Demystifying Electronically Commutated Fan Motors (ECM) in Data Centers

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Agenda

- Why use ECM motors in data center applications
- How to measure efficiency in data center applications
- Explaining the technology of EC motors
- Applying the technology in different environments

Reasons to implement the EC motor technology in computer rooms

Social Reasons:

- Global warming
- Depletion of fuel reserves

Financial Reasons:

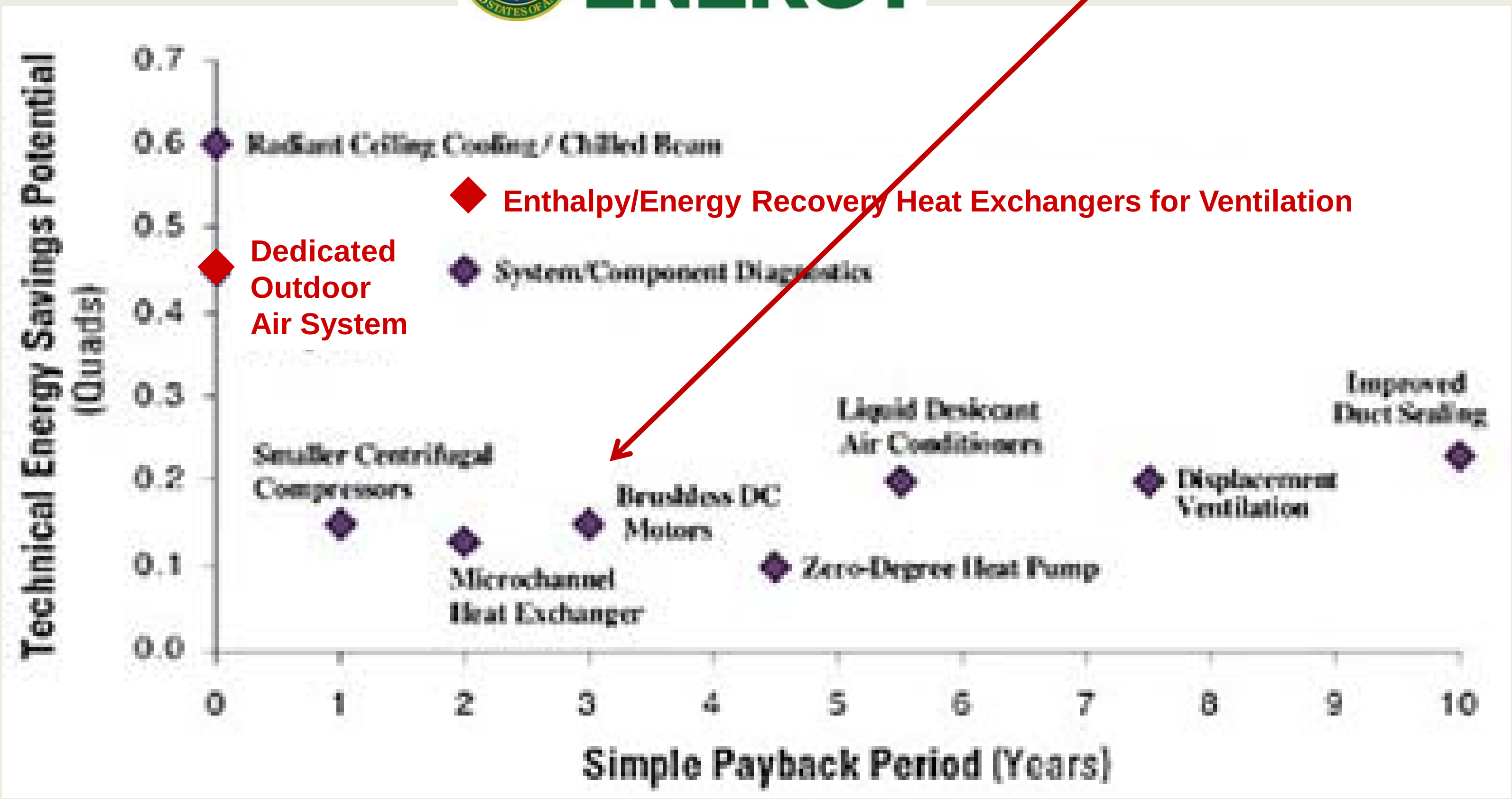
- Operating costs
- Energy use

Design Reasons:

- Fixes a major design problem in computer rooms
- A static design with evolving demand
- Redundancy
- Reliability

DOE Emerging HVAC Efficiency Technologies

QUALITÉ
INNOVATION
EXPERTISE



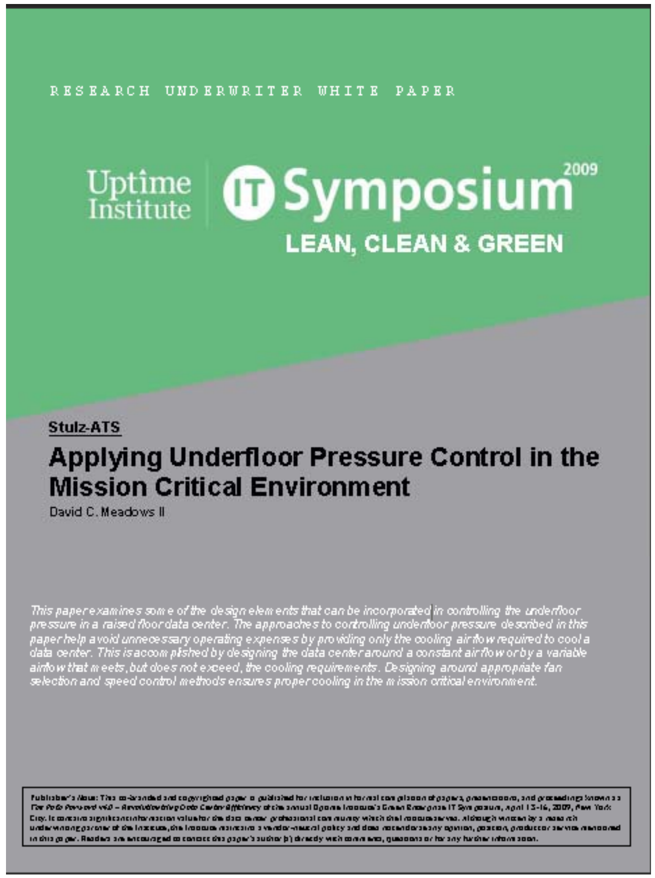
Our ASHRAE Colleagues

- "Estimates show that the total energy consumption by data centers amounts to almost **2% of electricity use in the United States**, which is equivalent to about 8 times 1000 MW," said **Roger Schmidt, ASHRAE President, Technical Committee on Critical Facilities**. "Government agencies and utility companies are very interested in finding a way to implement **programs to reduce the high energy consumption of data equipment and increase energy efficiency**"

Uptime Institute

Applying Underfloor Pressure Control in the Mission Critical Environment

''In many respects the **plenum fan is the better solution for variable speed operation,** due to the nature of the fan curve for this type of blower wheel. Unlike the forward-curved centrifigual fan, the plenum style fan tends to have a smooth curve without the prominent dip to the left of the peak value…"



RESEARCH UNDERWRITER WHITE PAPER

Uptime Institute | IT Symposium 2009

LEAN, CLEAN & GREEN

Stulz-ATS

Applying Underfloor Pressure Control in the Mission Critical Environment

David C. Meadows II

This paper examines some of the design elements that can be incorporated in controlling the underfloor pressure in a raised floor data center. The approaches to controlling underfloor pressure described in this paper help avoid unnecessary operating expenses by providing only the cooling airflow required to cool a data center. This is accomplished by designing the data center around a constant airflow or by a variable airflow that meets, but does not exceed, the cooling requirements. Designing around appropriate fan selection and speed control methods ensures proper cooling in the mission critical environment.

An interesting trend in modern day data center cooling is known as **underfloor pressure control (UPC)** is achieved by either maintaining constant underfloor pressure, **ensuring a constant volumetric flow rate of cool air to mission critical equipment or…**

Energy Use in Data Centers

- 100 times the density of a commercial building
- 24 hours of operation per day
- 365 days of operation per year

RESULTS: Your customers, data center managers, must pay special attention to energy consumption related to the operation of data centers.

Constraints of Computer Rooms

- Heavy consuming environment
  - Therefore, preservation of power is not really a priority
- The Design
  - More or less the same for the last 20 years
  - The design is the same vs a demand that evolves exponentially
  - The design of redundancy was not necessarily planed 'ADHOC'
  - The design was planned for the life of the equipment and not for the evolution of the ever-changing demand
  - Day 1 ≠ Day 365 …
- The Technologies
  - Technologies have evolved in the last 12 years to support IT change (Compression, ventilation etc…)
- Electricity in Maritimes \$ vs North America \$\$, Asia \$\$\$ and Europe \$\$\$\$.

RESULTS :

Your Customers, computer room managers must pay special attention to the evolution of their rooms both at the energy levels and at the design:

- - To do more with less
- - To evolve in the same infrastructure
- - To be profitable per square foot
  - Offer shared rental
  - Become a profit center

    Or else: Outsourcing

Agenda

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- Explaining the technology of EC motors
- Applying the technology in DataCenter environments

Energy efficiency measures

DCIE Data Center Infrastructure Efficiency

PUE Power Usage Effectiveness

PUE Definition

PUE Power Usage Effectiveness

$$\textbf{PUE} = \frac{\text{Total energy consumption of the space}}{\text{Energy consumption of IT equipment}}$$

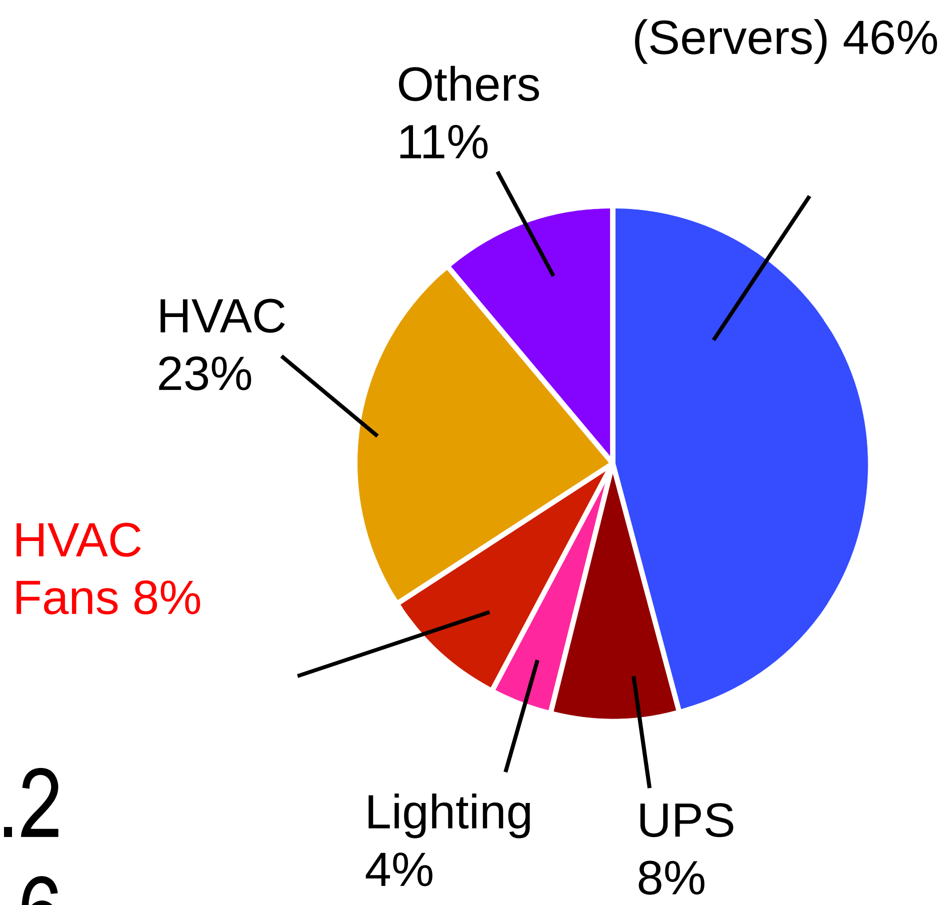
Total Power / Data supply

Scale:

- 1.0 Perfect
- 1.2 Excellent
- 1.6 Desirable
- 3.0 Mediocre

What is the current energy landscape of datacenters?

- Servers
- UPS
- Lighting
- HVAC Fans
- HVAC mechanical cooling
- Other energy consumption

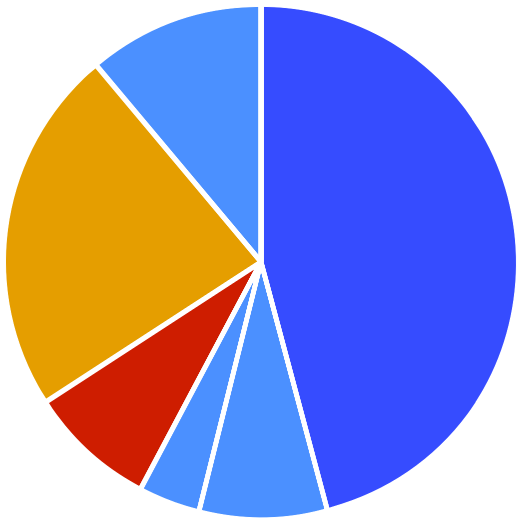


Average 2009 PUE: 2.2
Average 2012 PUE: 1.6

HVAC – The highest load after servers

The average percentage of the total energy consumption of HVAC space is currently …

31%



We therefore all have a responsibility to reduce the highest consumption!

Our rooms consume more and more energy

- The **density** of cabinet energy consumption is on the rise:
  - Day 1 $\neq$ Day 2
  - Blade Servers 5 kW → 10 kW → 20 kW…
  - Virtualisation
  - Quad, Octo, Atom processors (16 cores)

« PUE » expectations

Becomes a Design Criteria

Difference between comfort and precision air conditioning

	Comfort	Precision
Temperature	72-75°F, ± 5°F	72-75°F, ± 2°F
Relative Humidity	50%, ± 15%	45-50%, ± 5%
SHR	0.67-0.75	0.90-0.98
Load density	200-400 ft^2 / ton	50-100 ft^2 / ton
Air circulation	350-400 CFM / ton	550-600 CFM / ton
Air filtration	Important	Mandatory
Flexibility	Not required	Mandatory
Redundance	Not required	Mandatory
Hours of operation	1000-1500 hrs / year	8760 hrs / year

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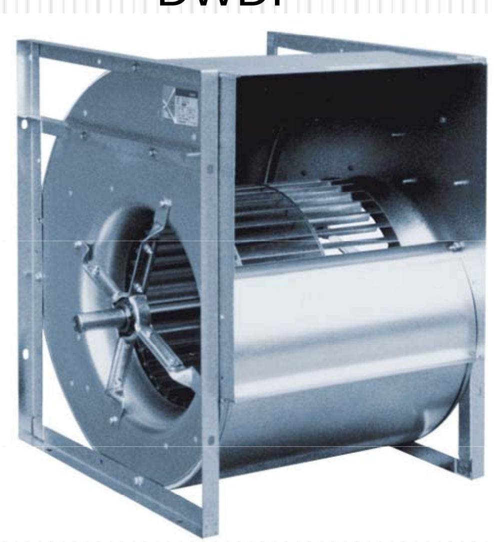
THE EVOLUTION

EC FAN
?

DWDI
AC Motor + VFD

DWDI



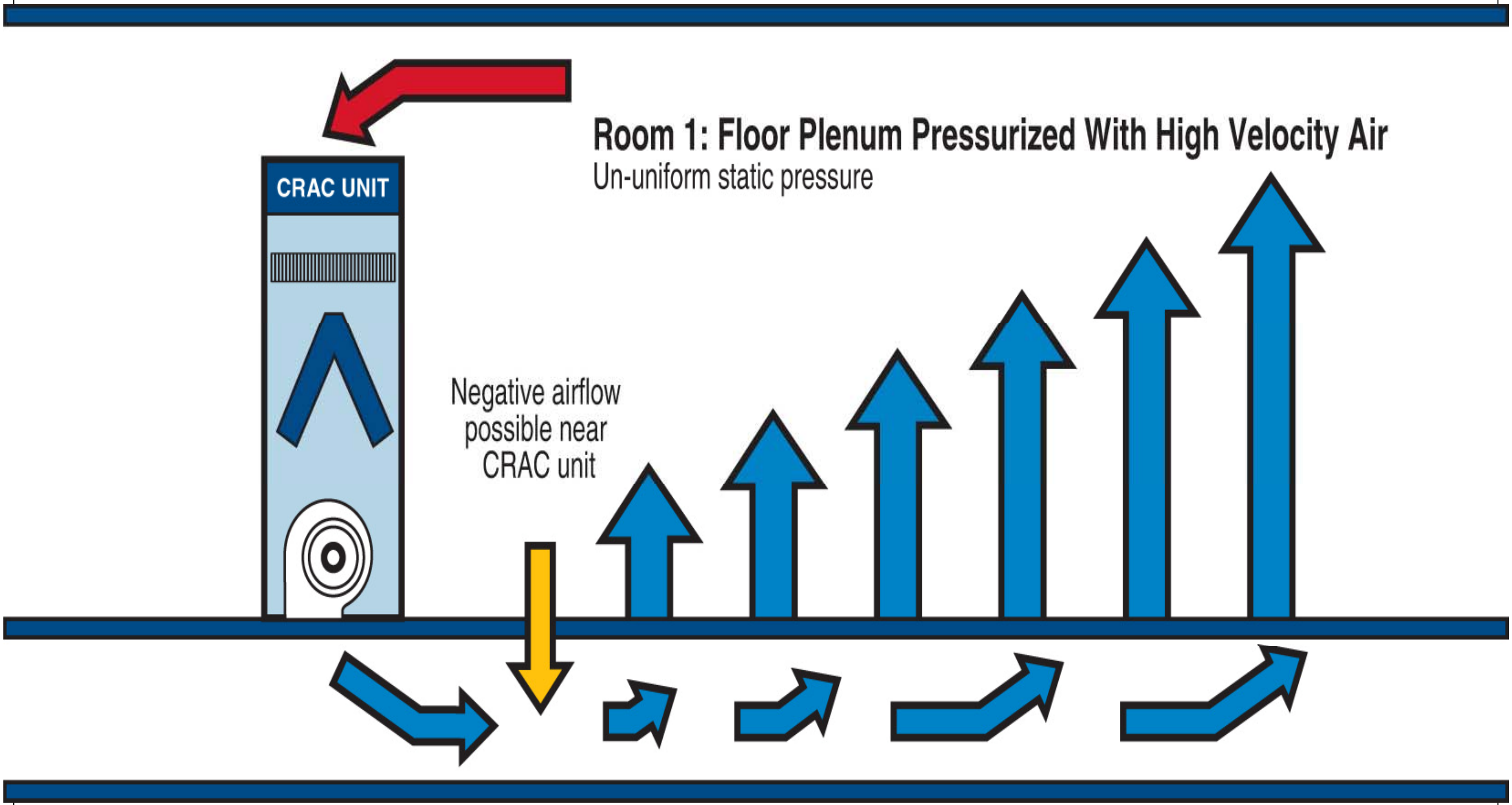
Electronically Commutated Fan "EC"

- EC fans have been accepted as the latest in energy efficient air movement technology. But what is an EC fan and what makes it so special?

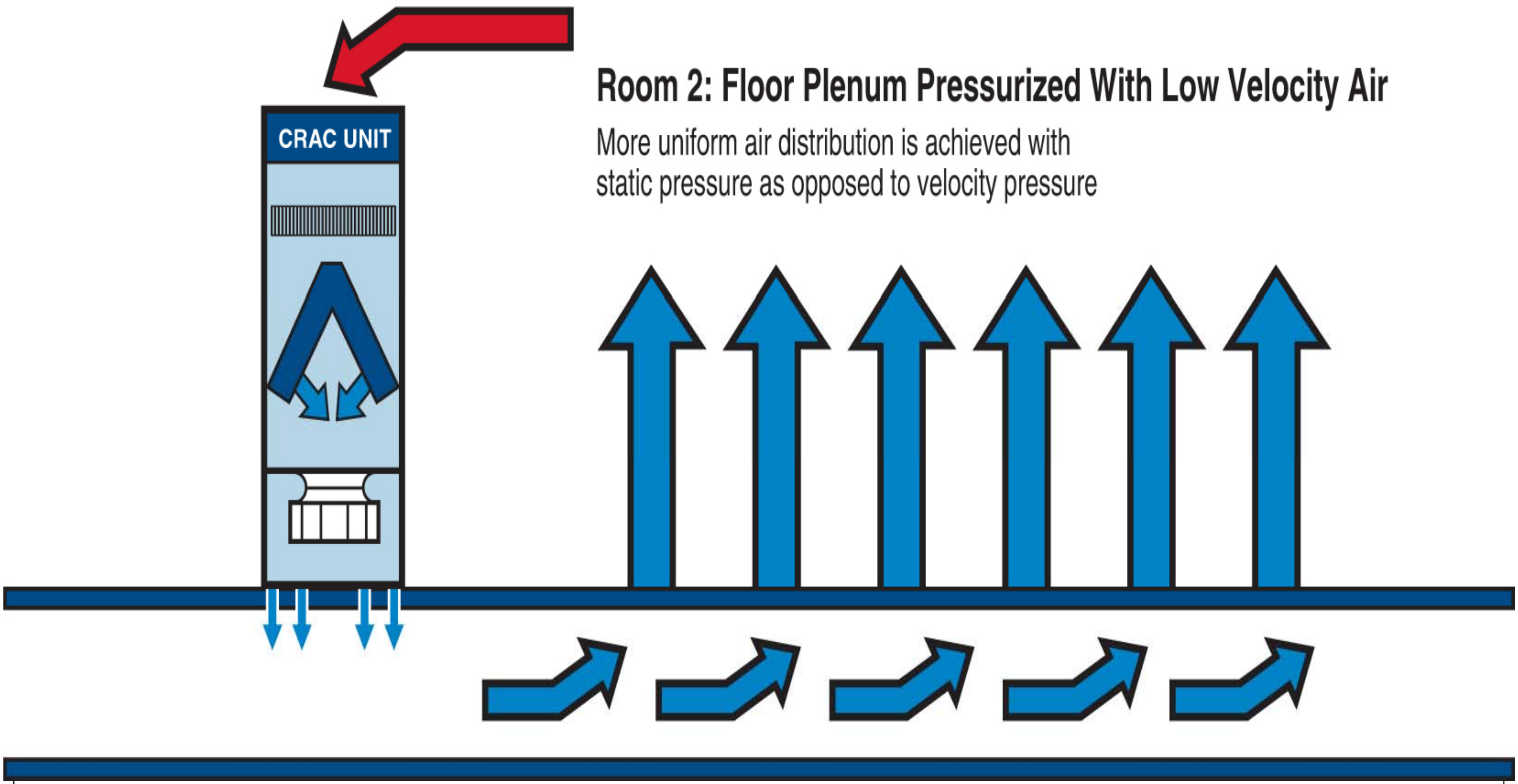
- An EC motor is a DC motor receiving AC power via an integrated electronic card that is involved in:

  - Not an intergrated VFD
  - AC / DC conversion
  - Electronic switching
  - Speed control of the motor by adjusting power output
    - Thus saving energy at reduced speed

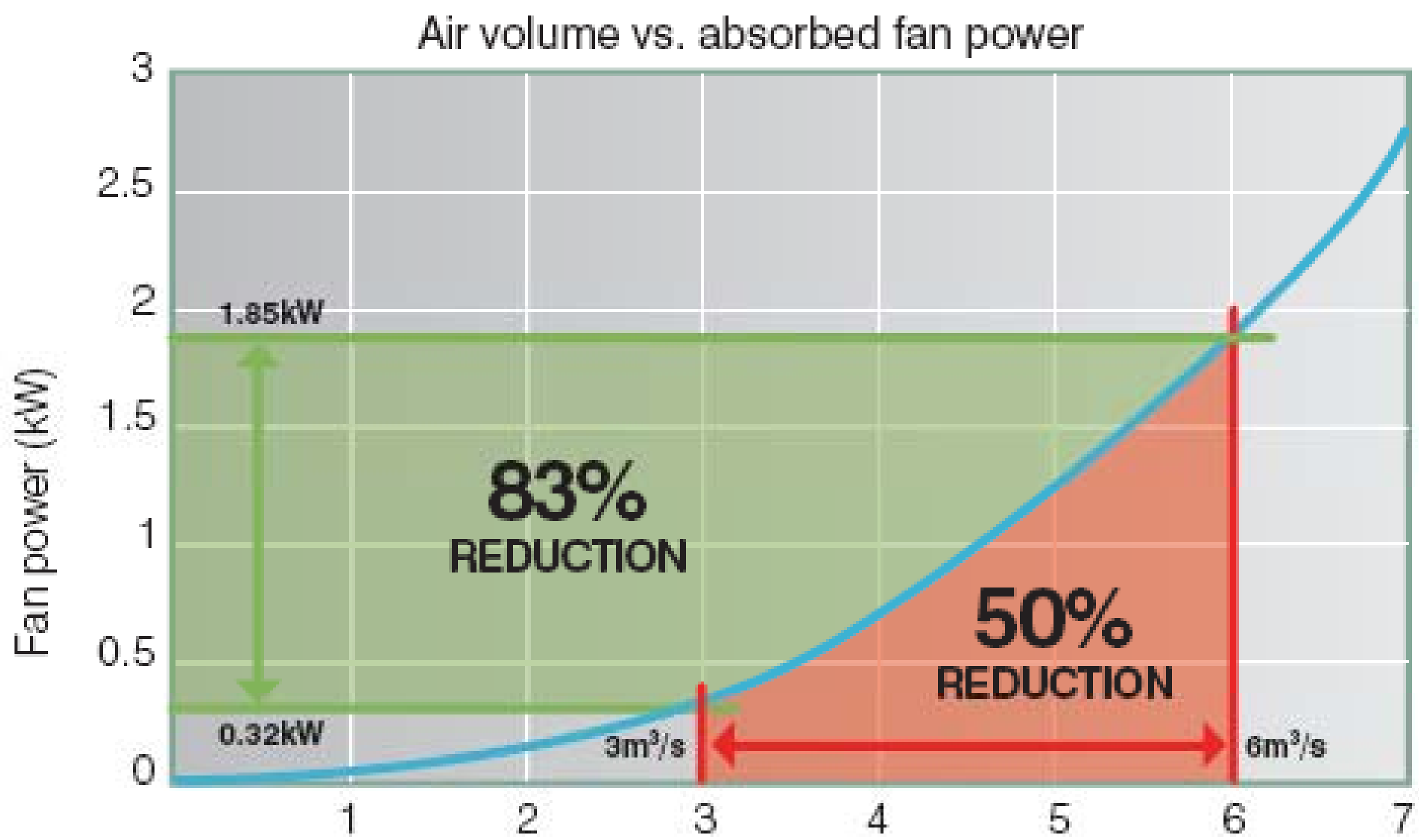
The Centrifugal Fan 'DWDI'

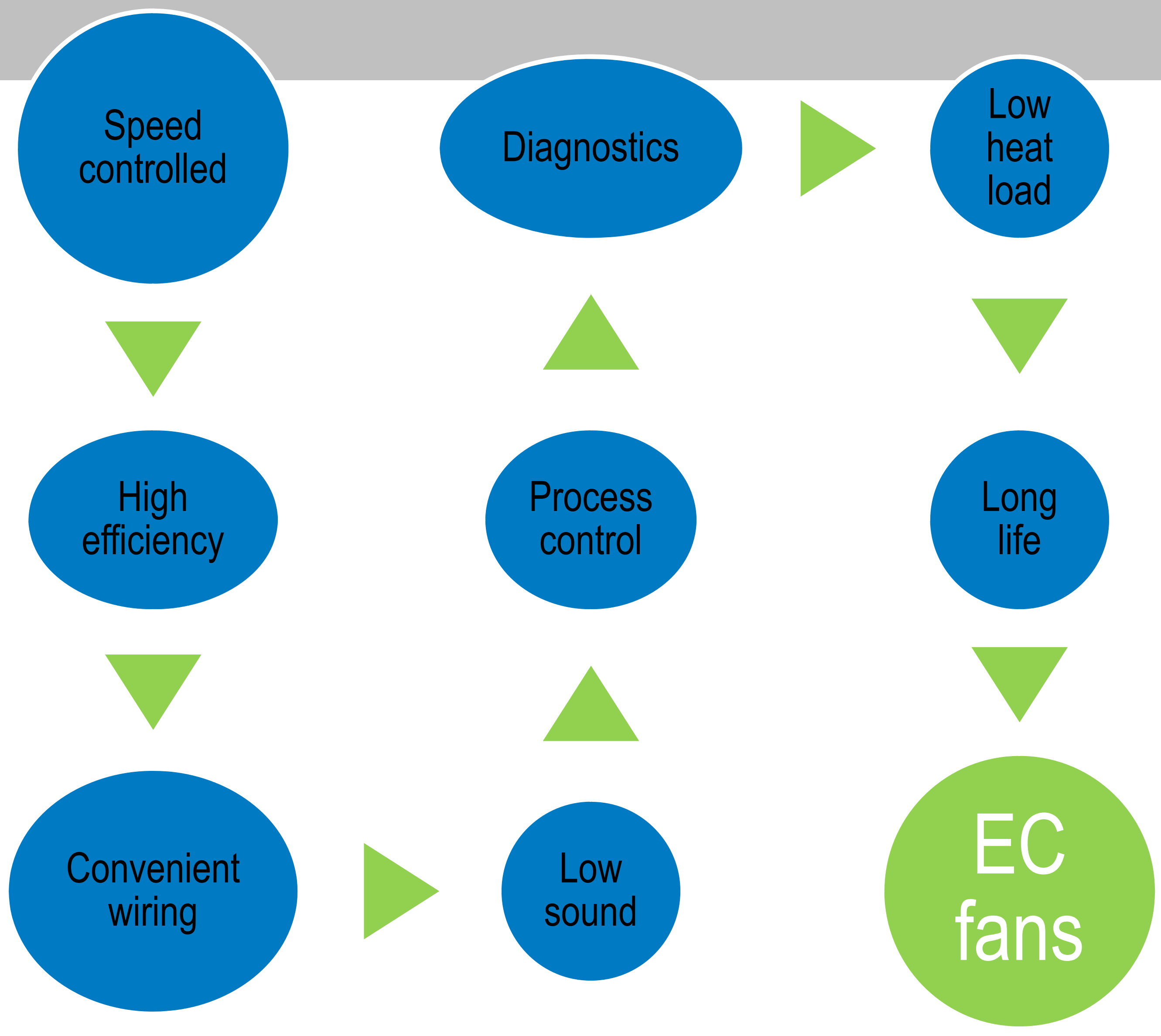


The Centrifugal << PLENUM>> Fan ‘EC’



Curve of ECM Fan




Speed controlled
High efficiency
Convenient wiring
Low sound
Process control
Diagnostics
Low heat load
Long life
EC fans

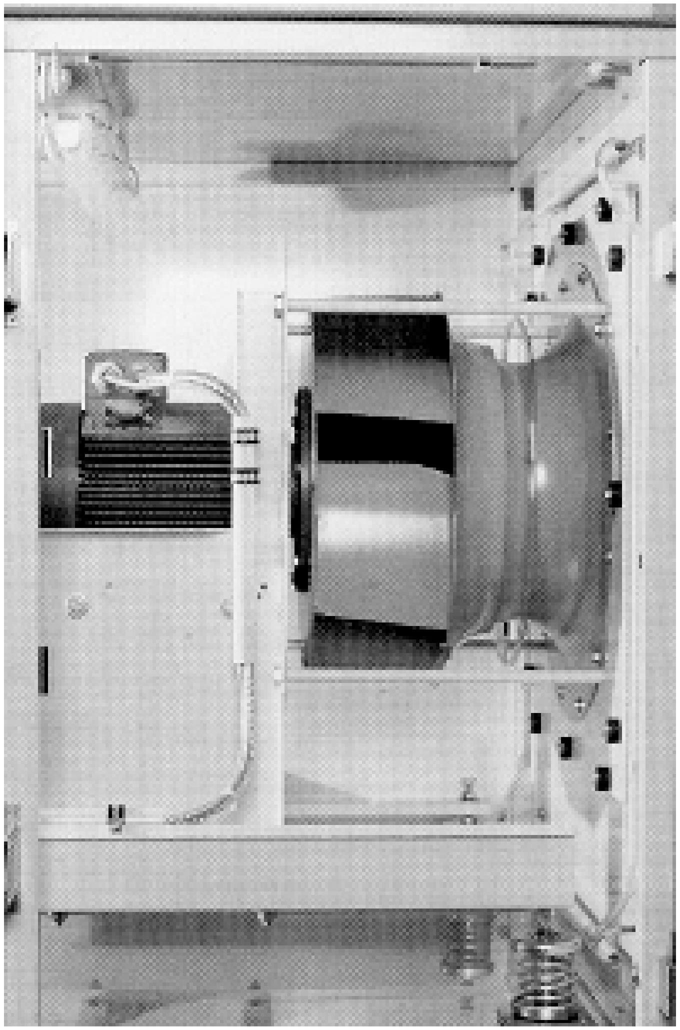
EC motor, different names

- ECM
- Electronically commutated motor
- Brushless permanent magnet motor

Let us concentrate on direct drive EC fan motors that are supplied with AC voltage.

Motorized fans

“standard motor”
NEMA or IEC



Clarifications

Induction motor + Supplied with AC voltage = "standard motor"

NEMA motor
IEC motor

Brushless permanent magnet concept + DC voltage = DC motor

Rarely used in HVAC

Sometimes in small CRE
(commercial refrigeration equipment)

Brushless permanent magnet concept + Supplied with AC voltage = EC motor

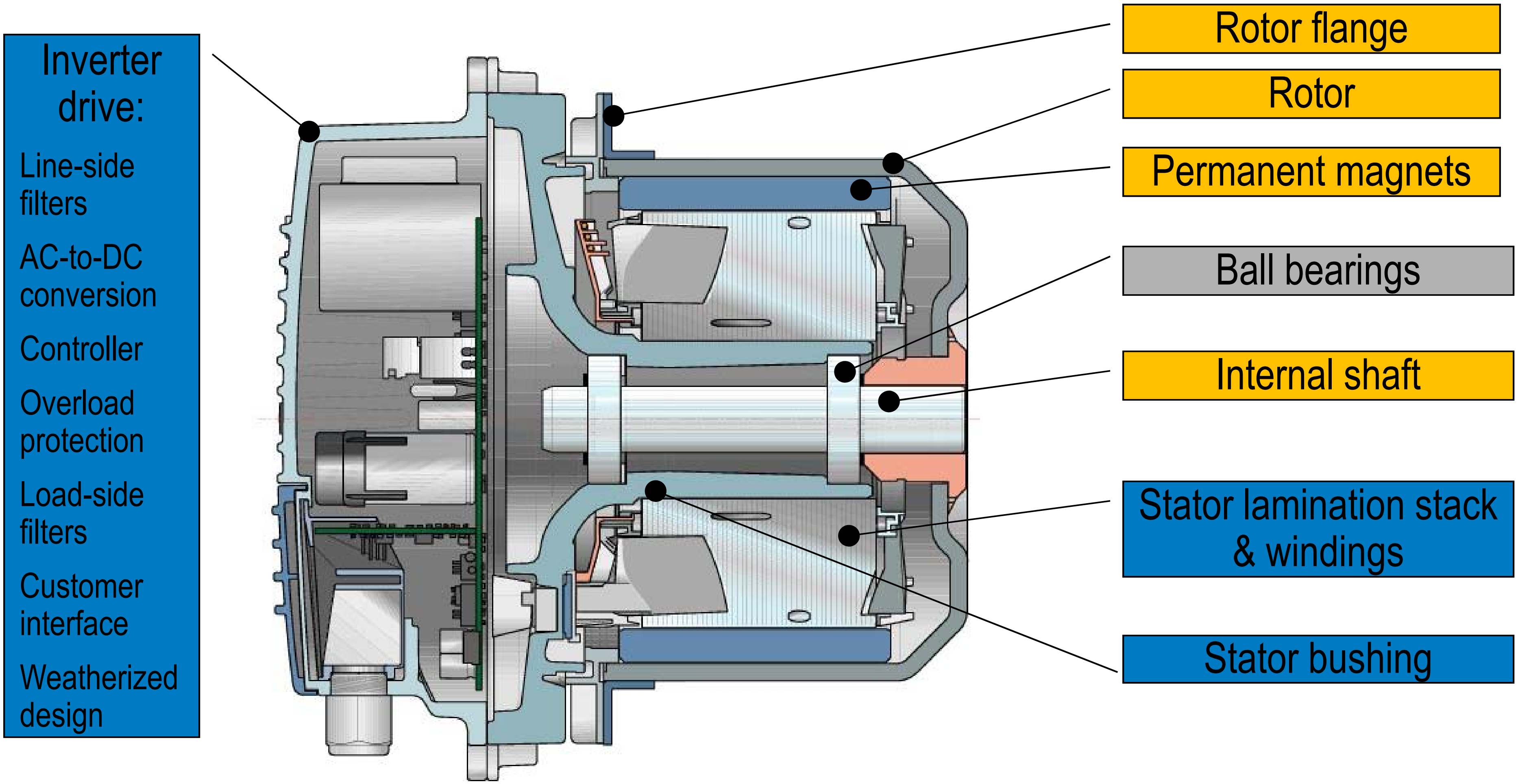
Have been widely used in residential HVAC

Since 2004 also in commercial + industrial equipment

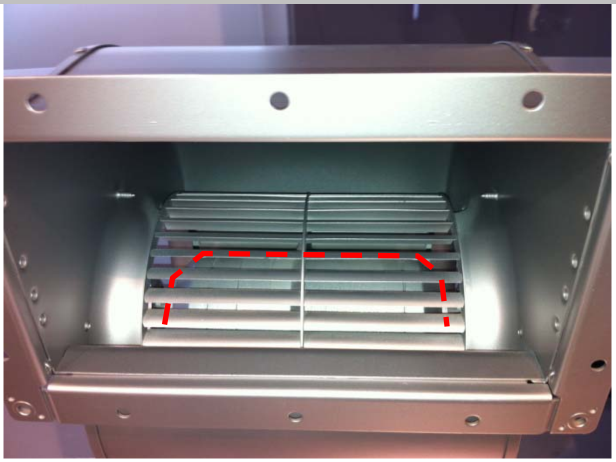
Fan motors in HVAC/R

Voltage supply	Rotor-stator arrangement	Concept	Coupling to fan	Dimensions	Comments
AC	Internal rotor motor IRM	Induction motor (optional inverter duty)	Shaft + hub	NEMA + IEC	“standard motor” (also inverter duty)
AC	External rotor motor ERM	Induction motor	Rotor is part of the fan	No formal standards	Very common outside of North America
DC	External rotor motor ERM	Permanent magnet brushless	Rotor is part of the fan	No formal standards	Common in electronics cooling and in vehicles
AC	Internal rotor motor IRM	Permanent magnet brushless (also rare earth magnets)	Shaft + hub	Sometimes close to NEMA	“EC motor” Residential and light commercial
AC	External rotor motor ERM	Permanent magnet brushless (ferrite magnets)	Rotor is part of the fan	No formal standards	“EC motor” 8W to 12kW

EC external rotor fan motor



External rotor fan motor: Dual inlet blower



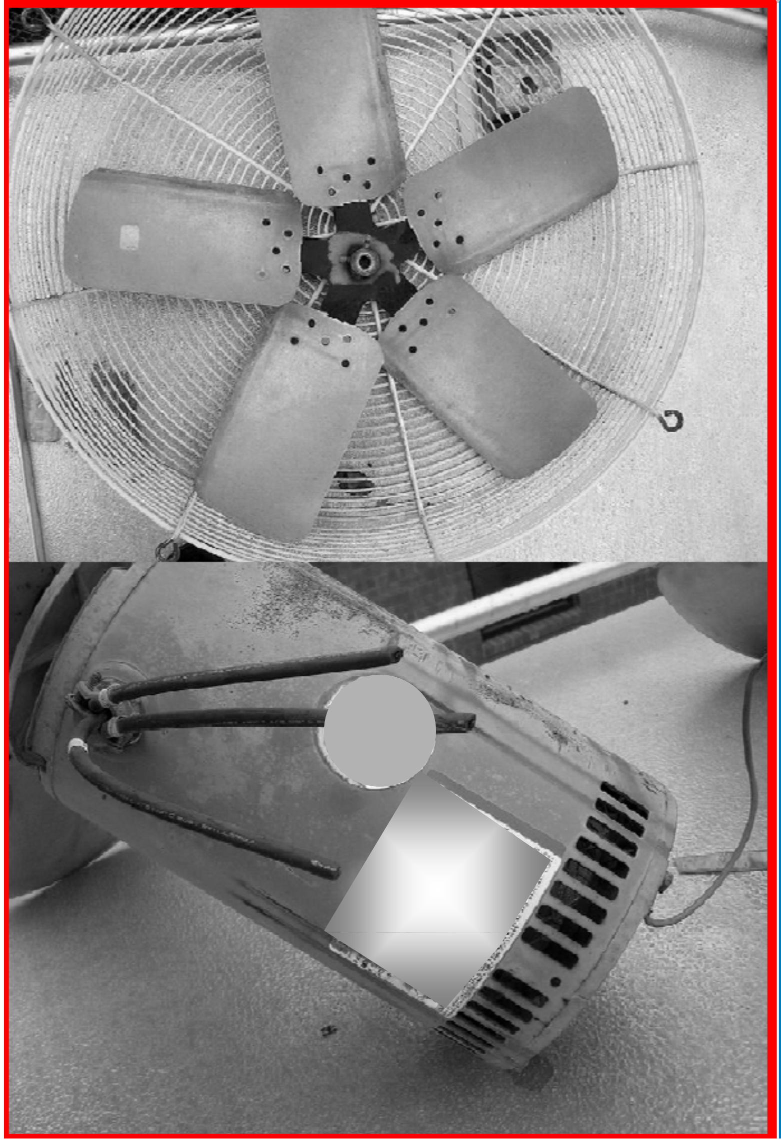
- Little obstruction of fan inlets
- Both sides same airflow

X

Centrifugal fans with EC external rotor motor

Axial fan comparison

Standard motor and fan



Fan with EC external rotor motor

EC fan motors

Permanent magnets

high efficiency, synchronous operation, no slip losses

Power electronics

each individual motor → redundancy

variable speed (continuously variable or in steps) → load matching

Controls electronics

convenient customer interface

process control, proportional–integral–derivative controller (PID controller)

direct digital control DDC

Completely integrated system

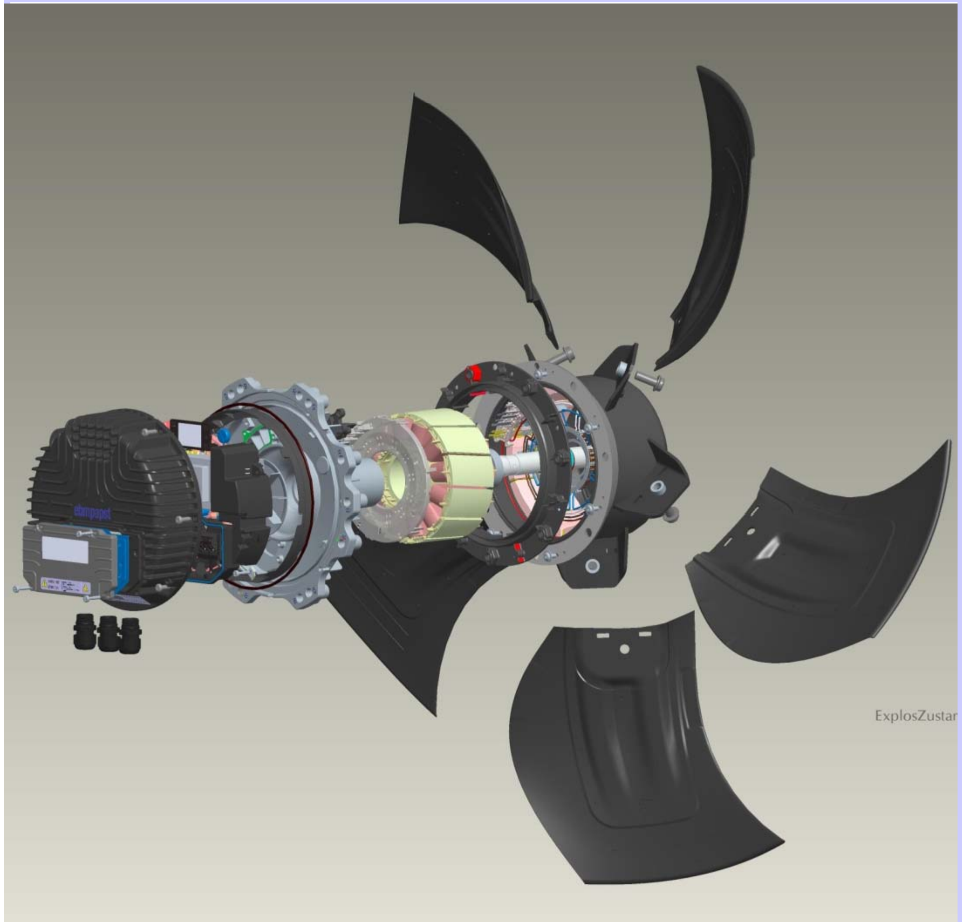
complete overload protection, electrical filters

ease of wiring, compatibility, low sound, warranty

Coupled to high-efficiency fans of various types and numerous sizes

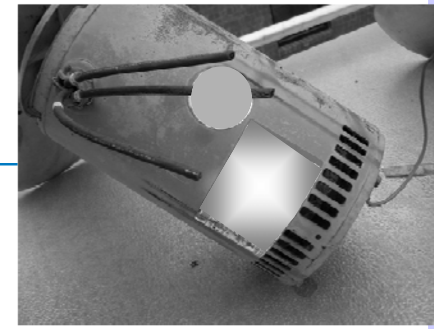
Variable speed 1.5HP motor and axial fan system

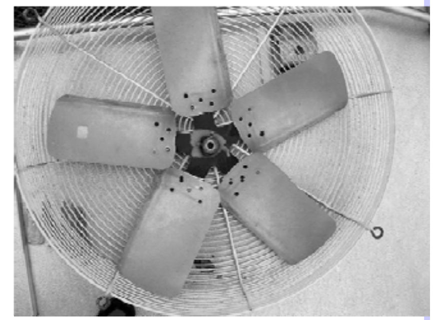
EC fan with integrated electronics



AC motor, fan, inverter & peripherals

motor filter





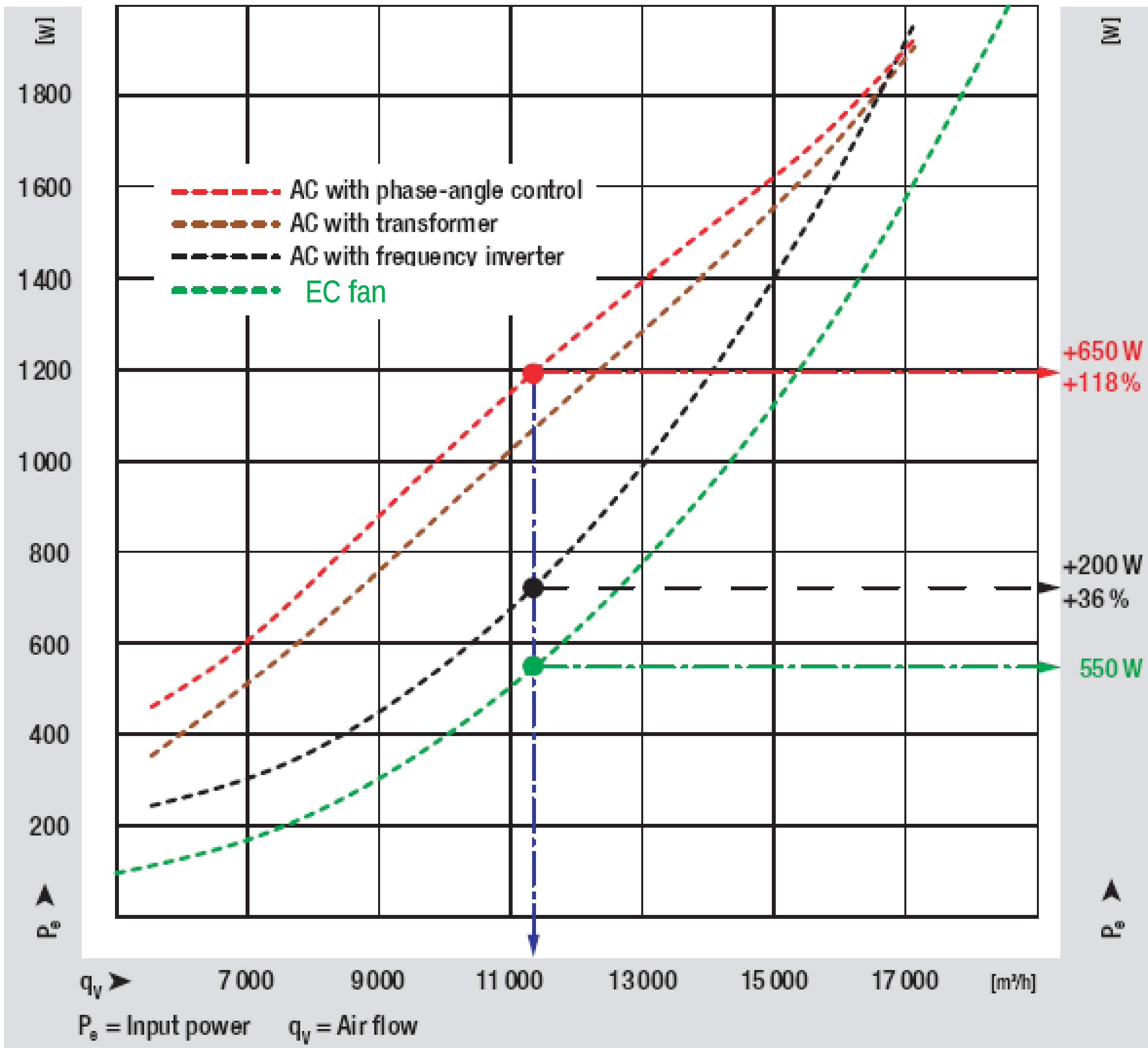
inverter

line filter

EMC filter

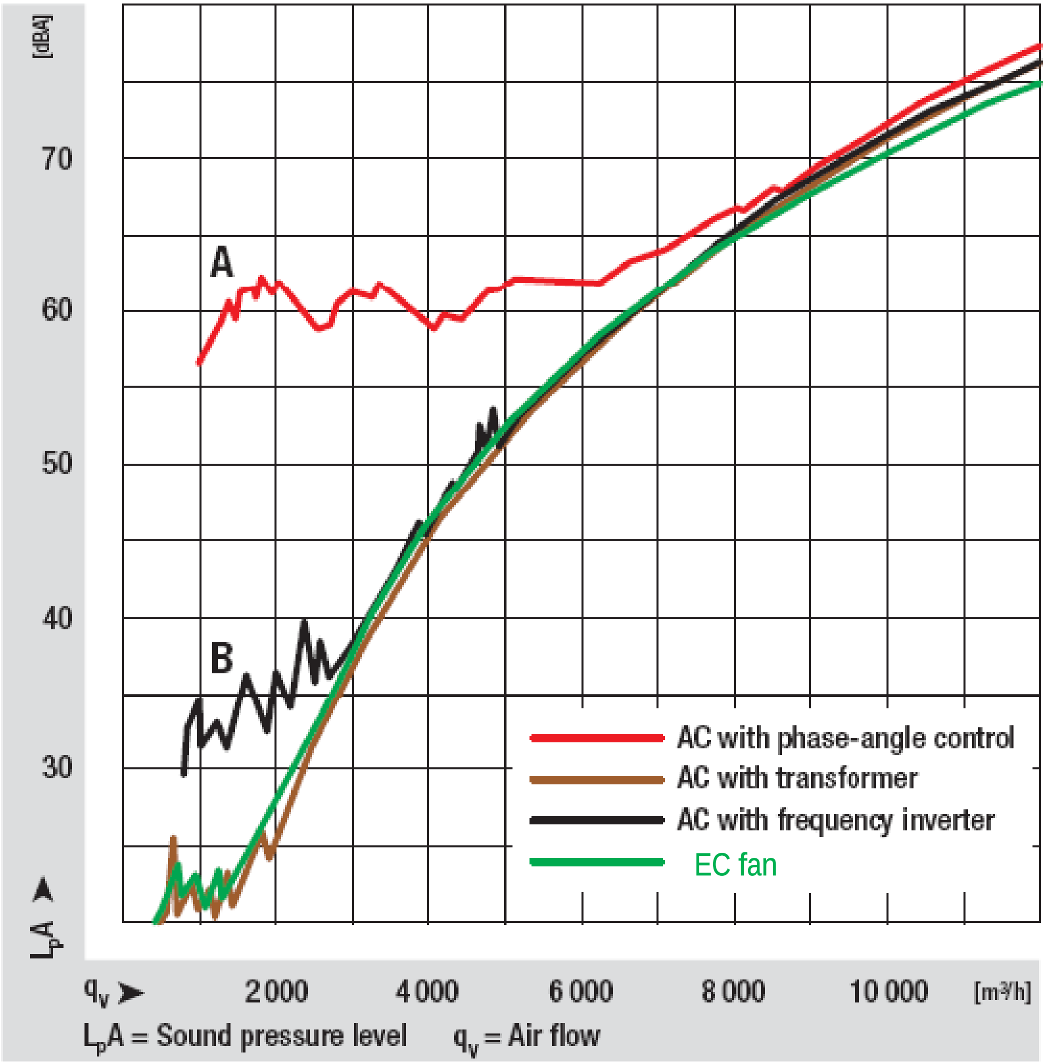
Electricity savings from various fan control methods

- Measured overall values, not just calculated from component efficiencies
- What you see is what you get.
- Wire-to-gas efficiency



Noise emissions from various fan control methods

- Advanced power electronics prevent motor cogging.
- No noise penalty from speed-control.



Air-cooled condenser

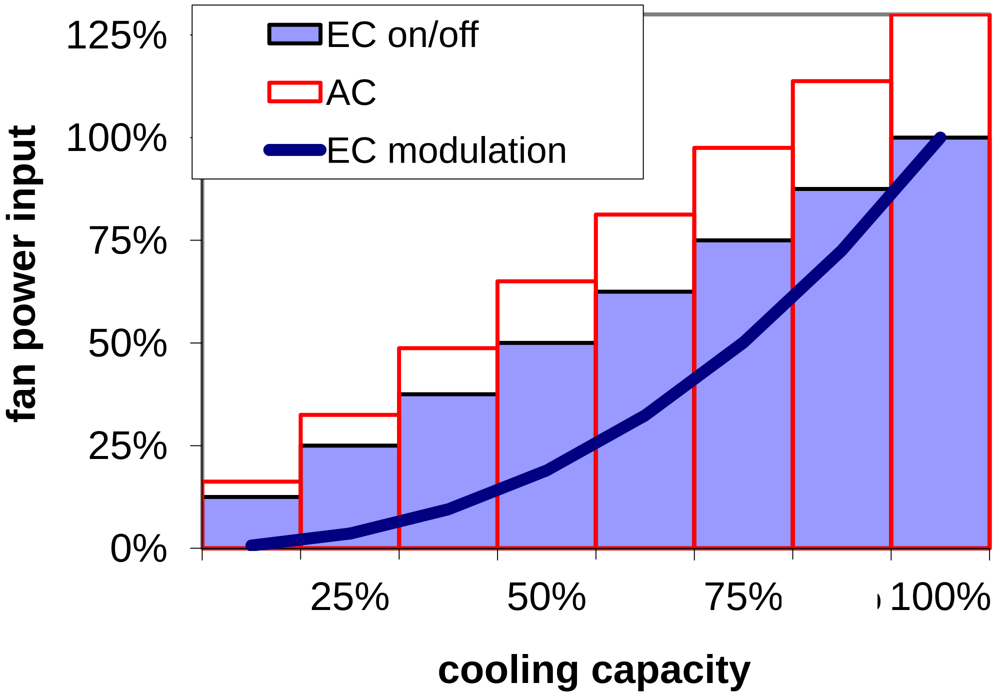
Standard AC motor and fan

EC fan with external rotor motor

External fan cycle control
30% higher current at full speed

Integrated head-pressure controller
3dBA quieter
additional 15% airflow reserve

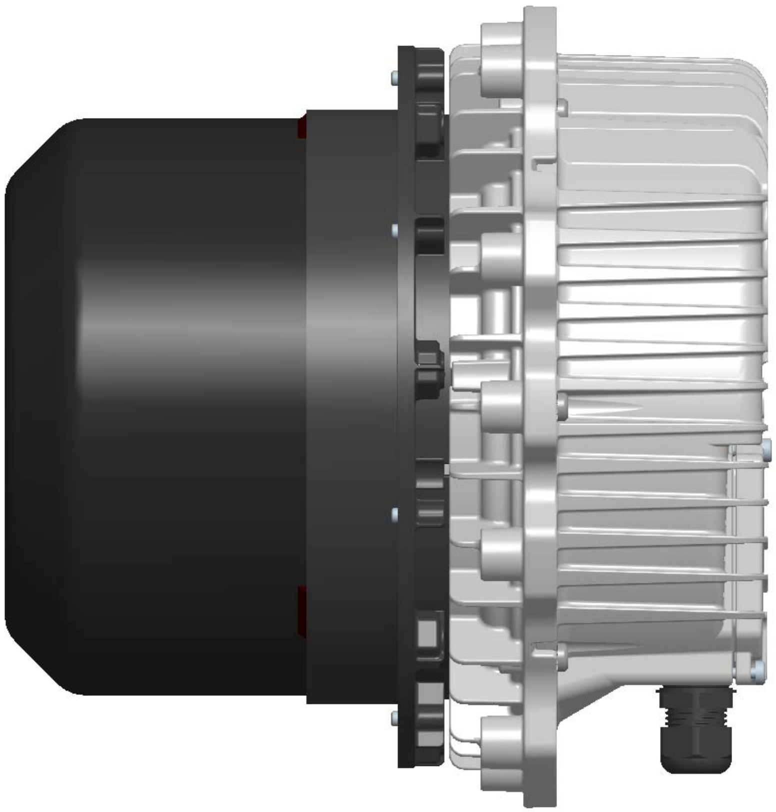
Fan power savings in multi-fan applications



✓Additional compressor power savings when continuously variable speed condenser fans are used with floating head-pressure control

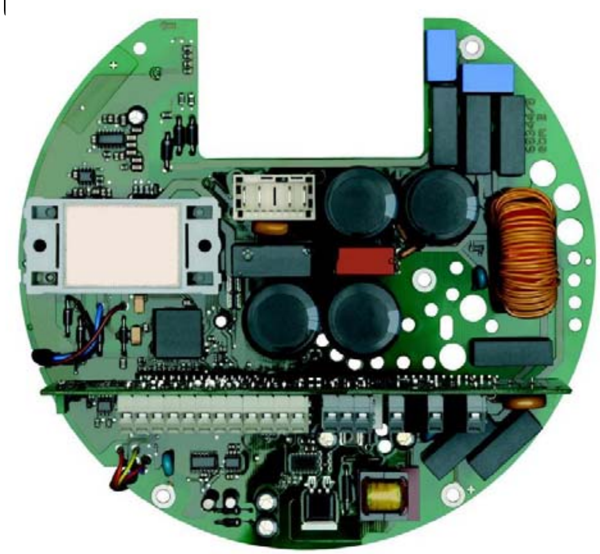
$P_1 \sim n^3$

EC motor construction details
Power Electronics

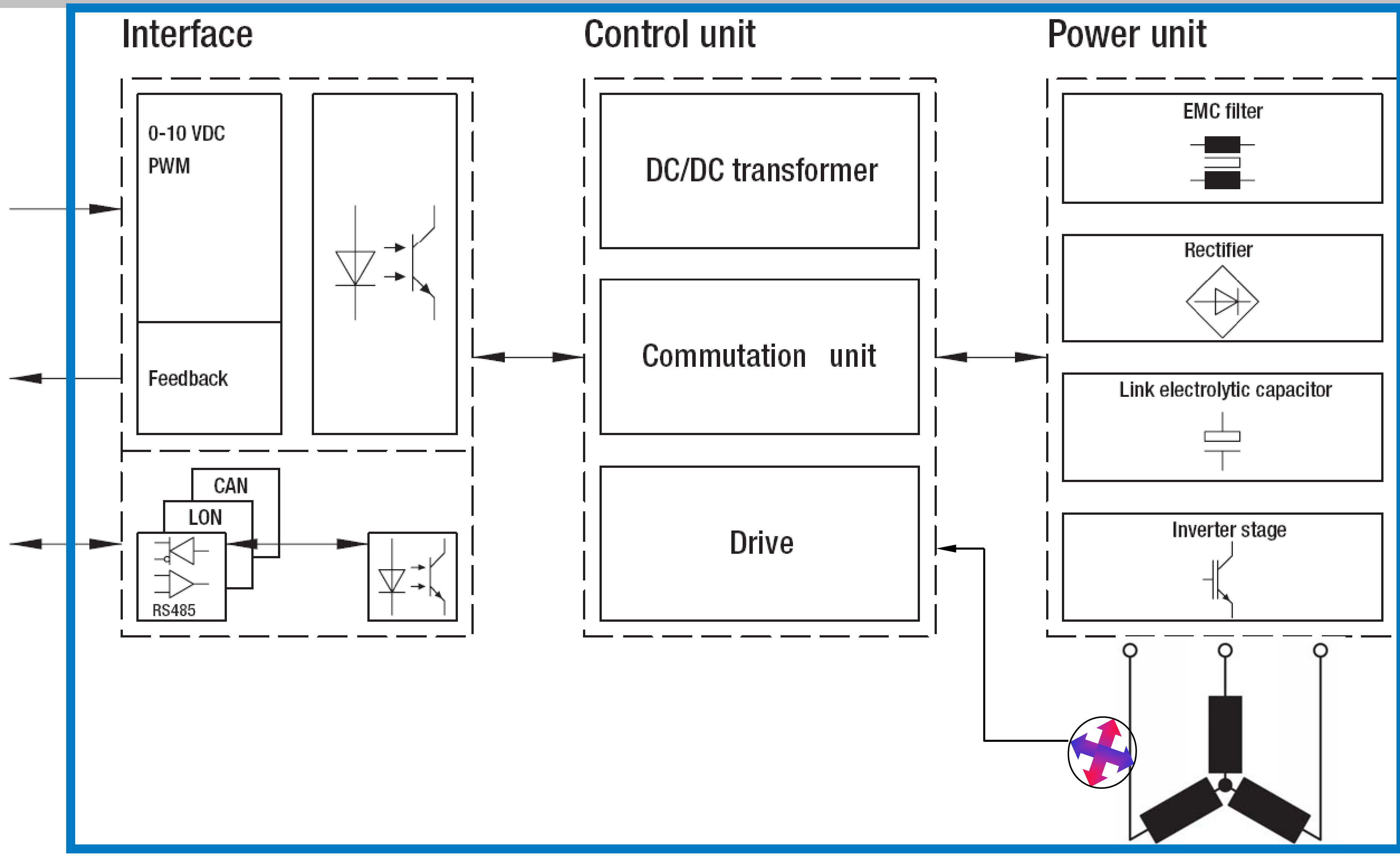


<u>Completely integrated in motor casing:</u>

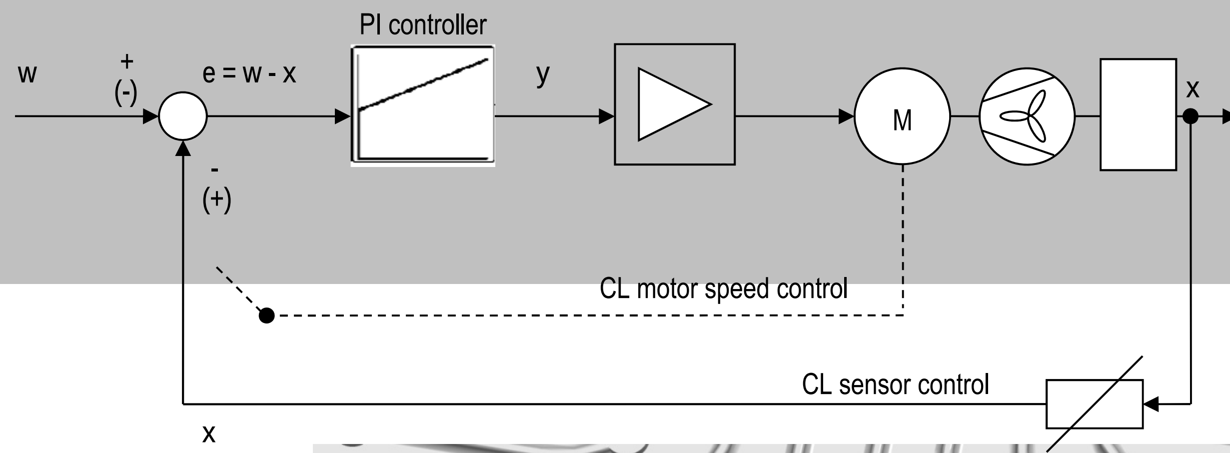
- Compatibility with the motor
- Line side filters for low emissions harmonics, radiofrequency & conducted noise
- Overload protection
- Low start-up current
- Low sound
- Simple hookup



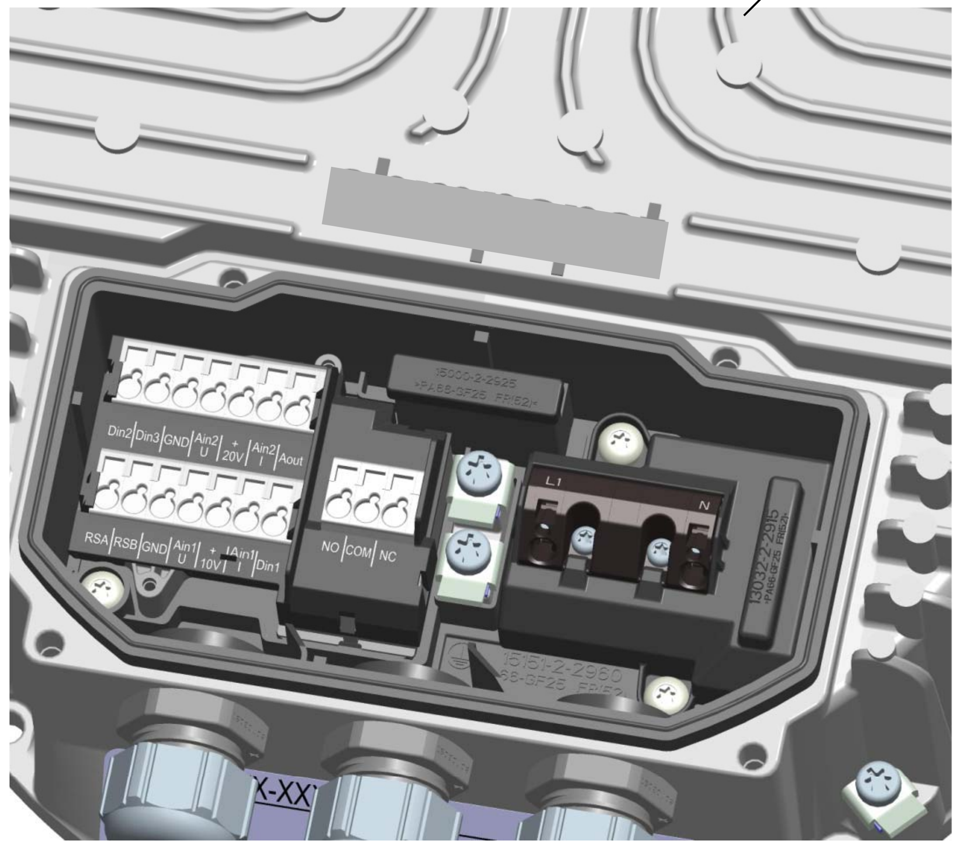
EC motor construction details
Power electronics / inverter drive



Controls

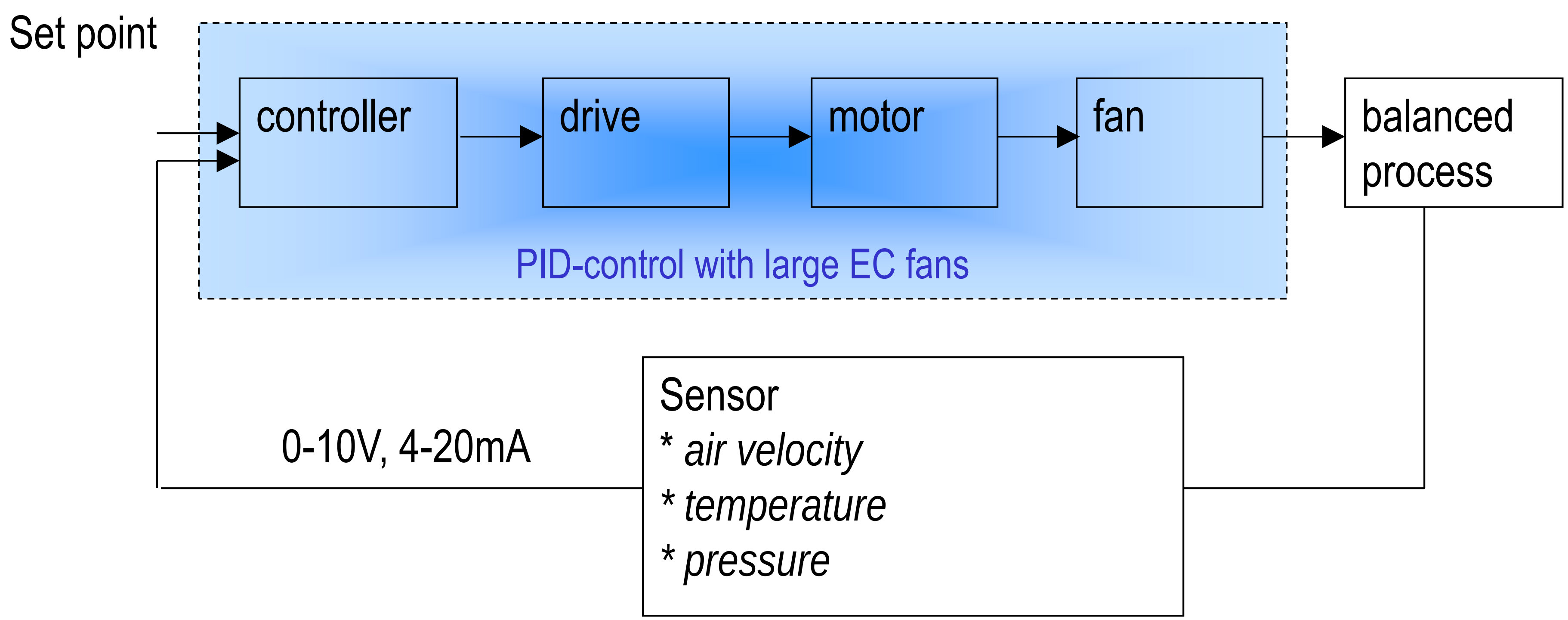


- Process control
  integrated PID loop
- 0-10V, 4-20mA, dry contact
- Modbus communication for commissioning + diagnosis from remote
- Sensor signal conversion from analog to DDC at no cost.
- Very detailed motor information for advanced load management
  smart grid



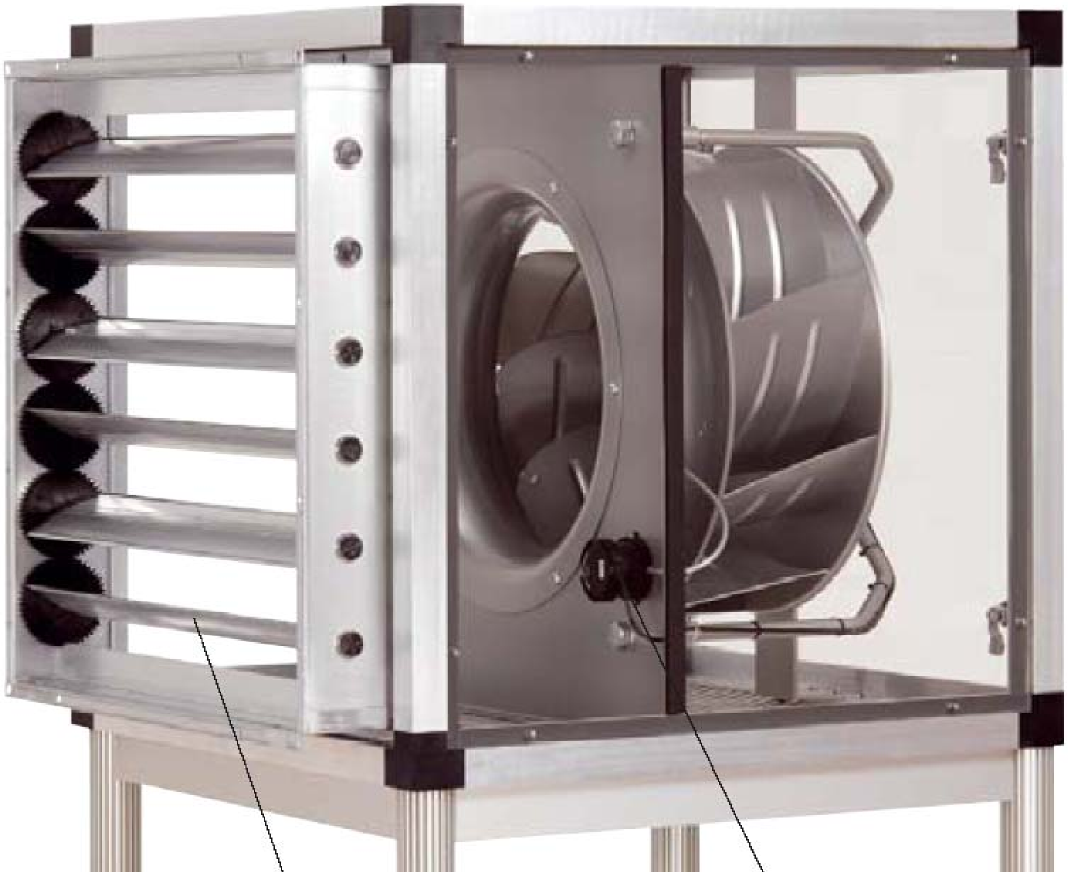
condenser wiring

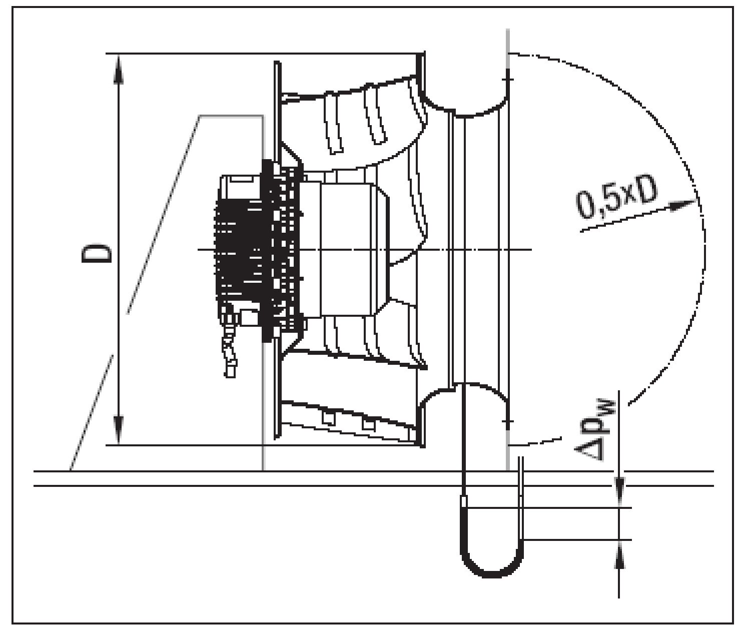
EC controllability



Closed loop sensor control

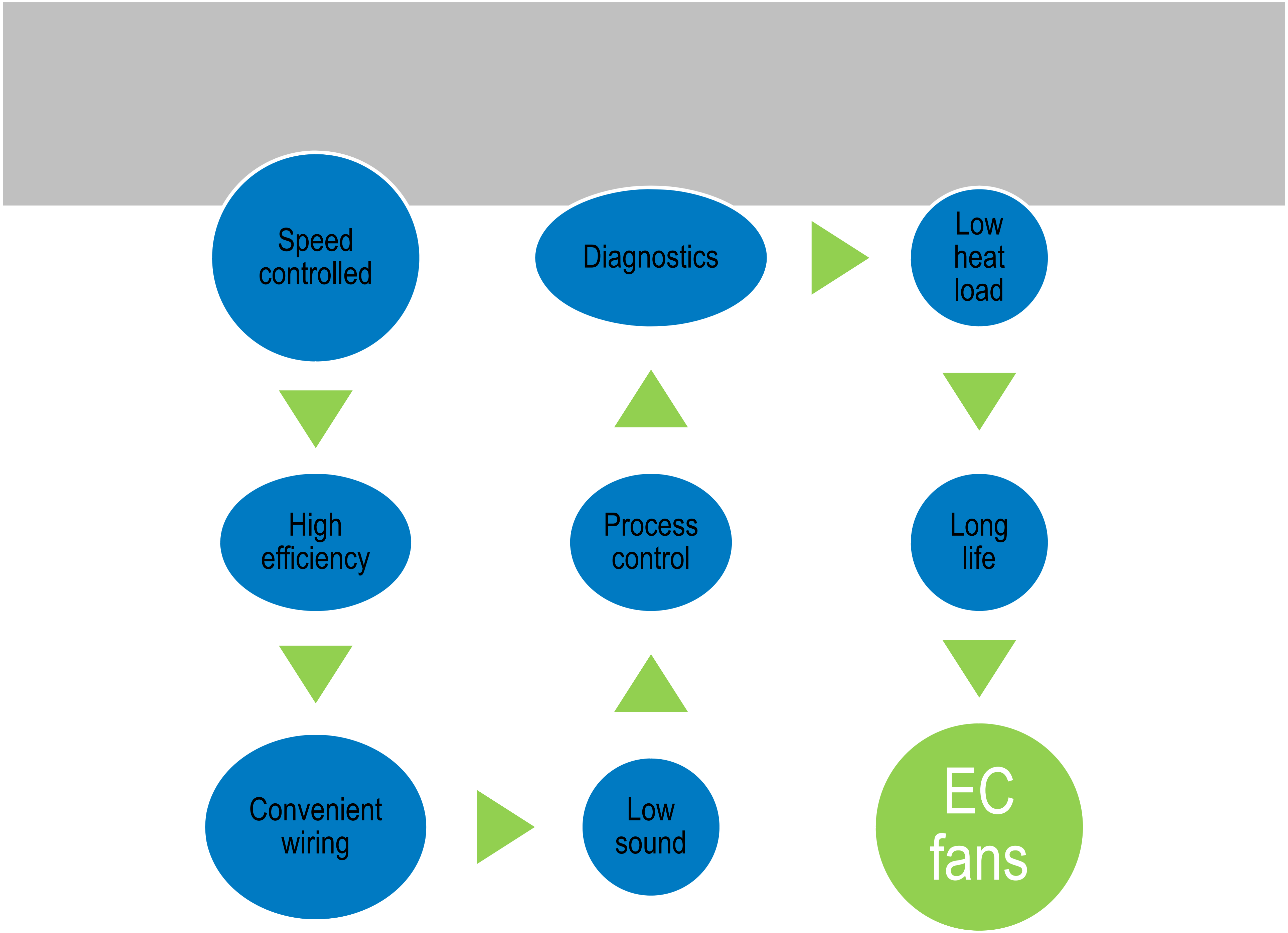
Constant flow control with backward curved fans

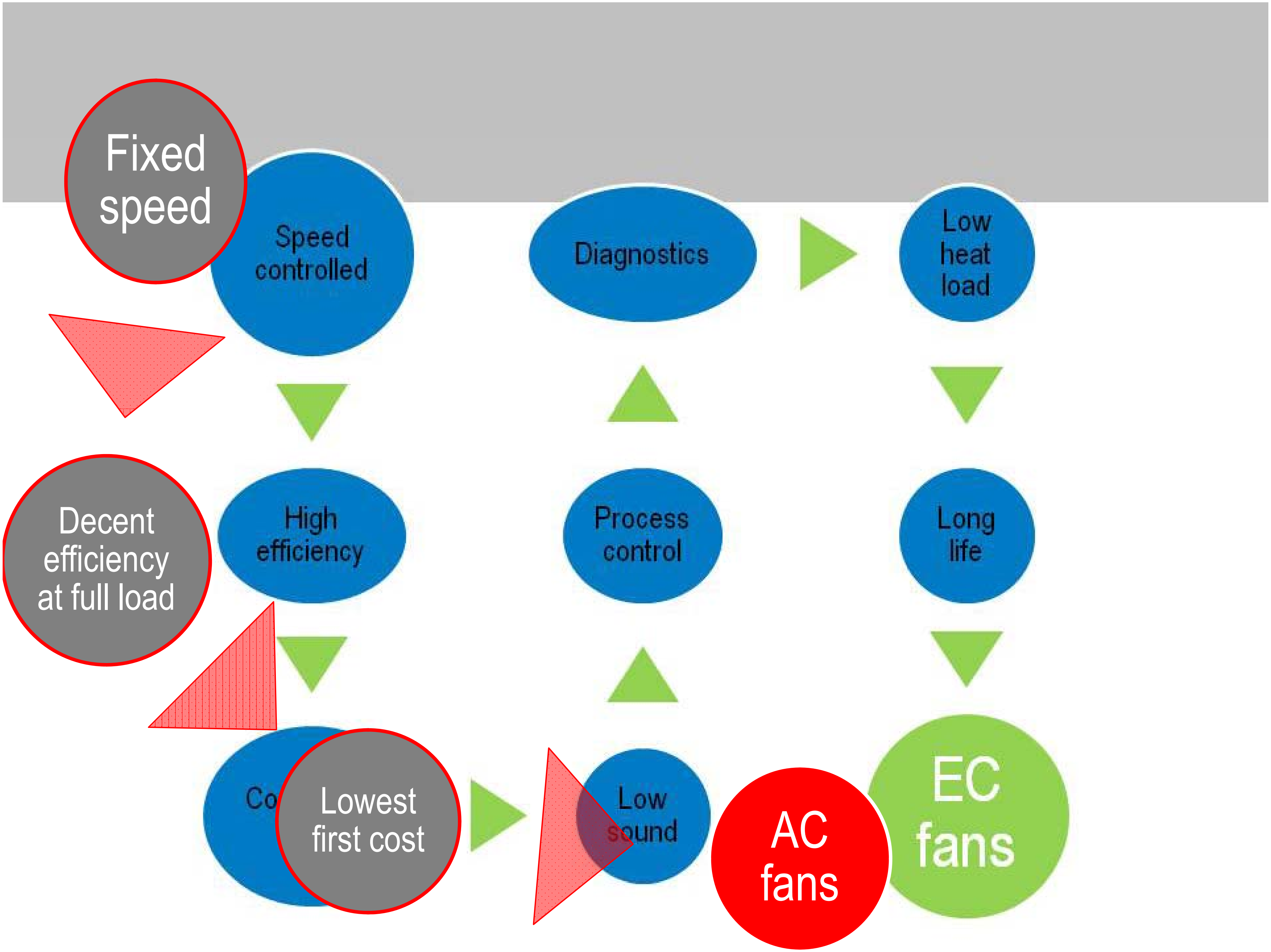




Louvers to demonstrate impedance change

Static pressure sensor


Speed controlled
High efficiency
Convenient wiring
Low sound
Process control
Diagnostics
Low heat load
Long life
EC fans



Fixed speed
Speed controlled
Diagnostics
Low heat load
Decent efficiency at full load
High efficiency
Process control
Long life
Lowest first cost
Low sound
AC fans
EC fans

Ordre du jour

- Pourquoi utiliser les moteurs EC dans les salles informatiques

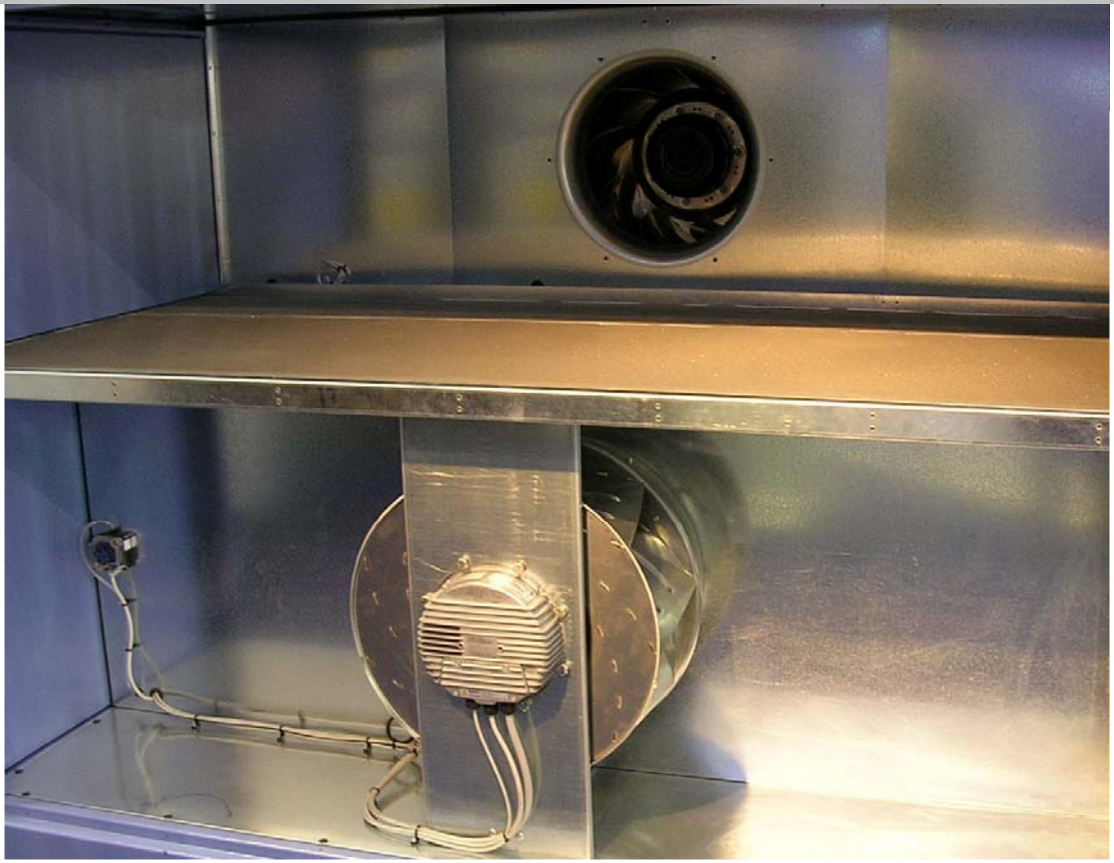
  'Why use ECM motors in data center application'
- Les mesures de performance d'une salle informatique

  ' How to mesure efficiency in data center applications'
- Explication de la technologies des moteurs EC

  'Explaining the technology of EC motors'
- Application de la technologies EC dans différentes applications
  - ' Applying the EC technology in different application'

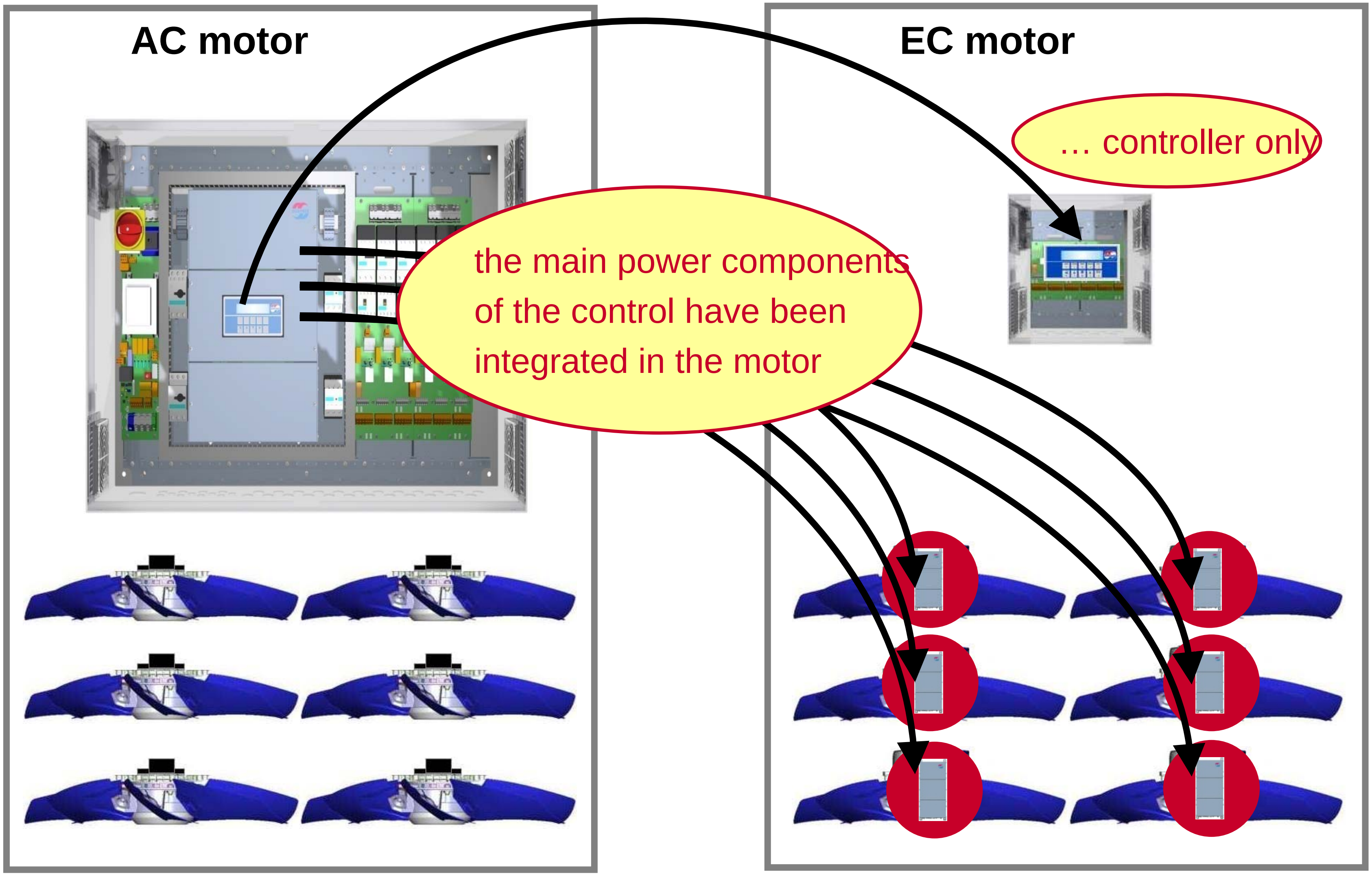
Air handlers

Key features of EC technology

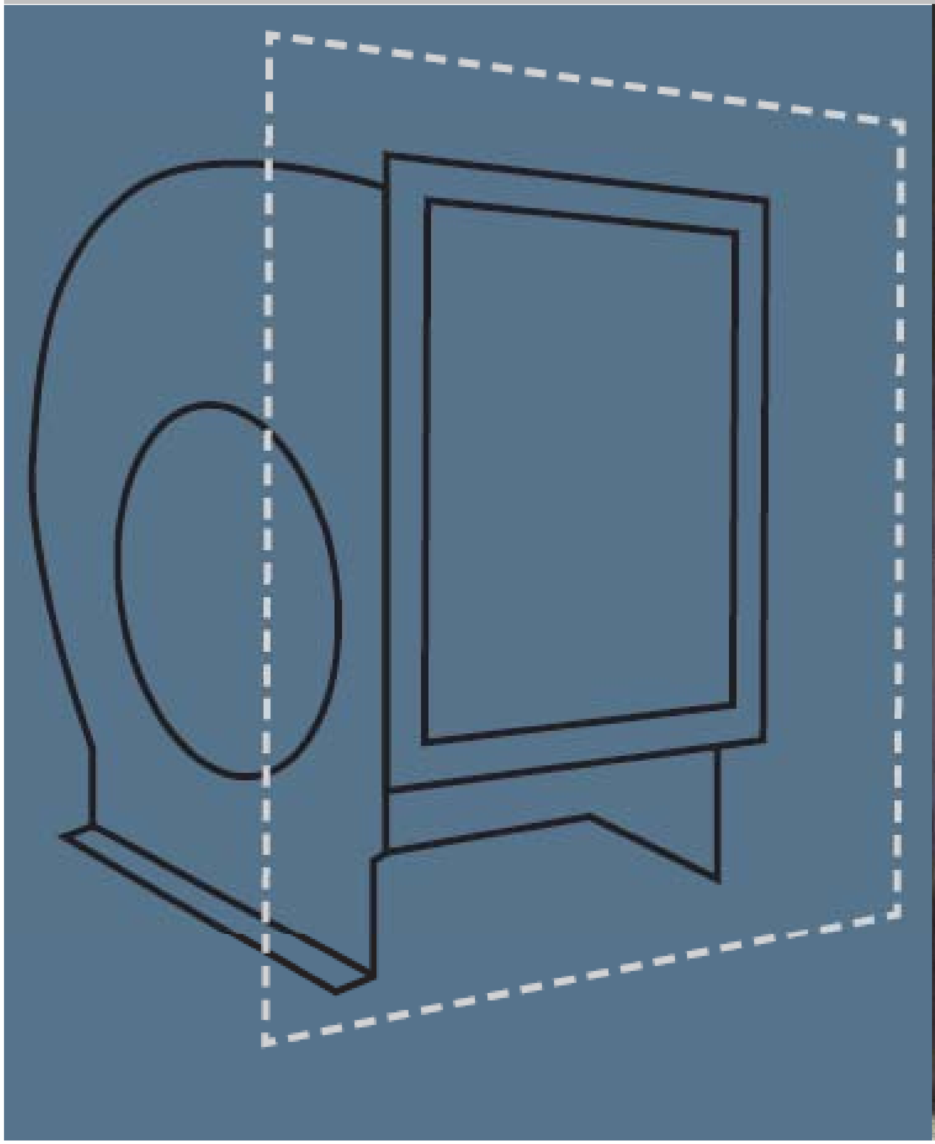


- Space
- Simplicity

Comparison AC+EC motors speed controller

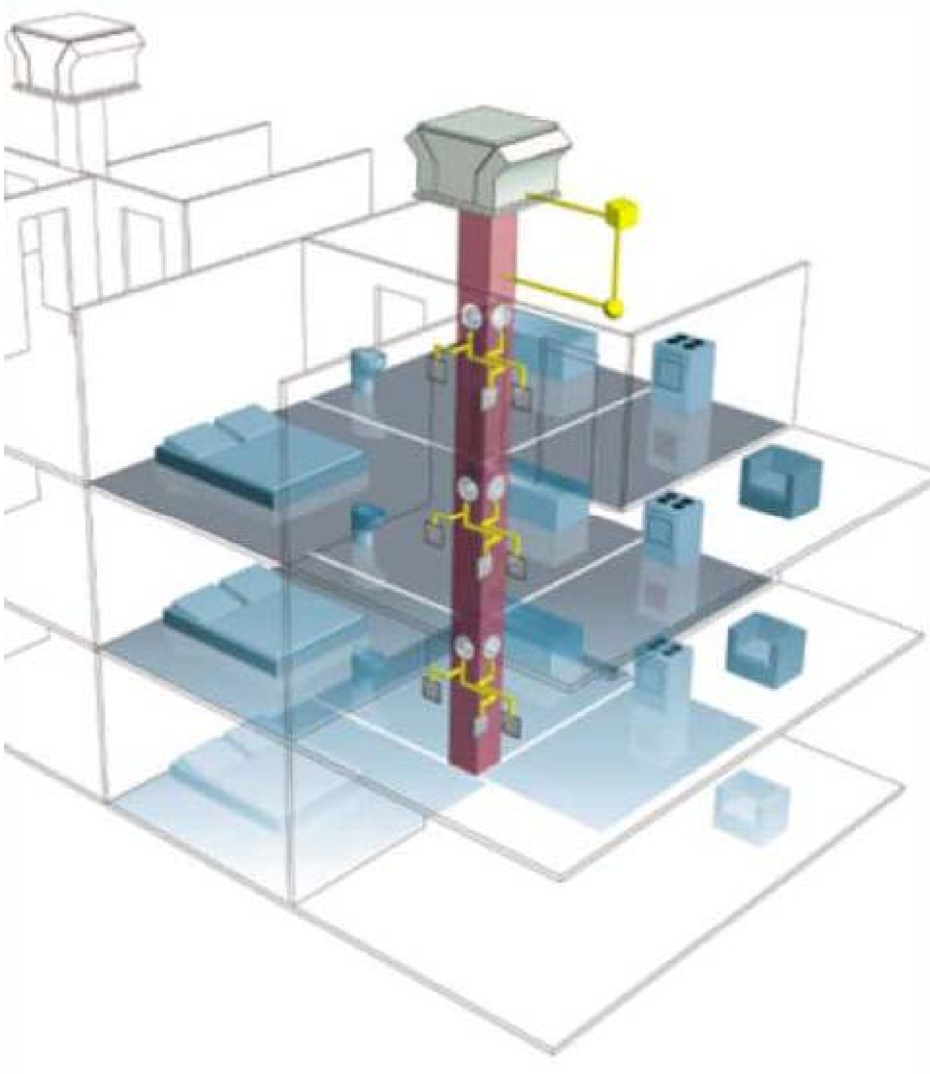


Fan array



Ventilation
with closed loop pressure control

Key features of EC technology



- •Controllability
- •Low noise
- •Efficiency

Condensing boilers

Key features of EC technology

- •Controllability
- •Low noise
- •Supersynchronous speed

Cleanroom manufacturing

ceiling filter units with active power factor controller (PFC)

Key features of EC technology

- Individual diagnostics
- Individual control input
- Electromagnetic compatibility
- Low current, also at startup

Current: -50%   Power: -30%   Harmonics: none

Air-cooled condensers

Key features of EC technology

- •Lowest noise
- •Easy to wire up
- •Head-pressure control
- •Reliability
- •Weatherized motor
- •Highest motor efficiency at all speed

Walk-in coolers, display cases

Key features of EC technology

- Efficiency, lowest heat load
- Reliability

Vending machines, coolers

Key features of EC technology

- Efficiency, lowest heat load
- Low sound

Questions

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