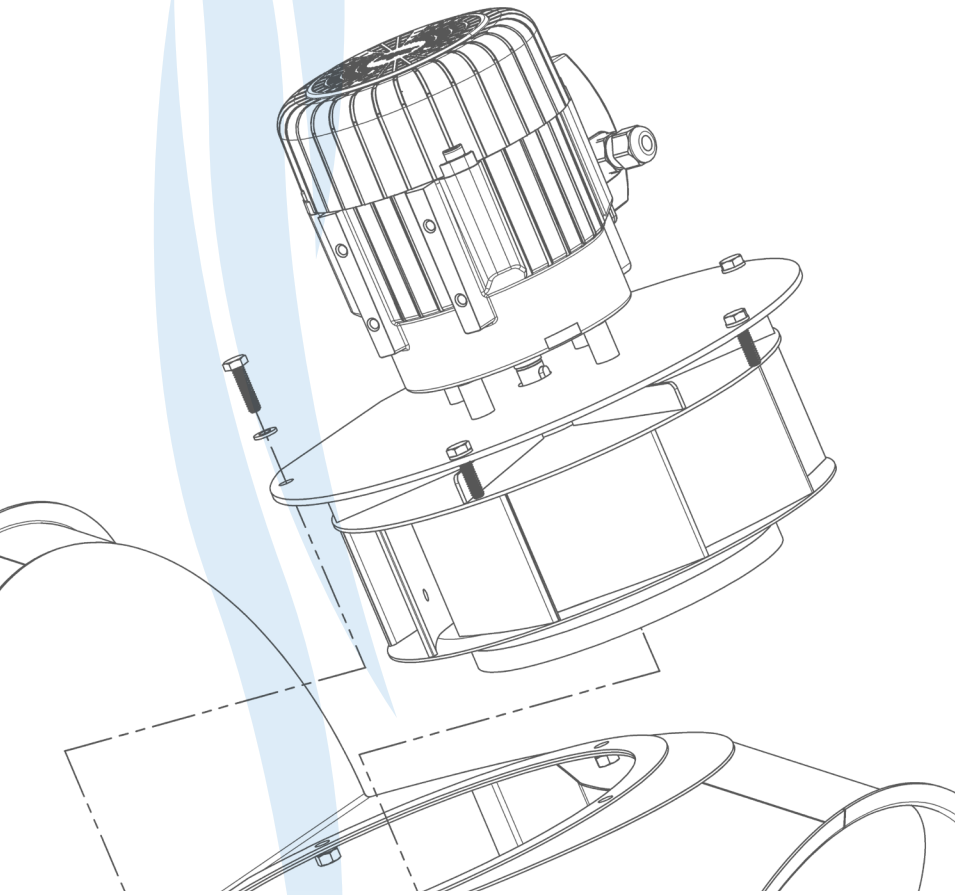
ENERVEX®
VENTING DESIGN SOLUTIONS

Fan and Motor Efficiency:

WHY ELECTRONICALLY COMMUTATED (EC) MOTORS?

30% more energy efficiency — and a whole lot of other reasons why "AC" is not the future of industrial motors

WHITEPAPER



Did you know,

Industry today consumes roughly **42%** *of the world's electricity.*

Two-thirds *of that electricity is used to power electric motors.*

The AC induction motor is a 100-year-old technology with severely limited efficiency.

Yet, AC motors still power the majority of many industries.
This is changing.

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MOTORS INTO PERSPECTIVE?

AC motors are the workhorses of industry. Yet, they are power hogs

Let's put this into perspective…

There are roughly **25 million** small-frame AC motors employed as fan drive units. Assuming average power consumption (over last five years) of 150W and a duty cycle of 75%, these units consume **25 billion kWh of power** each year.

This means that, given one reactor generates 850 mW annually, the **average annual output from three nuclear reactors** is needed to supply the power for just these small-frame AC motors!

EC Drives the Future of Energy Consumption

Rising energy costs and new government regulations have spawned revolutionary innovation in motor technology. Electronically Commutated (EC) motors used in various fan applications — such as refrigeration, air conditioning and building systems — consume roughly 30-40% less power than AC motors. So if all 25 million small-frame AC motors in our earlier example switched to EC, this could save nearly 10 billion kWh, permitting an entire nuclear power station to shut down!

> *This is great news for everyone: engineers, OEMs and owners who actually pay the power bills.*

EC technology is the future of sustainable energy consumption in industrial and residential appliances, pump and HVAC applications. In this paper you will learn the benefits of EC motors, 'what is an EC motor?', how they work, how they are different from traditional induction motors, and some tips for making the switch.

BENEFITS OF EC MOTORS

When looking at AC power consumption and other variables, there's no comparison. Electronically Commutated Motors:

- **Are roughly 30% more energy efficient**
- **Offer higher power with a smaller size & weight**
- **Virtually silent (no hum)**
- **Lower CO_2 emissions significantly**
- **Are easy to install; less time, money & space required**
- **Available in more sizes & power outputs**
- **Extend life span, lower TCO & accelerate payback**
- **Allow end-products that are simpler & smarter with added features/reliability**
- **Provide better controls & regulatory compliance**
- **Offer substantial torque over a wide range of speeds**

What is an EC Motor?

Different Names, Same Technology

You may hear EC motor technology referred to as Electronically Commutated Motor (ECM), Permanent Magnet, Brush Free, Brushless DC (BLDC), Brushless Direct Current (BLDC) or Brushless Alternating Current (BLAC). Some of these vary slightly in design but carry the same basic concept. Whatever you call it, EC technology is here to stay.

The new Integral Horsepower Motor Rule has prompted engineers to replace or retrofit many of today's 1HP or smaller motors to EC. These include small electric motors, furnace fans, air conditioning, pumps, fans and compressors. Larger integrated systems (1HP to 10HP) will bring incrementally higher energy savings, including large pumps and commercial HVAC systems, rooftop condenser units and ventilation systems. While the EC motor is not a mandate for these applications, it's the only technology currently available to meet today's energy regulations and dramatically reduce TCO.

Innovation Drives Business Value

The market sees massive value in transitioning to EC. In the next decade, virtually all AC induction motors will be replaced, whether by new construction or retrofit. Industry leaders such as NovaTorque and QM Power are cost-engineering EC technology to enable any operating speed you need at both 50/60 Hz frequencies. This flexibility allows you to use the same product to match the performance requirements of different applications while still benefitting from increased efficiency, even in international applications where you are dealing with differences in voltage.

> *In a Nutshell: An EC motor is a brushless DC motor that tailors the motor's speed to perfectly match the demand in fans, pumps, compressors, rooftop units and HVAC systems.*

In addition, the available range of AC input EC fans is expanding all of the time. There are axial and centrifugal fans, forward curved and backward curved, single inlet and double inlet, single phase and three phase; these are often directly interchangeable with their AC equivalents. EC offers OEMs more than just energy efficiency. It is an opportunity to bring new technology and functionality to their products.

JOURNEY TO EC TECHNOLOGY

In 2004, new demand for first-floor washers and dryers created a need for high-efficiency washing machines that were also very quiet. And so, the first generation of controlled induction motors (CIM) was born. The market's response was high, as CIMs delivered 70% efficiency compared to AC induction motors, which can be as low as 35% at very low loads.

Swimming pool pumps followed suit in 2008, when the industry launched a variable-speed EC motor that could cut energy requirements by as much as 75%.

Today EC technology is being looked at everywhere from plant engineers and wastewater treatment plant operators to health clubs due to its ability to lower power bills and pay for itself in just a year or two.

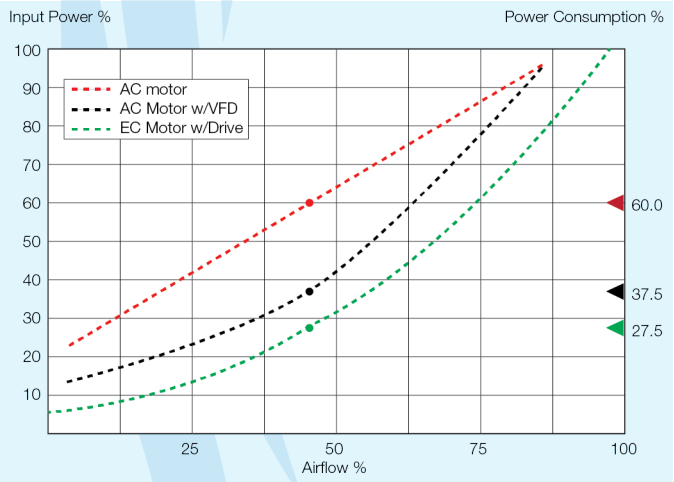

Chart 1
Power Consumption for Various Motors. It shows how even an AC motor that is VFD controlled can use 36% more energy than an EC motor at partial loads.

How EC Motors Work

Design Differences: Bye-Bye, Brush

Basic DC motors rely on carbon brushes and a commutation ring to switch the current direction, and therefore the magnetic field polarity, in a rotating armature. The interaction between this internal rotor and fixed permanent magnets induces its rotation.

In an EC motor, however, the mechanical commutation has been replaced by electronic circuitry. Through its **brushless design,** the magnetic field is already established by permanent magnets on the rotor. This allows you to **supply the right amount of current to the fixed armature in the right direction at precisely the right time for accurate motor control.**

No Speed Limits

In an induction motor, AC power supplied to the stator creates a magnetic field. The field rotates with respect to the frequency of supply voltage, inducing an opposing current in the rotor. The rotor will then turn to oppose the direction of the rotating magnetic field. The speed of the rotor can't be higher than the synchronous speed.

This is a common problem in typical AC motor types, including:

- **Shaded pole**
- **Capacitor run**
- **Capacitor start**
- **Three-phase AC motors**

The EC motor design does not impose these speed limitations.

Not Your Father's Motor

The brushless EC motor has external electronics, a rotor with permanent magnets, and a stator which has a set of fixed windings. A circuit board continually switches the phases in the fixed windings to keep the motor turning. Speed is controlled by commutation electronics, so motors are not limited to synchronous speeds, and can rotate much faster than traditional AC motors.

The EC motors' designs are cost-competitive. They use less material and low-cost ferrite magnets to achieve superior performance and higher efficiency than comparable motors. Due to their flexibility, EC motors are now finding homes in everything from small appliances to conveyor belts and large rooftop condenser units.

Speed Control Pays Off

> *The biggest efficiency advantage of EC motors comes from speed control.*

NEMA Efficiency Level	IEC Efficiency Class
Standard	IE 1
High Efficiency	IE 2
Premium Efficiency	IE 3
Above-Premium Efficiency	IE 4
TBD	IE 5 (under development)

Chart 2
NEMA versus IEC efficiency classification. Yellow box shows current NEMA efficiency requirement in the US compared to IEC efficiency requirements in most industrial countries outside the US.

Think of it like driving a car...

Imagine if you turned on the engine and went to 100% of the speed, then tried to control the speed of the car by using your brakes every time. That's how most commercial and industrial applications work today with AC.

Sure, you can get AC motors with multiple speeds, or external control devices. But these are often very noisy or not optimized for the system. What's more, they require a complicated system of filtering and protection to properly protect the motor shaft from damage such as electrical fluting.

EC motors automatically and continuously adjust to meet current demand. Multiple speed options come standard. The commutation circuit can easily accept inputs — such as PWM, 4-20mA, and 0-10V linear — to control the speed typically in the range of 10-100%. The control side of EC motors is a low-voltage circuit separate from main power. The circuit can even provide voltage to power external sensors; no need for separate DC power supply for these sensors.

"BONUS" BENEFITS

In addition to efficiency through speed control, the EC motor offers a wide range of advantages to engineers, OEMs and building operators:

Smaller motor size.
Achieve the same power output at a lower weight; more space to add features to your end-products, etc.

Consistent performance, even abroad.
Not completely dependent on voltage and frequency; small changes in voltage do not impact motor output. Plus, 50 or 60 Hz can be used with no impact on performance. So regardless of what voltage or frequency is coming out of wall, or what country that wall is in, the motor will always perform the same.

Protection
against voltage overload, low voltage conditions, phase loss, power surges, locked rotor and overheating. In many three-phase input EC motors, for example, there's no more guessing which wire is L1, L2 or L3.

Output.
Internal monitoring functions can be easily accessed by the designer to provide end-user feedback about the motor or appliance – for example, error code, motor life, motor temperature and tachometer.

Soft start.
Reduces startup current, prevents nuisance breaker trips, and allows lower component ratings in the system.

Noise.
No hum or spikes with voltage frequency.

Good heat dissipation.
A cooler motor means better reliability and longer life.

Sustainable design.
The EC has a thermoplastic encapsulation of the laminated core in the stator; its high-grade plastic material provides great electrical insulation. In addition, the one-piece rotor around the stator provides aerodynamics; guaranteed high level of IP protection (IP54); shock-proof sealing; and longest service life on the market.

Preservation of resources.
OEMs like the EC's one-piece rotor with press-fit shaft, which reduces manufacturing steps and parts needed, thanks to its multi-function components.

Common Uses

Exhaust air systems such as hotel bathroom fans, EC fan lines for the rooftop, and central HVAC systems in residential high-rise buildings require noiseless, reliable and highly efficient energy consumption. The EC motor with pressure control is the perfect solution.

One common use for EC motors is the air curtain. Where blowers create an air flow barrier, EC motors allow adaptation of the air flow velocity to suit your requirements.

EC technology matches the blower's performance to part-load requirements to achieve significant power savings and lower acoustic noise levels.

Other uses include evaporator fans in refrigeration systems, ventilated building façade systems, range hoods, clothes dryers, duct fans, fans in refrigerated display cases and more. All of these applications enjoy an average 40% reduction in power consumption from switching to EC.

SELECTING A MOTOR

Engineers want the simplest motor available without unnecessary features. But, pro-tip: going on price alone puts the motor at danger of costly failure.

Always consider the pros and cons of each motor type before making a decision.

As the first step in selecting a motor, here are some good questions to ask:

- **What's the required torque at intended operating speeds?**
- **What's the impact of efficiency loss?**
- **What's the operating environment & have you accounted for worst-case loading?**
- **What do you need to keep the motor functioning over the design life?**
- **What regulatory standards are there? For instance, outdoor water, dust?**
- **What type of bearing system is required?**
- **What's the mounting system** (lugs attached, belly band, resilient or welded, bolts from motor face, etc.)?
- **What are the power requirements?**
- **What type of overload protection is needed?**
- **Can your installation provider outline a rapid payback period?**

EC motor designed for use with external motor controller.

EC motor designed with integrated motor controller

EC MOTORS FROM ENERVEX

ENERVEX now provides the Domel EC Motor, which offers a wide range of advantages:

- **Available speed ranges from 100 RPM to 4000 RPM**
- **EDrive Motor Controller provides soft start and speed control**
- **Very little efficiency change with varying loads:** Remains around 94% to 85% efficiency
- **Virtually silent motor (no hum)**
- **Insulated shaft bearing design mitigates electrical damage (fluting, shaft grounding issues, etc.)**
- **Less heat, lower bearing temperature, greater reliability**
- **Ability to support multiple input voltages**
- **Lighter weight – 2HP EC motor is only 18 lbs. vs. 30 lbs. for a 2HP ABB motor**
- **Replace current motors without any fan modification**
- **Consistent efficiency; reducing fan speed by 40% reduces power by 80% (see chart)**
- **Three speed control options:**
  Drive Mounted Dial (optional)
  0-10V DC Lead (standard)
  Remote Mounted Dial (optional)
- **Special features:**
  BUS communications (such as ModBus): allow easy integration into existing building management systems by enabling two-way communications between the device and motor, with information and rich feedback.

  Complicated control scenarios such as reverse rotation on startup to loosen a blocked rotor, and soft-start override to loosen a frozen fan blade.

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NOT YET CONVINCED?

Check out these additional proof points:

Taco, Inc. was able to reduce energy use in some of its pumps by over 60%

NovaTorque's axial air gap motor achieves power efficiencies above 90% over a wide range of motor shaft speeds

By changing to EC fans, a regional based hospital calculates energy savings to exceed $28,000 (240,000 kWh) per year

JUST CALL US. PHONE 770.587.3238

ENERVEX staffs experts in high-efficiency EC motors for commercial and residential fans, appliances, pumps, and HVAC applications. We can demonstrate the potential energy savings and fast payback you could get from switching to EC motors in your operations.

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