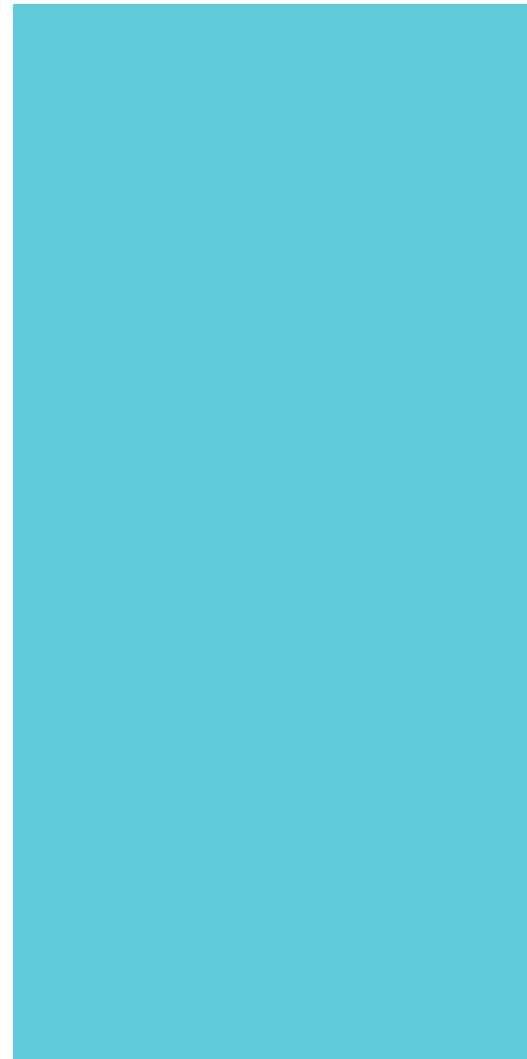
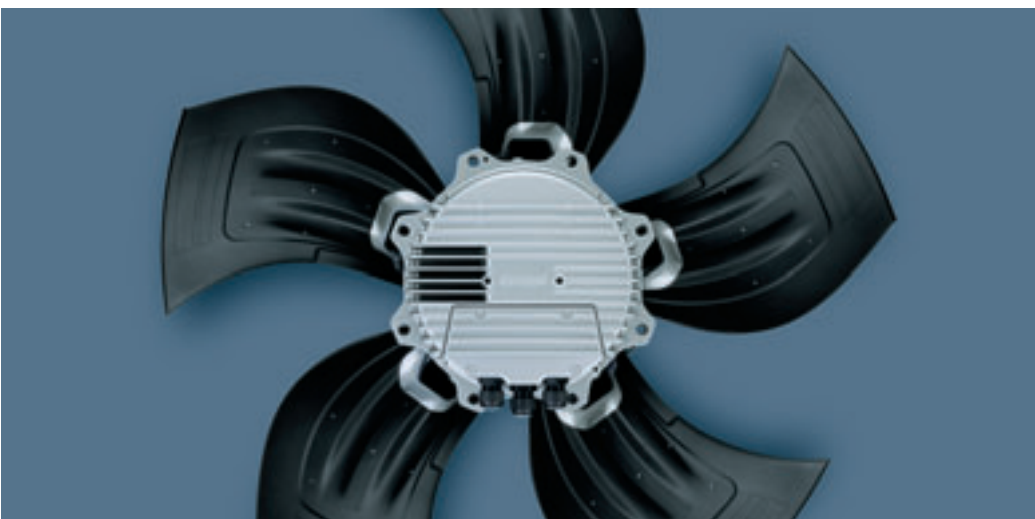


ebm-papst EC technology

Introduction to theory & technology. Overview of real-world applications & benefits.



Responsibility for ecology and economy



The engineer's choice

ebmpapst

ECconomy plus ECology equals EC technology ... made by ebm-papst

As your R&D partners, the economic success of your products is just as important to us as it is to you. Our development of fans, blowers and drive solutions, which are used in a wide variety of industries and applications, is always focused on maximum efficiency. Cost efficiency is the goal, and energy efficiency is one of the most direct ways there! Moreover, we share a great deal of responsibility with regard to environmental requirements. These are centred on protecting the global climate and conserving resources. In this brochure, we will show what ebm-papst EC technology can actually do for economy plus ecology – for us all!

First in EC technology: ebm-papst

As a globally active manufacturer of top-quality industrial products, ebm-papst has always pursued a corporate policy that views technical progress and environmental protection not as a contradiction, but as an inseparable whole. When it comes to the environment, we make no compromises in the development of our products. All of the motors, fans and blowers we produce are energy-efficient and durable, and not only conform to all applicable standards, but for the most part exceed them. Thus developing and promoting EC technology was one of our most important challenges, starting over 30 years ago. For over 12 years, mains powered ebm-papst EC technology has been the worldwide standard in areas such as clean room technology, providing reliable performance 24 hours a day, 365 days a year.

Today, the far-reaching possibilities of ebm-papst EC technology provides comprehensive arguments to new users and those who are converting (from AC to EC) and who have both economic and environmental goals in mind. There is no question that in future, we will continue to further develop and perfect our ebm-papst EC technology for the benefit of both our customers and the general population.

ebm-papst EC technology: High-tech for your number-crunchers

According to the German Electrical and Electronic Manufacturers' Association (ZVEI), the largest potential for saving electrical energy is in the area of electric drives. With average energy savings of 30 %, EC technology is the primary factor responsible for this potential.

ebm-papst EC technology is at the heart of a wide variety of today's different fans and blowers and thus is available in the most varied applications and industries. Altogether we offer the broadest range of EC products worldwide. Wherever it is used, our EC technology demonstrates its advantages. The most convincing feature is the high energy savings ... and the bottom line shows an aggregate profitability that is unmatched. However, other benefits, such as significant noise reduction, also pay off for you and your customer. In short, by using ebm-papst EC technology, you fulfil the diverse requirements of your customers, the market and society at large.



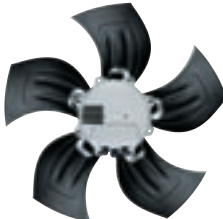



GreenTech – economy and ecology going hand in hand

GreenTech follows a firmly held conviction: each newly developed product must exceed the economic and ecological performance of its predecessor. To this end, we are constantly improving materials and processes, flow behaviour and power – and reducing energy consumption. State-of-the-art energy, air-conditioning and ventilation technology provides maximum energy efficiency in our plant. Numerous environmental prizes, distinctions and the groundbreaking energy levels, which fall below even the most stringent limits, are the reward for our efforts.

GreenTech pays off for our customers, particularly due to the ebm-papst EC (electronically commutated) technology. It is not only the heart and soul of our philosophy, but also the core of our most efficient products. It attains efficiency up to 90 %, provides maximum energy savings and makes the products maintenance-free. With integrated open or closed-loop control and bus compatibility, it is an environmentally sound and, in the long run, more cost-effective alternative to AC technology.

Exemplary: Maximum efficiency with ebm-papst EC technology

| | | | | |
|---------------------------------|---|---|--|--|
| <p>A3G910 axial fan</p> |  | <p>Applications: Heat exchangers, e.g. for cold storage spaces, ventilation, air-conditioning and refrigeration technology</p> | <p>Six fans work in one heat exchanger. At an average duty cycle of 75 %, this means an annual savings potential of over 24 MWh. This corresponds to approx. 14.4 tonnes of CO₂ and saves 2,998 Euro* per year.</p> | <p>Savings potential compared to similar standard models based on this example:</p> <p>29.1 %</p> |
| <p>R3G560 radial fan</p> |  | <p>Applications: Roof fans, air handling units (AHU), clean rooms</p> | <p>Four roof fan units are on an office building with a floor space of 1,200 m². At an average duty cycle of 60 %, a savings of up to 6.7 MWh is possible here. This corresponds to approx. 4 tonnes of CO₂ and saves 841 Euro* per year.</p> | <p>Savings potential compared to similar standard models based on this example:</p> <p>21.5 %</p> |

* 12.55 Cent/kWh, average electricity price for industry in Germany; as of April 2008 (Source: German Electricity Association/VdEW)

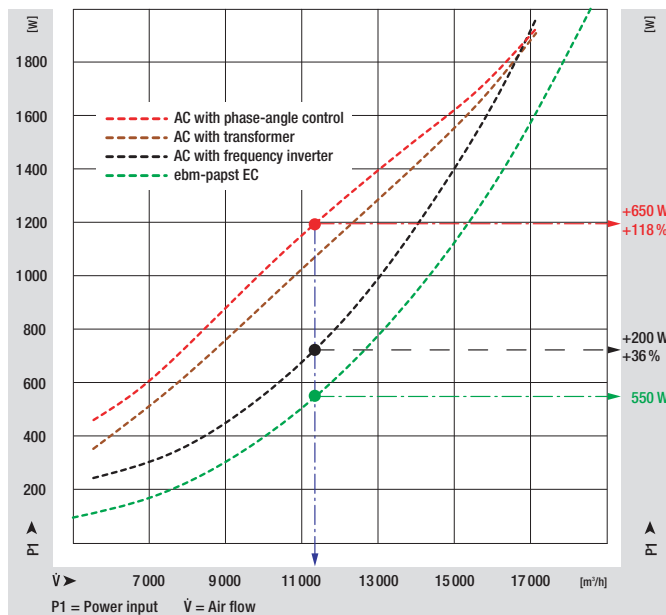
Green products from “green” production: We understand environmental management holistically.

Average energy savings of 30%: Now you're talking!

In ventilation, air-conditioning and refrigeration technology, the world of information technology, heating or building systems. In industrial automation, automotive, or telecommunications, wherever fan or drive technology is employed, it is necessary to continuously find ways to decrease energy consumption. Whatever their industry, our customers' goal is to be able to offer end products that simply save costs. Energy is expensive and getting more so every day. The refrigerated case in the supermarket, the heating system in the single-family home, the climate control system in the office building: wherever energy is used, an average savings of 30% is possible using ebm-papst EC technology. And those aren't just words – it's a fact!

Example: Energy savings in HVAC technology

Another fact: at every speed, the EC fan by definition operates very efficiently. Thus an energy saving of over 10% is attained for condensers/ evaporators in which ebm-papst EC fans work, even at nominal speed. In the continuously controlled range, the relative and absolute savings are substantially greater. Compared to ebm-papst EC technology, conventional phase-angle control can use twice as much energy, if not more.



Power input for various control methods

Using this formula, you can easily calculate the cost savings for your application.

$$Cs = Rt \cdot Es \cdot Ec$$

Cs = Cost savings (€/year)

Rt = Run-time (hours/year)

Es = Energy savings (kW)

Ec = Energy costs (€/kWh)



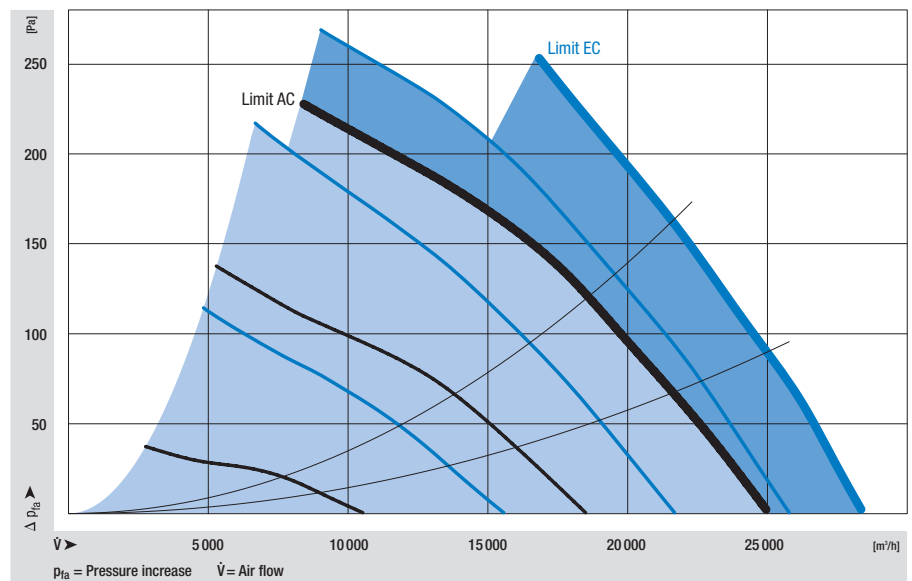
Best performance under all conditions: We guarantee it!

Just one example of many: the air-conditioning and refrigeration systems of a supermarket. This application requires peak loads on hot summer days; normal operation is adequate at moderate temperatures; and after sundown, whisper-quiet night-time operation is required in order to not disturb neighbours. These are just examples, but are also real-world conditions that ebm-papst EC technology takes fully into account. With its intelligent open and closed-loop control options, the air-conditioning or cooling systems can be adapted easily to all requirements of manufacturers, owner/operators, consumers, and the general public. With guaranteed high savings potential for energy and costs.



Example: Possible power for condensers/evaporators

The graphics below, based on the example of size 800 ebm-papst axial fans in AC and EC technology, make the difference clear: ebm-papst EC technology can be used in the entire blue range. Moreover, in the dark blue range, ebm-papst EC technology has significant power reserves compared to AC technology. ebm-papst EC technology allows operation at peak load – with very quiet operation.



Power range of AC and EC fans

- AC
- EC
- EC power reserves

Energy-saving ebm-papst EC fans provide the optimum climate in offices and homes.

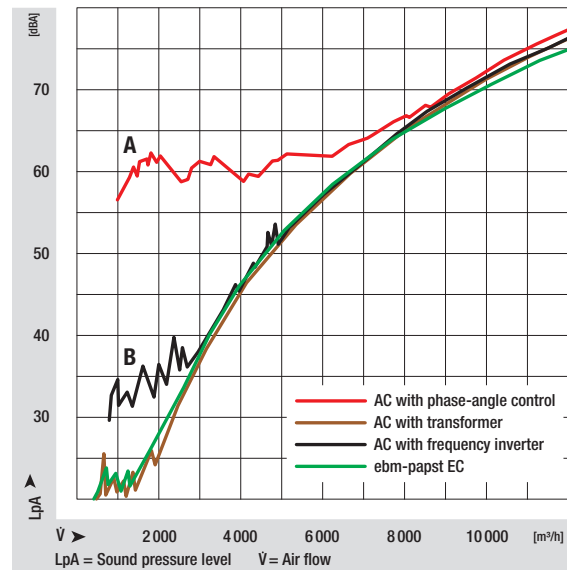
Minimal noise emission: That sounds good!

Think, for example, about air-conditioning in office buildings. Think about heating boilers in residential spaces, range hoods or refrigerators, electronics cooling of computers, ventilation and air-conditioning in the automobile, in commercial vehicles, and on and on. Of course, in all of these applications, function, reliability and safety are everything! Still, the consumer wants to hear absolutely nothing about it – quite literally. Here is something that sounds good: in every application, EC fans, EC blowers and EC drives made by ebm-papst provide power that can barely be heard!

Example: Noise reduction at all speeds

ebm-papst EC technology is really something to hear – or, actually, to not hear. You hear no motor noise across the entire speed range. The advantage: when demand for cooling is low, such as at night, very low operating speeds can be selected. The resonance levels typical for frequency inverter operation – which, by the way, are not always eliminated even in our competitors' EC products – or "phase noise" do not exist in our products, as a different operating principle is involved.

Furthermore, combining AC motors with frequency inverter without an all-pole sinusoidal filter can cause winding and bearing damage. This possibility is eliminated in ebm-papst EC technology.



Noise behaviour for various control methods

A: Phase-angle control, hum noise (300 Hz)

B: Frequency inverter whistle – motor and device resonance caused by frequency inverter-controlled motor



Everything included, from the control to motor protection: That's "plug and blow"!

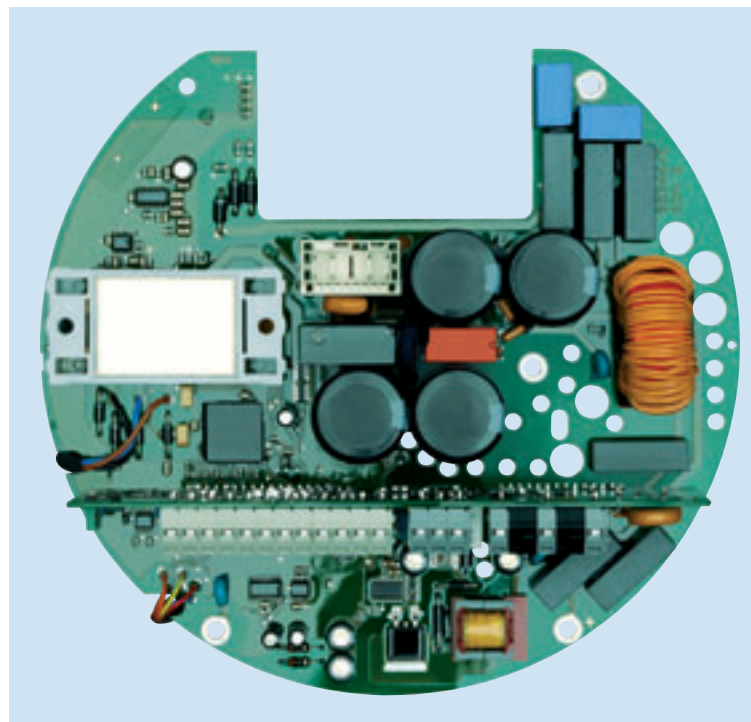
Move air – for an all-inclusive price! This is another of the great benefits of ebm-papst EC technology. From the PID servo amplifier to the radio interference filter, from the motor protection to the current supply for the sensor, our EC products already have all the features they will ever need. "Plug and blow" is this easy: just do the application check! See for yourself which additional components are required for conventional AC products or even competitor's products. As you can see below, we have simply ticked all of the features already included in an ebm-papst EC fan.

Example: Your all-inclusive advantage for an ebm-papst EC fan

Fewer additional peripherals, less installation complexity – and all useful features already wired and completely inspected. That is how simple ebm-papst EC technology is to use in real-world applications. The features in detail:

- 1 PID servo amplifier:** Only one corresponding sensor is required for pressure or temperature control. The set value, control range, heating and cooling are adjustable.
- 2 PFC/mains choke** reduce current reverse transfer. At rated output, the power factor is typically greater than 0.9.
- 3 The phase failure detection** prevents 2-phase running. If one phase fails, the fan switches off. When the phase is restored, the fan starts up again independently.
- 4 The radio interference filter** reduces emission and susceptibility of line-bound interference voltage.
- 5 The motor protection** provides effective thermal protection for the motor and electronics with automatic shutoff in case of excess temperature.
- 6 The motor filter** prevents bearing currents and therefore bearing damage. Resonance noises are avoided by patented software and hardware.
- 7 The current supply** for the sensor is fed via the fan.
- 8 Due to the integration of the commutation section,** shielded wires are not necessary.

| | |
|---------------------------------------|---------------|
| 1 PID servo amplifier | ✓ |
| 2 Power Factor Controller/mains choke | ✓ |
| 3 Phase failure detection | ✓ |
| 4 Radio interference filter | ✓ |
| 5 Motor protection | ✓ |
| 6 Motor and noise filter | ✓ |
| 7 Current supply for sensor | ✓ |
| 8 Shielded wires | not necessary |



*Intelligent electronics – intelligent power:
An EC fan already includes everything
it will ever need.*

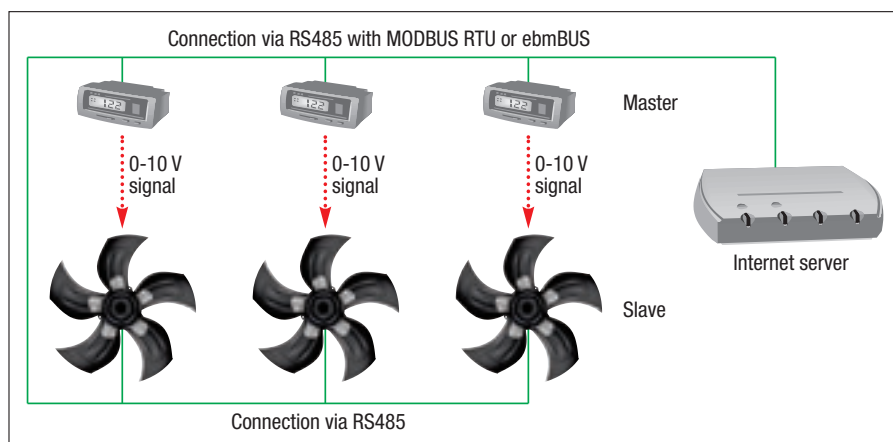
Everything networked and controlled reliably: That's intelligent!

There is hardly any application for fans in which maximum EC intelligence cannot demonstrate its advantages. Take, for example, the remote monitoring ability via Internet/modem, which makes all information, including speed, motor temperature and operating messages or alarms, available at any time – and, if desired, even anywhere in the world. Another example is the reduction of current reverse transfer and thus of harmonics, meaning less load on the power system – and that put simply wires, fuses and contactors can have lower ratings.

Remote monitoring – made easy!

Function monitoring via Internet/modem takes place via RS485 interface: ebmBUS, MODBUS RTU. The information can be processed and evaluated using software such as the ebm-papst LISA control software or software on the customer's side. The information is available worldwide via Internet. Preventative maintenance is possible this way. The following information can be read out:

- Running time
- Speed
- Current
- Voltage (intermediate circuit)
- Power input (can be calculated from current draw and voltage)
- Temperature of motor
- Temperature of electronics
- Temperature of power section
- Operation mode (control of temperature, pressure and air flow; actuator/controller; set value/actual value)
- Operation and alarm display = alarm signal



Current reverse transfer – reduced significantly!

By the way, the mains choke also comes as standard in ebm-papst EC fans, while for many competitor's products, it has to be purchased separately. The critical advantage for you is that the lower current draw allows fuses, contactors and wires to have lower ratings, making them more cost-effective.

Fewer types, less logistics, less expense: That's logical!

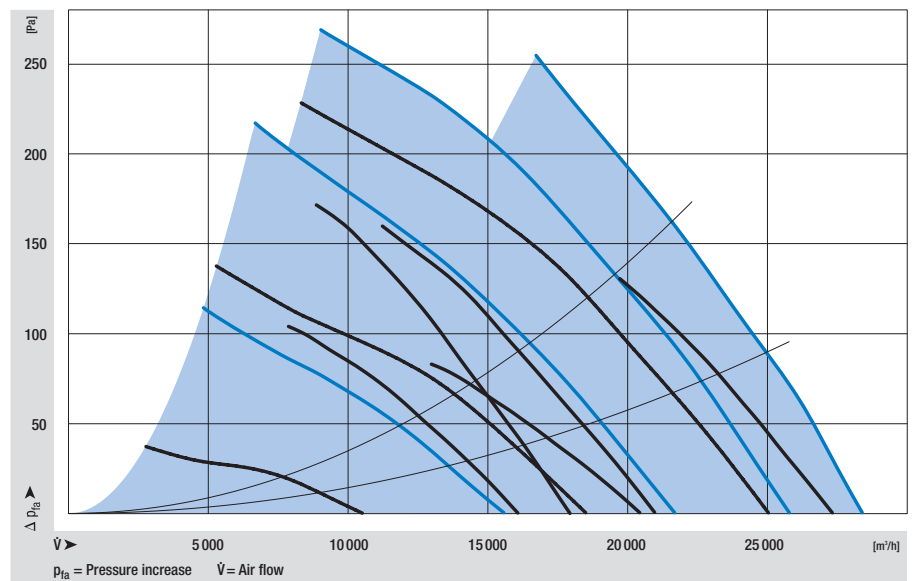
ebm-papst EC technology replaces AC technology – in the best possible way. This replacement is a big step forward, not only in terms of energy efficiency, noise reduction and intelligence, but above all in terms of logistics! After all, if you wanted, you could replace up to 8 different AC axial fans, each with different blade angles, with just a few ebm-papst EC axial fans while still providing a fully equivalent replacement. Assume the highest possible flexibility for your applications, even worldwide. Expect fewer types, easy stock-keeping, less logistics – and, in sum, a significantly reduced financial outlay.



**Remote monitoring via Internet/modem:
Everything is possible.**

One instead of many: How to replace AC with EC

If we consider optimum efficiency and an ideal selection of motor sizes for the respective operative range, then 8 AC variant fans can definitively be replaced by 4 ebm-papst EC variants. As the graphics clearly illustrate, 4 EC variants cover the entire blue area, while AC without additional open loop speed control can be used on the black curves only.



Can be used worldwide without any problems!

ebm-papst EC fans feature a wide voltage input. So their curve remains practically unchanged over the entire voltage range. Our fans can be used worldwide, regardless of voltage and frequency.

- 3-phase, 200–240 VAC, 50/60 Hz
- 3-phase, 380–480 VAC, 50/60 Hz
- 1-phase, 200–277 VAC, 50/60 Hz
- Each is controllable to the required operating point

Worldwide leader: The widest range of EC fans and motors

So many individual applications and requirements – so many customised options are offered by our comprehensive range of EC axial and centrifugal fans. There is no ventilation, air-conditioning and refrigeration technology application that you cannot implement using EC technology – and, moreover, with quality, reliability and expertise. Most importantly: always the best match for your application, as we have the world's widest range of EC fans and motors.

ebm-papst EC axial fans:

One principle, countless possibilities

ebm-papst's axial fans prove their reputation as energy-saving wonders by moving air for hot or cold air exchange in a wide variety of devices and systems. Some of their outstanding features are the small installation depth, low noise level and exceptional efficiency, and are particularly well suited for use in heat exchangers. Furthermore, in EC design, they become intelligent "energy-saving wonders" for an extremely wide range of applications, primarily in ventilation, air-conditioning and refrigeration technology.

ebm-papst EC centrifugal fans:

High performance, quiet movement

ebm-papst centrifugal fans with backward curved blades have outstanding aerodynamic efficiency. Especially when used in applications such as air handling units (AHUs), computer slide-in modules, telecommunications systems, clean room technology, roof fans, range hoods, automotive and rail technology, etc., these fans are real space-saving wonders.

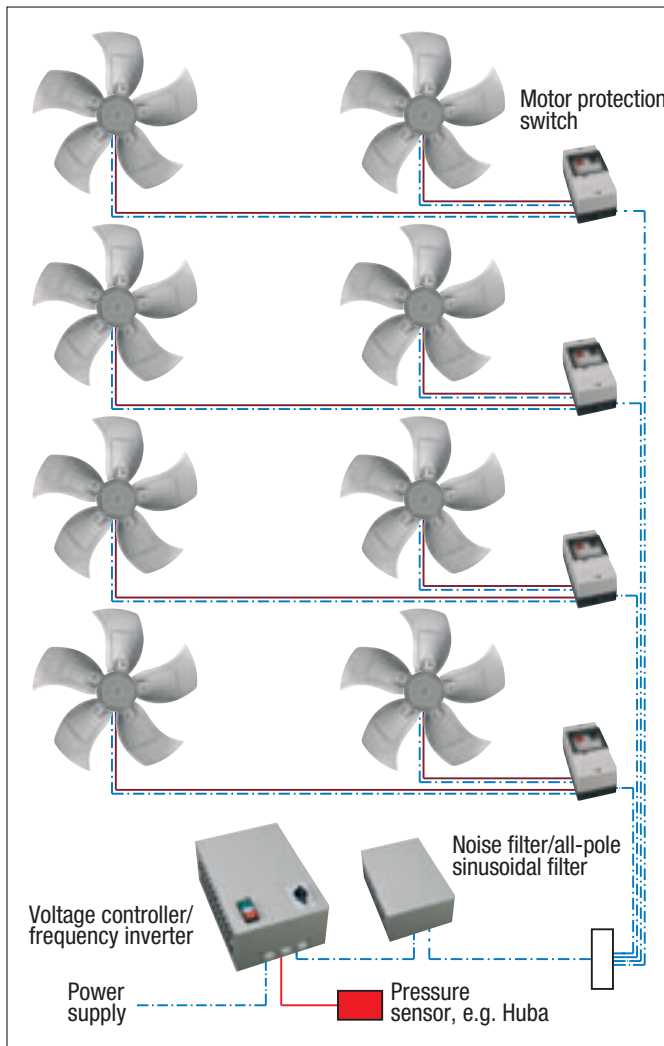


We offer the broadest range of EC products worldwide.



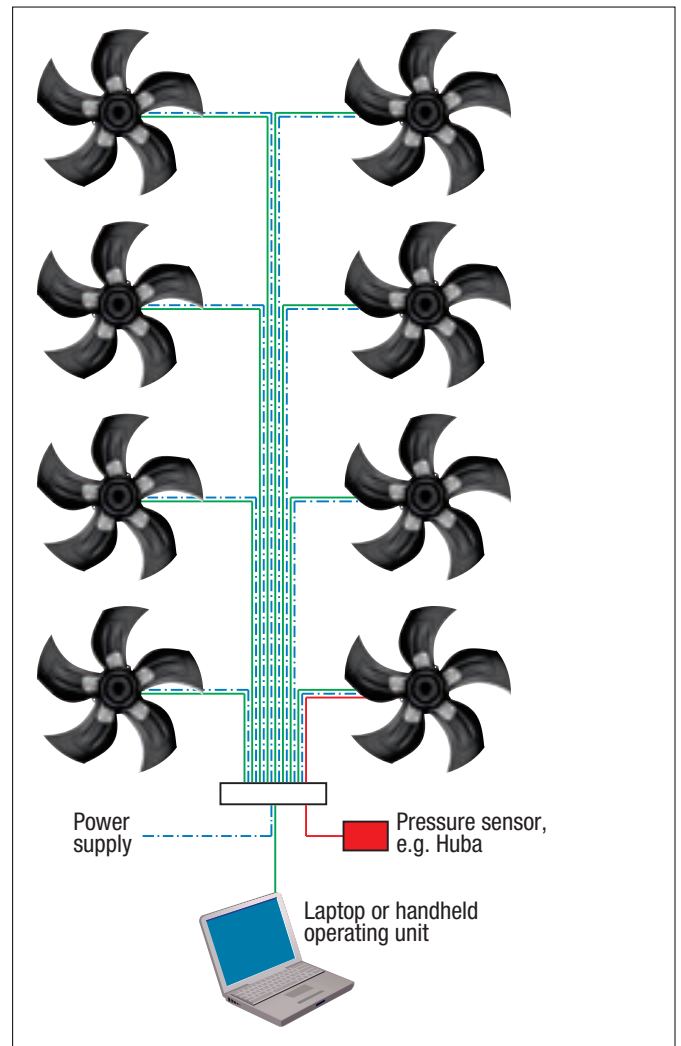
Real-world applications prove: More intelligence equals less effort!

The ultimate ebm-papst EC technology: For you, this primarily means "integrated electronics". Everything you could ever need, from the servo amplifier, EMC filter, passive PFC, current supply for the pressure sensor, motor protection to the alarm relay is already integrated in the fan. Master and slave fans can be programmed using a laptop or handheld operating device. But once programmed your installation is completely self-regulating. Operation messages or alarms are signalled without additional input via relay or networked via ebmBUS.



AC technology: More expense, fewer possibilities

A basic fact: with AC fans, you simply must expect greater expense for wiring, connections and networking. Additional motor protection is required. For frequency inverter operation, an all-pole sinusoidal filter is necessary. For voltage-controlled fans, the use of a noise filter is necessitated by the operating principle in order to reduce unwanted motor resonance.

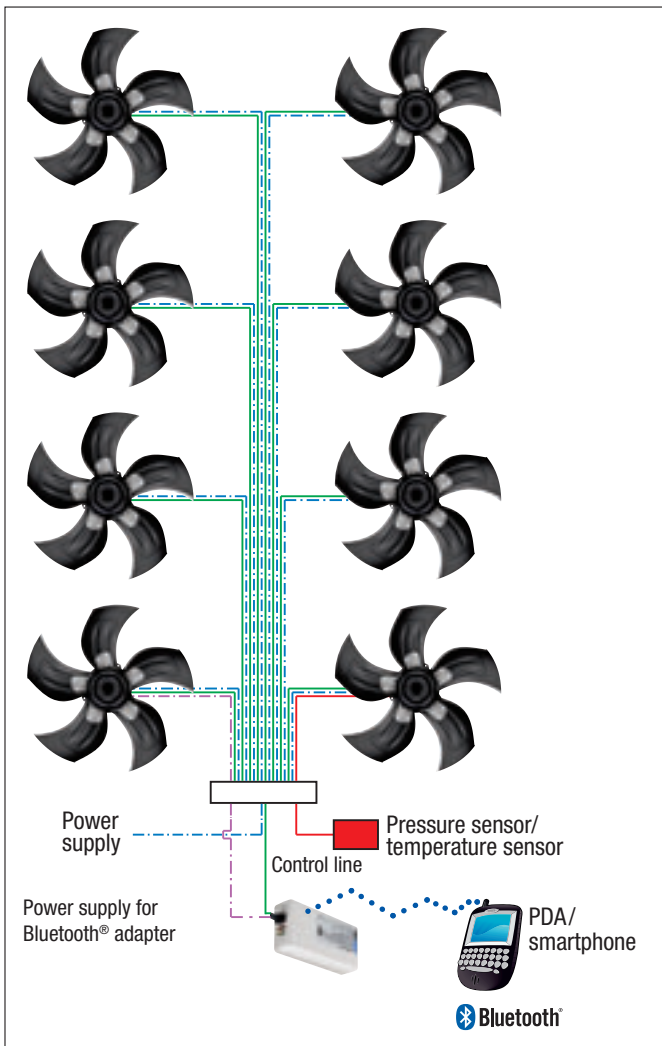


EC technology: Simply better networked

Using ebm-papst EC fans, it is easy to implement networked systems with many fans. Redundant operation of all EC fans is based on greatly simplified wiring and uncomplicated connections. Each EC fan can do it all – master with PID controller or slave. Convenient monitoring using laptop or desktop computer.

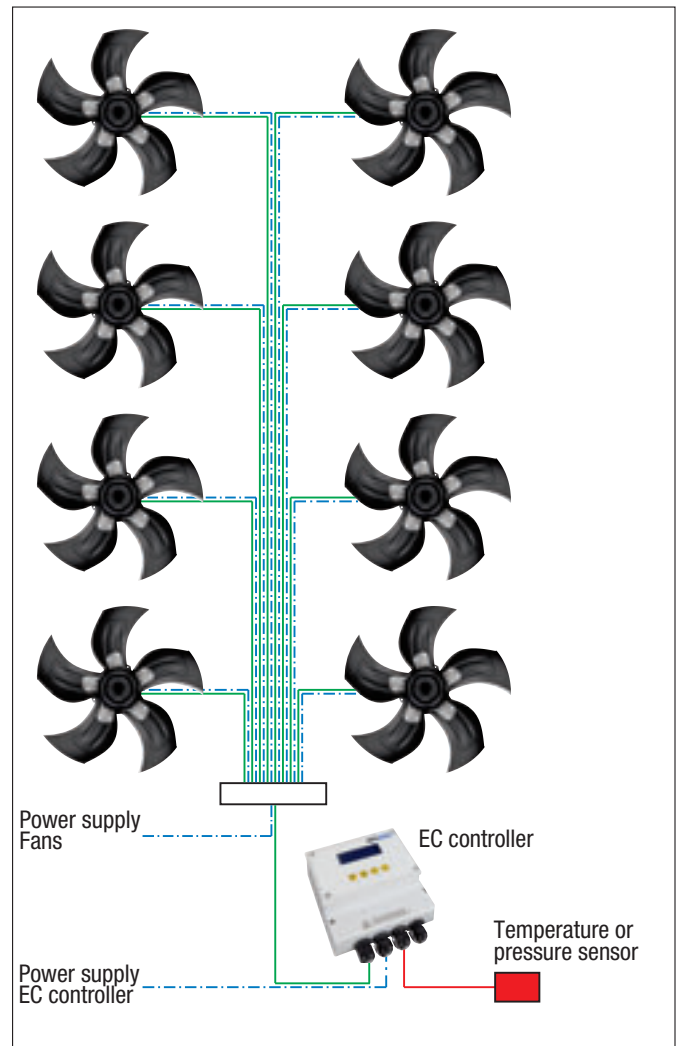


This is an example of a real-world application using ebm-papst EC axial fans. The same, of course, holds true for ebm-papst EC centrifugal fans, wherever you use them.



EC technology: Completely independent

Precisely for difficult-to-access fans in complex applications, ebm-papst EC technology can be a critical advantage.



EC technology: Simply better controlled

The schematic illustration shows ebm-papst fans with EC controllers and connected sensor for controlling the EC fans. Of course, you enjoy the same benefits in terms of easy wiring and connection, but without networking. The plain text display enables easy on-site adjustment of your fans.

Real-world applications prove: More intelligence equals lower costs!

Just one example of intelligent energy savings: a condenser, such as that used in cooling equipment. The device is equipped with 4 AC fans and, alternatively, with ebm-papst EC technology. The energy savings possibilities of EC technology compared to AC fans are considerable – as the following graphics show.

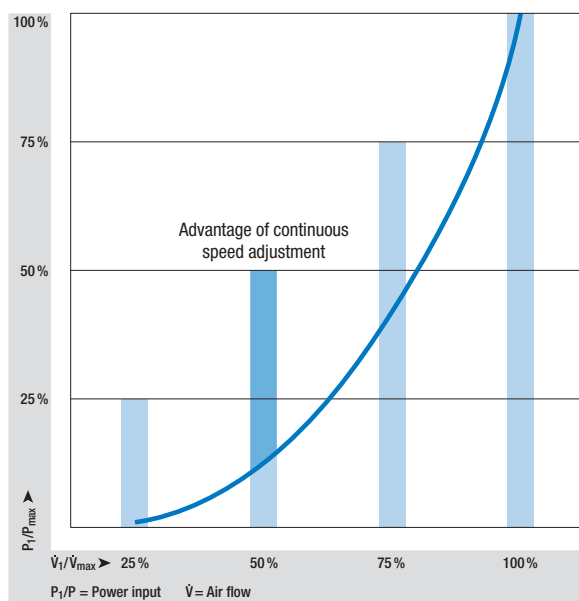
Example: Expect considerable savings potential!

This is a comparison of 2 condensers, each with 4 size 800 axial fans: one condenser with conventional AC technology, the other with the innovative ebm-papst EC technology. To configure the respective optimal cooling capacity for different cooling requirements, the air performance is adapted to the fans. For the condenser with AC fans, this is done by cutting individual fans in and out. The condenser with ebm-papst EC fans has a better solution: it does this by continuously adjusting the speed.

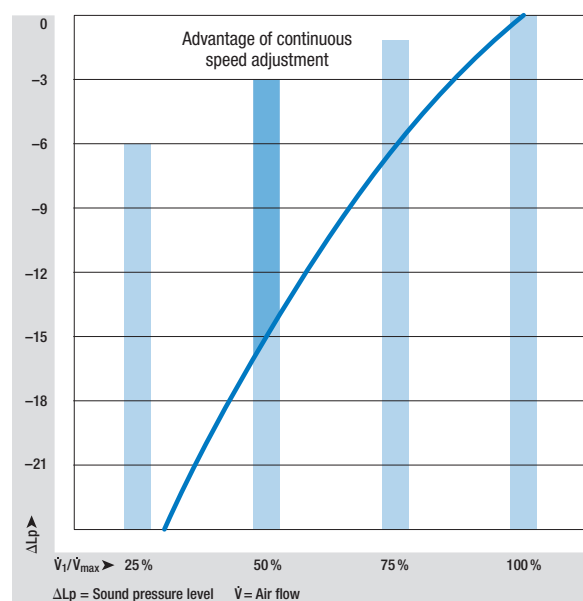
In on/off operation, individual AC fans are switched on and off by external switching devices in order to attain the desired utilisation. The fans that remain in operation continue to run at full speed.



ebm-papst EC technology enables continuous adjustment of the speed to the demand. All fans remain in operation, resulting in substantial energy savings in power input. The graphics below show the possible energy savings and noise reduction in direct comparison of on/off operation and continuous speed adjustment:



Low energy consumption: The bars show the power input of fans that are switched on or off. The blue line shows the power input with continuous speed adjustment.



Lower noise: While shutting off half of the fans (one-half of the air flow) decreases the noise level by only about 3 dB, speed reduction to one-half the air flow attains an improvement of 15 dB.

Now, in a concrete example, on/off operation of AC fans is compared to speed-controlled ebm-papst EC fans. The efficiency advantage of EC motor technology results in extra energy savings that is above the theoretical values of the diagrams below.

On/off operation: To control the air performance according to various cooling requirements or to adapt it to those requirements, the current practice is still to switch individual AC fans on or off.

| AC Air performance | Shutoff = On/off operation for AC fans | | |
|--------------------|--|-------|-------------------|
| | Number of fans in operation | Speed | Power input in kW |
| 100 % | 4 | 100 % | 7.40 |
| 75 % | 3 | 100 % | 5.55 |
| 50 % | 2 | 100 % | 3.70 |
| 25 % | 1 | 100 % | 1.85 |

Modulating operation: All devices and fans remain in operation simultaneously. The optimum cooling capacity is attained via closed loop speed control.

| EC Air performance | Closed loop speed control of the EC fans | | |
|--------------------|--|-------|-------------------|
| | Number of fans in operation | Speed | Power input in kW |
| 100 % | 4 | 100 % | 6.68 |
| 75 % | 4 | 75 % | 2.84 |
| 50 % | 4 | 50 % | 0.84 |
| 25 % | 4 | 25 % | 0.11 |

The direct comparison: With closed loop speed control, the power input is decreased substantially: at one-quarter of the required cooling capacity, even up to 94 %.

| Air performance | Reduction of power input with EC |
|-----------------|----------------------------------|
| 100 % | 10 % |
| 75 % | 49 % |
| 50 % | 77 % |
| 25 % | 94 % |

Brief sample calculation:

Savings potential in kWh: If we assume the load profile shown to the right, energy demand is decreased substantially in modulating operation. The annual energy demand is reduced by 56%!

| Load duty cycle | Annual hours per load case | AC: power requirement with shutoff kWh per year | EC: power requirement with speed control kWh per year |
|-----------------|----------------------------|---|---|
| 10% at 100 % | 876 | 6,482 | 5,852 |
| 30% at 75 % | 2,628 | 14,585 | 7,464 |
| 40% at 50 % | 3,504 | 12,965 | 2,943 |
| 20% at 25 % | 1,752 | 3,241 | 193 |
| | 8,760 | 37,274 | 16,451 |

At this load profile, the annual energy consumption is reduced by: 56 %

Savings potential in €: The use of innovative ebm-papst EC technology always pays off for the owner/operator.

| Savings from EC per year (0.09 €/kWh) | Savings from EC per year (0.12 €/kWh) | Savings from EC per year (0.15 €/kWh) | Savings from EC per year (0.18 €/kWh) |
|---------------------------------------|---------------------------------------|---------------------------------------|---------------------------------------|
| 1,874 € | 2,499 € | 3,123 € | 3,748 € |

Unprecedented: A win-win for the operator and the environment!

When you use intelligent ebm-papst EC technology, everybody wins: companies, people and the environment. It not only pays off in real money for every owner/operator, it also conserves precious energy resources.

But that's not all. In addition to the "savings effect," you can also expect a significant reduction of noise emissions. At lower speeds, ebm-papst EC fans are even quieter. You will hardly know they are there.

In this brochure, we hope to give you an introduction to the theoretical and technical aspects of ebm-papst EC technology. We provide real-world examples to give you a comprehensive overview of the benefits of our EC products for your financial success. If you have any other questions for our specialists, simply contact us.

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