Consideration of system approaches for motors and motor-driven units: rationale and implementation challenges

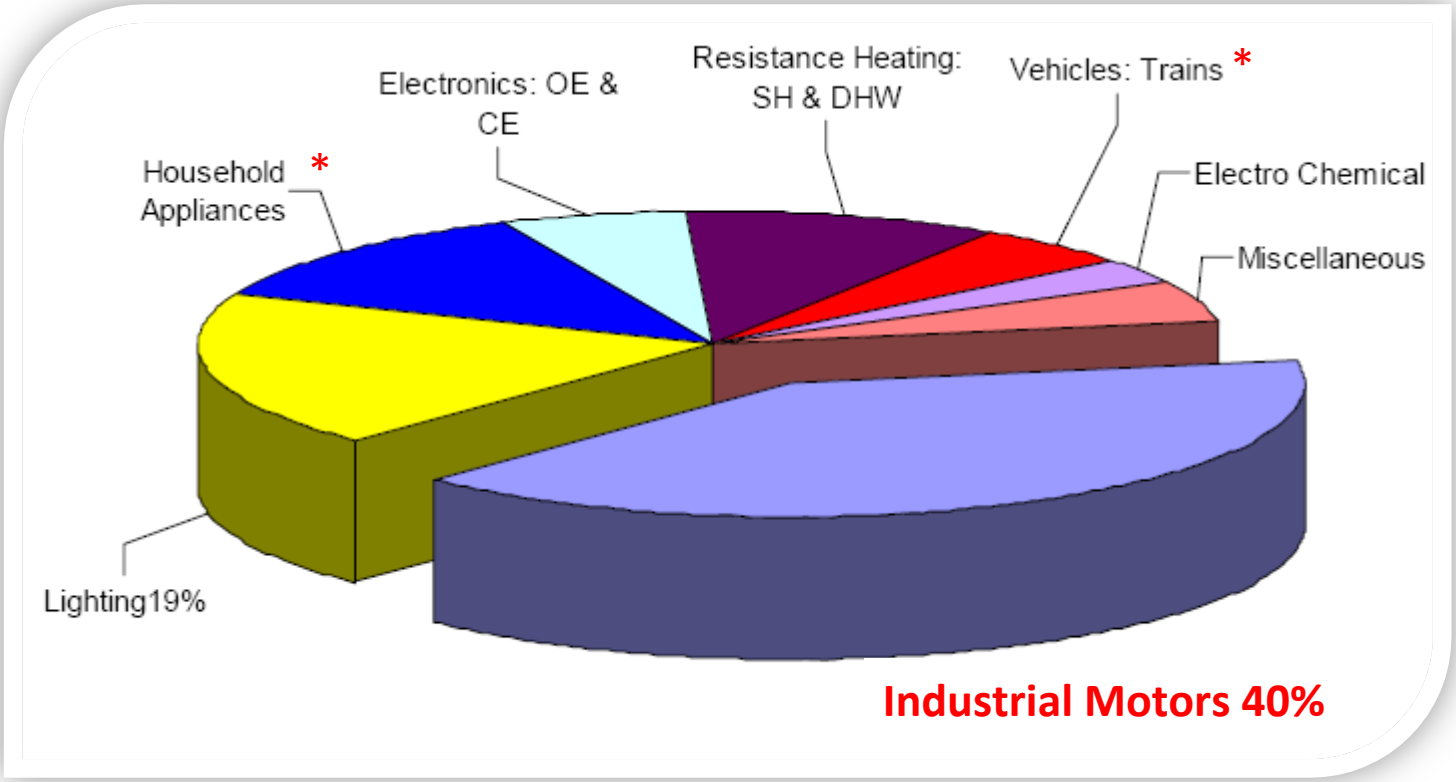
Anibal De Almeida

ISR – University of Coimbra

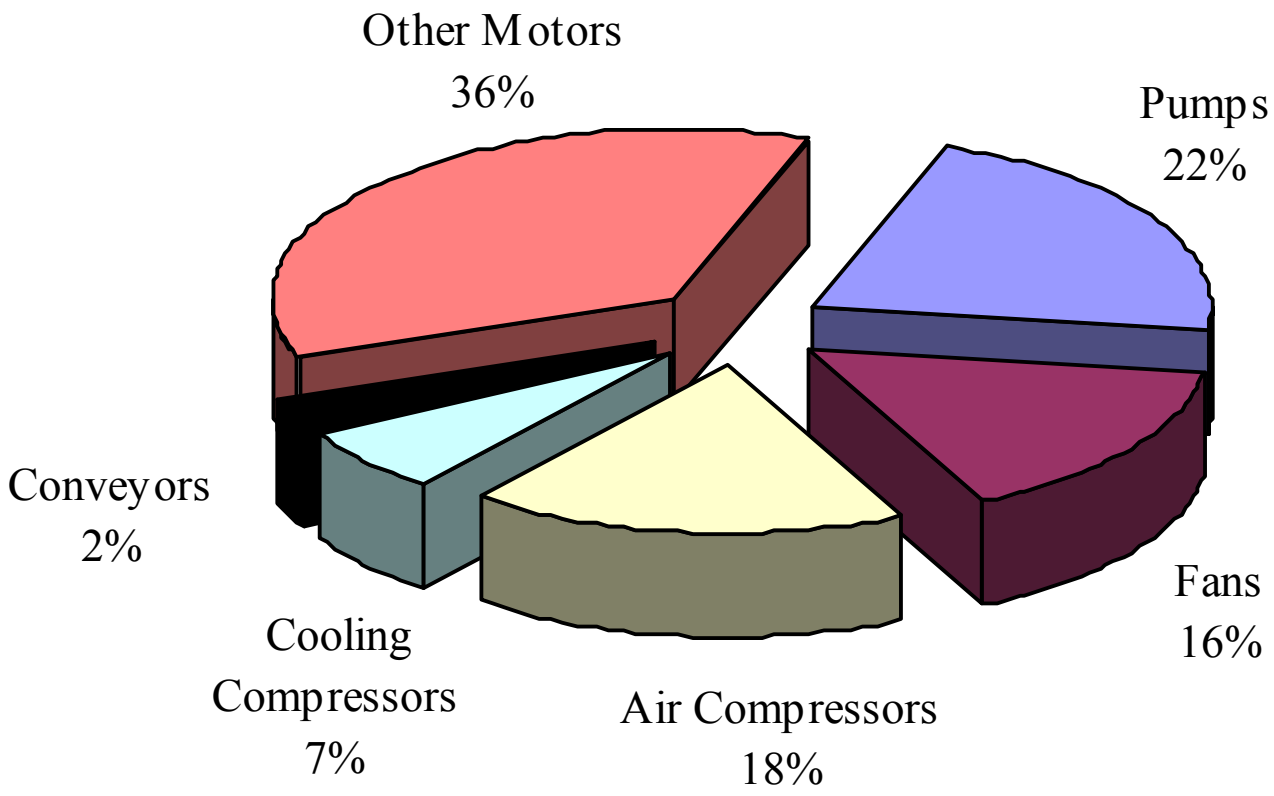
Motor System Energy Use

Global Electricity demand by end-use

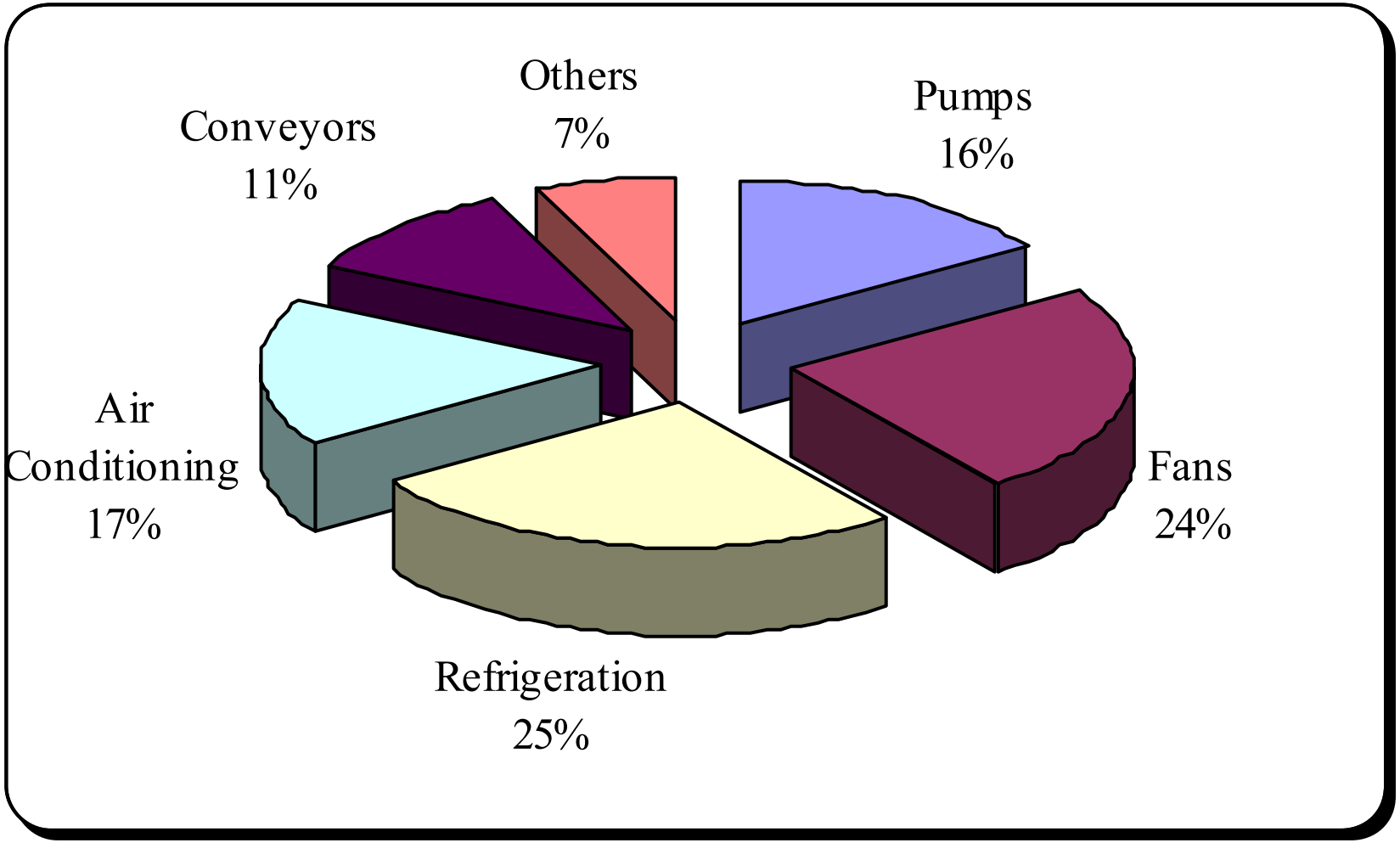
Source: A+B International 2008



Disaggregation of motor electricity consumption by end-use, in the Industrial sector



Disaggregation of motor electricity consumption by end-use in the Tertiary sector



Motrs Regulation 640/2009

In Regulation 640/2009 “electric motor” is defined as a single speed, three-phase 50 Hz or 50/60 Hz, squirrel cage induction motor that:

- **has 2 to 6 poles,**
- **has a rated voltage of U_N up to 1 000 V,**
- **has a rated output P_N between 0,75 kW and 375 kW,**
- **is rated on the basis of continuous duty operation.**

LOT 30 -Scope of Study

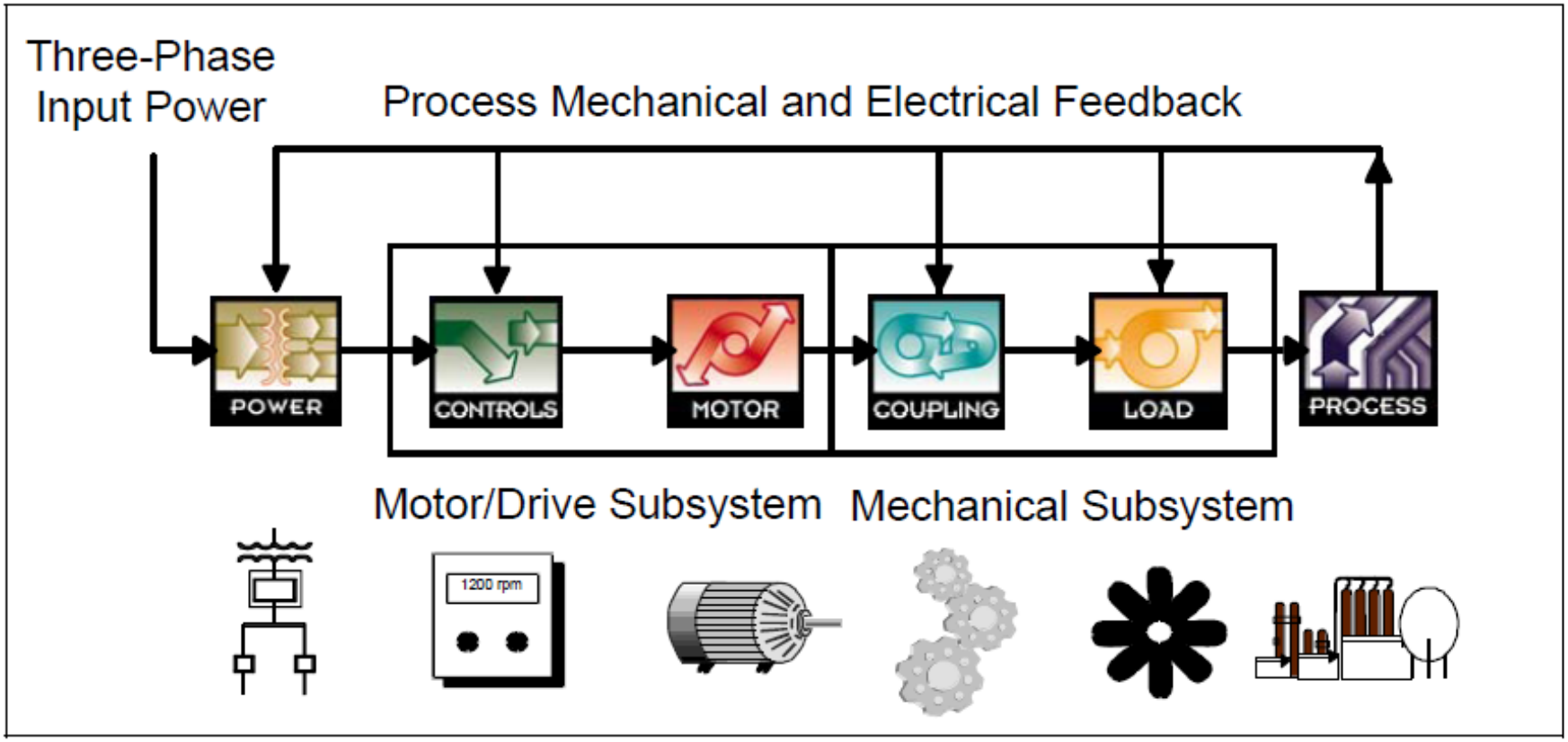
Included in the study are motors not included in Regulation 640/2009, that:

- are capable of continuous duty operation, i.e., motors capable of continuous operation at their rated power with a temperature rise within the specified insulation temperature class
- are integrated into other equipment but that can be tested separately
- have a rated power P_N from 0,12 kW to 1000 kW

LOT-30 Scope of Study

- VSDs
- Soft-Starters
- Electro-mechanical starters

Motor System

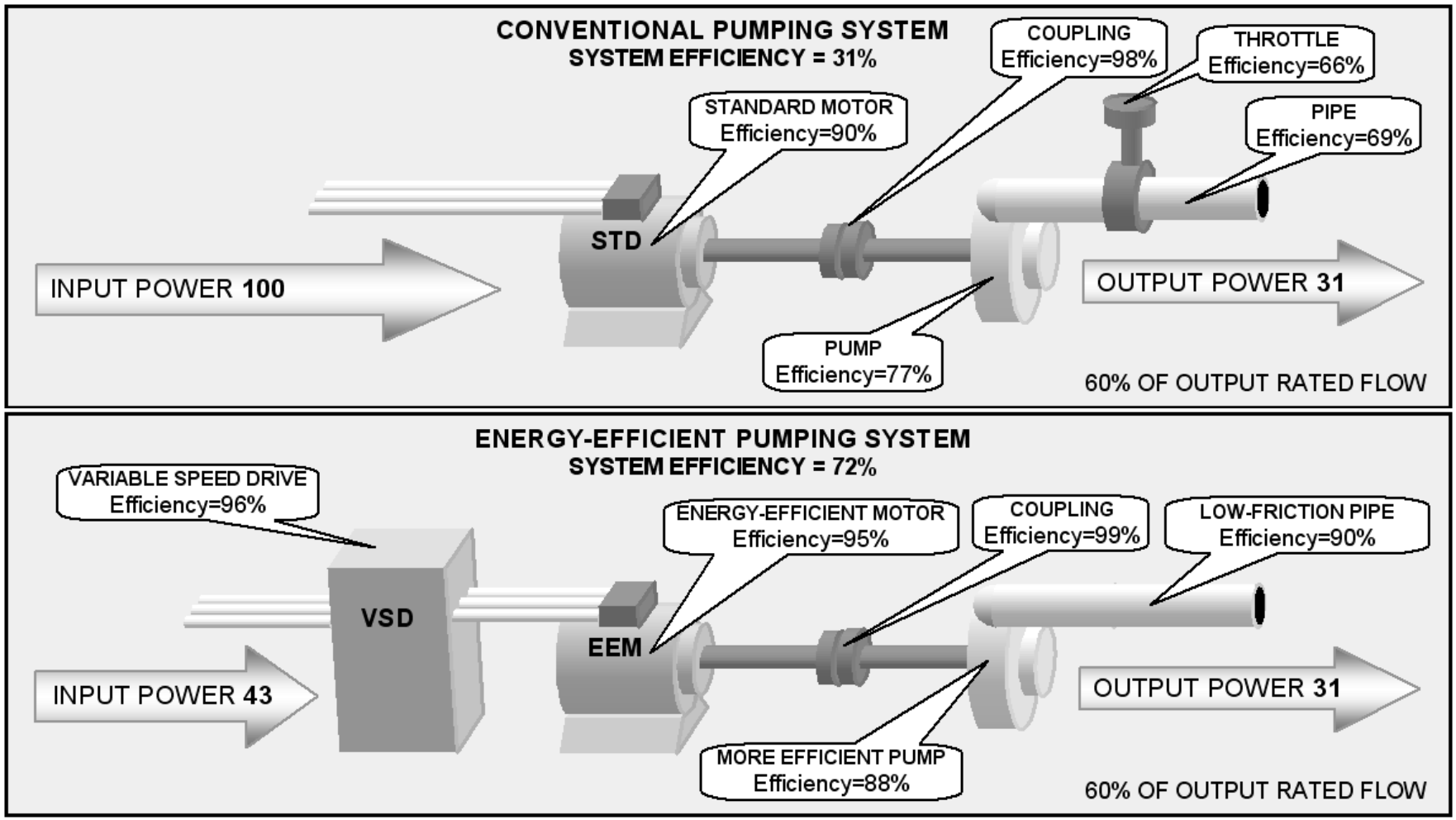


Motor Systems Energy Use

The efficiency of a motor system depends on several factors, including:

- motor efficiency
- motor speed/torque control
- proper sizing
- power supply quality
- distribution losses
- mechanical transmission
- maintenance practices
- end-use mechanical efficiency (pump, fan,
- compressor, etc).

Pump System Efficiency



Benefits of Motor System Optimization

- Cost reduction;
- Improved operational reliability and control;
- Ability to increase production without requiring additional, and possibly constrained, energy supply;
- Avoidance of capital expenditures through greater utilization of existing equipment assets;
- Recognition as a “green company”

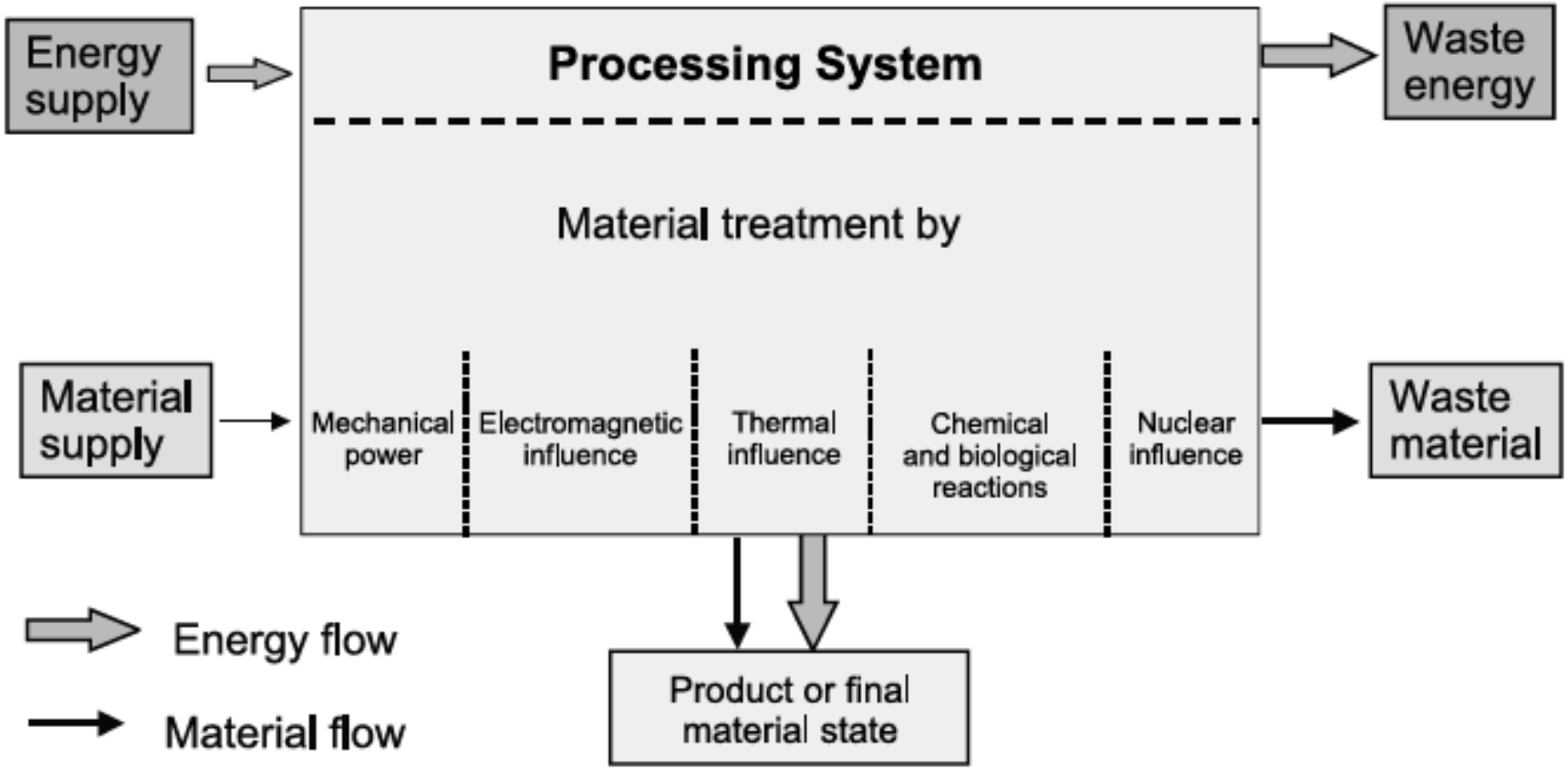
Information, behavioural organisational and market barriers

- Companies have limited knowledge and access to information about new and existing energy saving technologies.
- Companies may perceive technical and operational risks of implementing energy efficiency projects due to unfamiliarity with energy-reducing technologies and practices relative to core business projects.
- Professional and functional boundaries within the organisation limit the collaboration required to identify and support energy efficiency
- Energy prices and taxes are subsidised in some countries in the industrial sector; therefore, companies may not pay the full cost of their energy use and have less incentive to reduce consumption.

Financial Barriers

- Investments in energy efficiency projects do not meet financial criteria within companies (especially in countries where interest rates are high)
- Companies lack access to capital
- Investments impose too high a risk due to lack of familiarity with energy-savings projects relative to core business projects and difficulty in predicting future energy prices.
- Businesses like to use capital and resources to grow and expand their business. When they want to reduce costs, they want to do so without spending too much capital. Companies will often only fund projects with an 18-month to two-year payback or less, unless it has a productivity or growth outcome as well.

Variables in Processing Systems

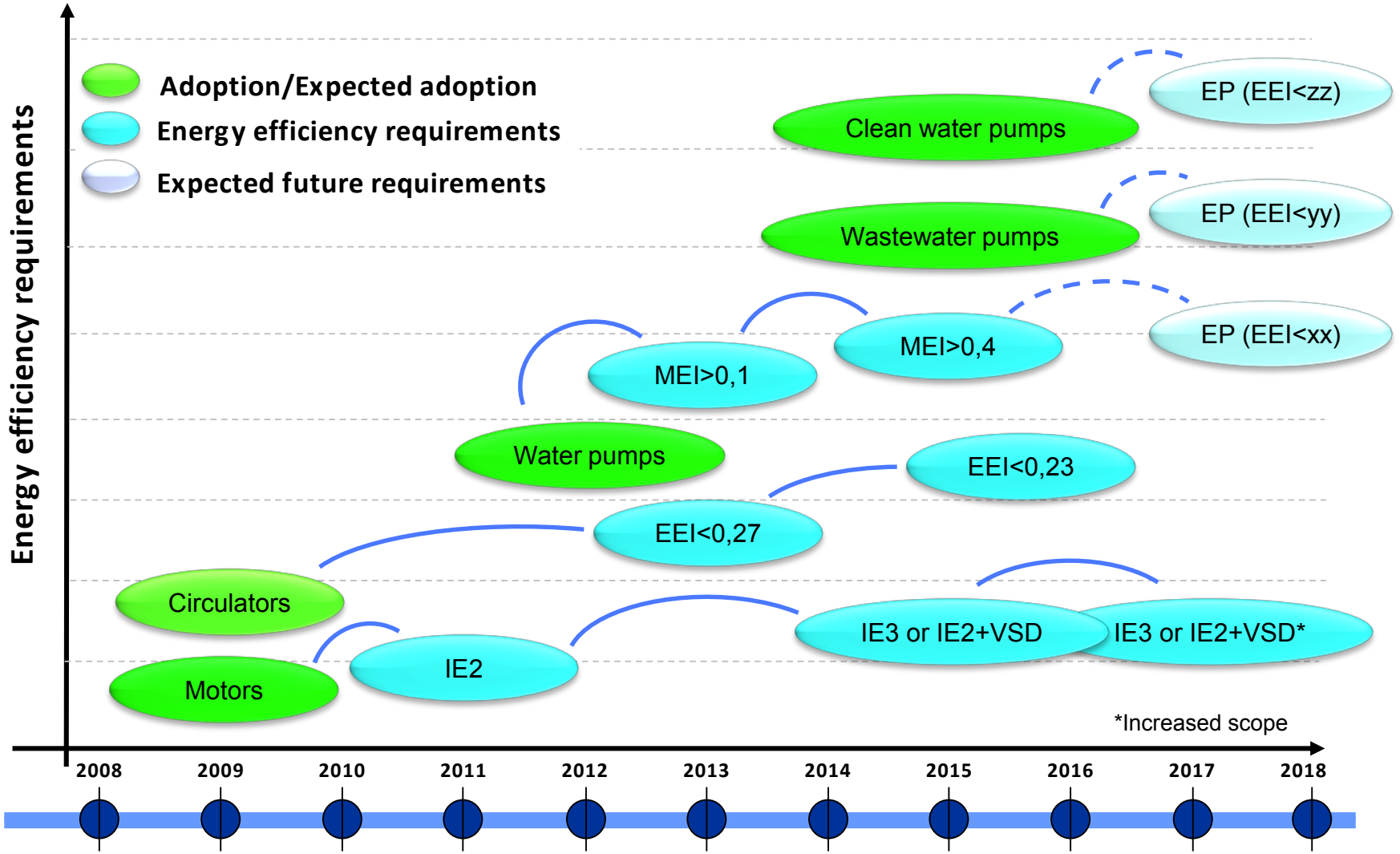


EcoDesign Directive

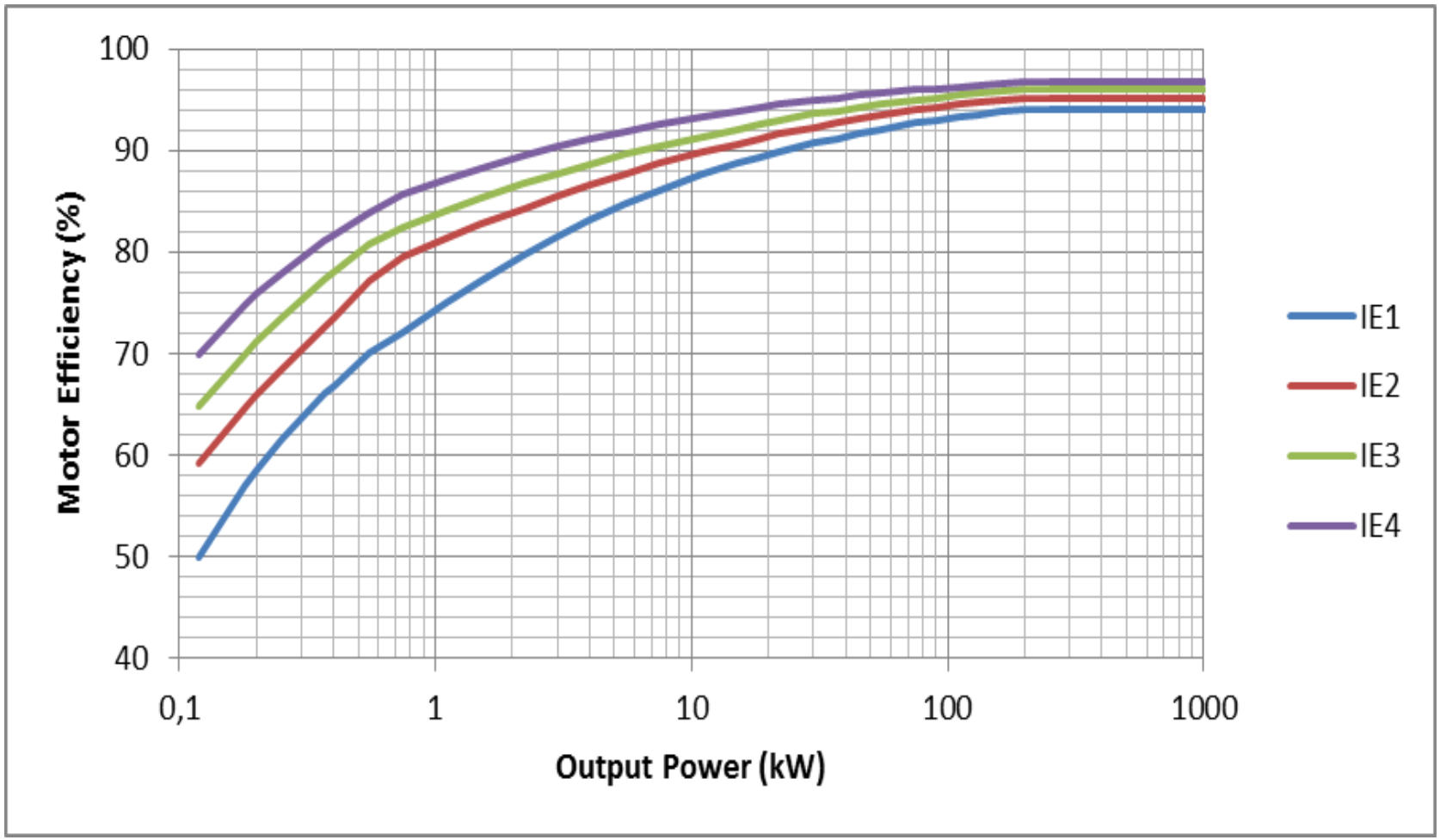
The MEErP methodology foresees three levels for the analysis of the environmental and resources impacts during the use phase for ErP with a direct energy consumption effect:

- Individual product
- extended product (e.g. product + controls)
- technical systems (how the performance of the product influences the performance of the broader system it is included in) and functional system

Summary of EuP/ErP legislation and ecodesign requirements concerning pumps and motors

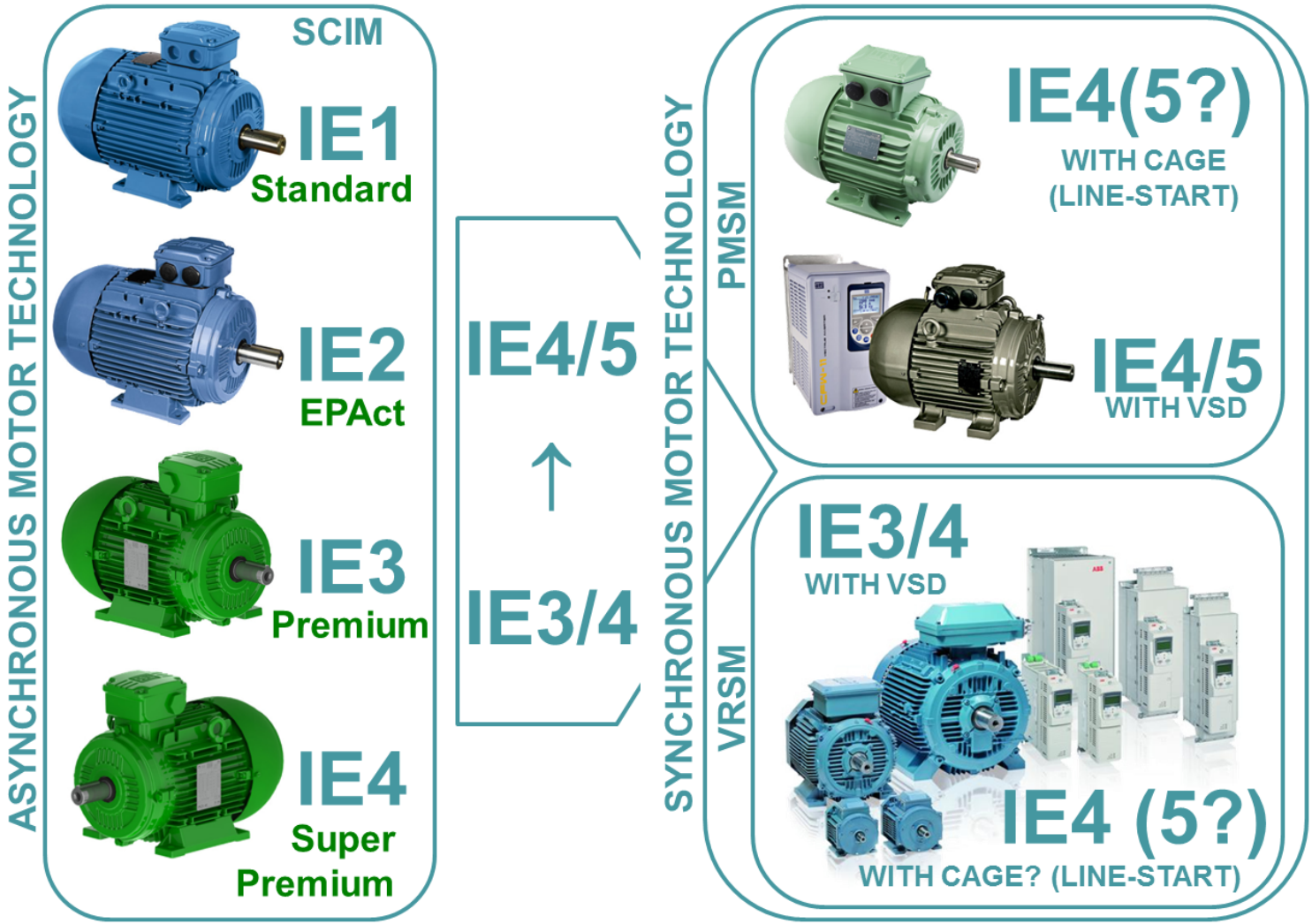


Motor Classes

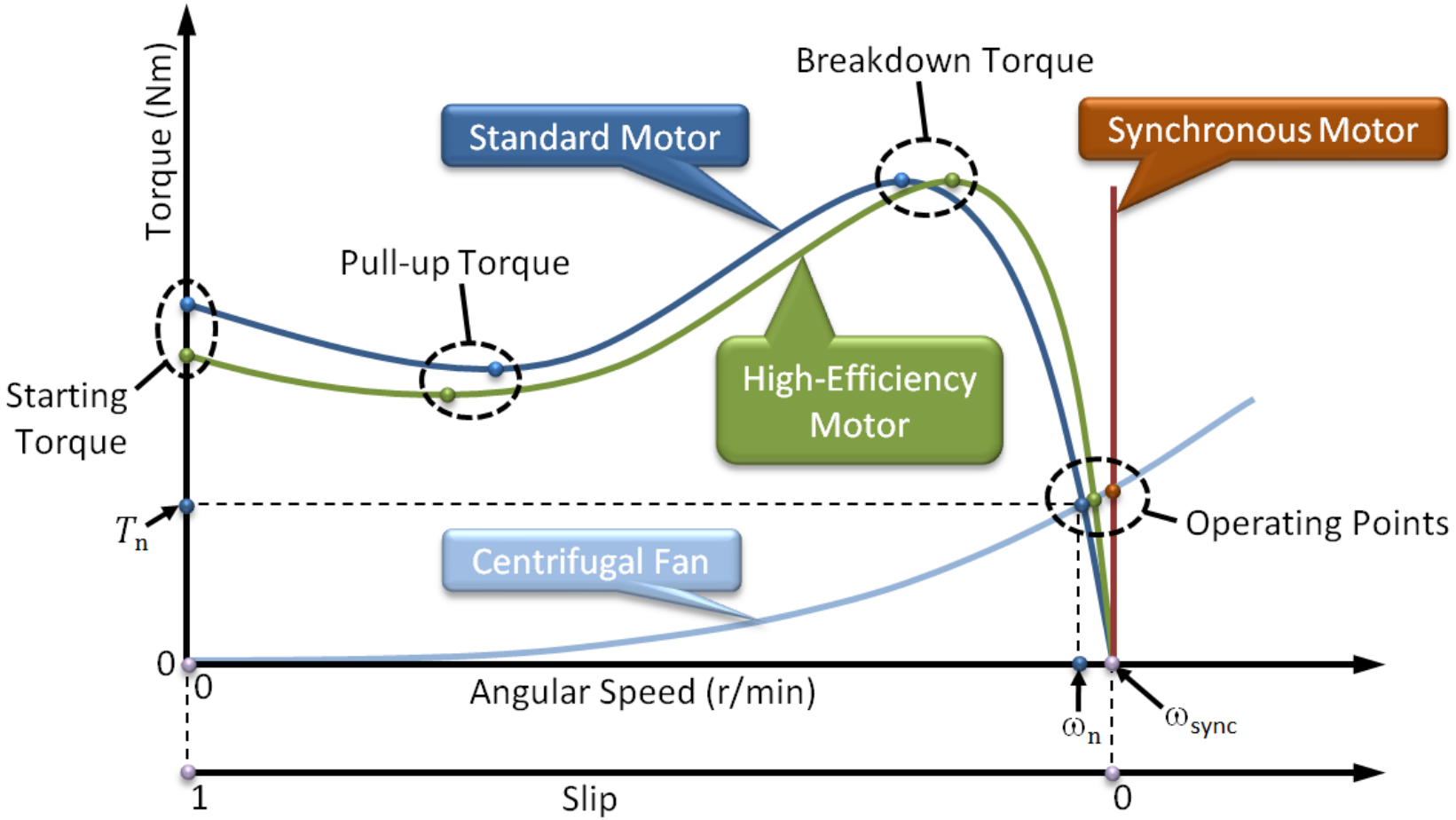


Source: IEC 60034-30-1 (CDV)

IEC-NEMA Commercial Motor Technology Classes

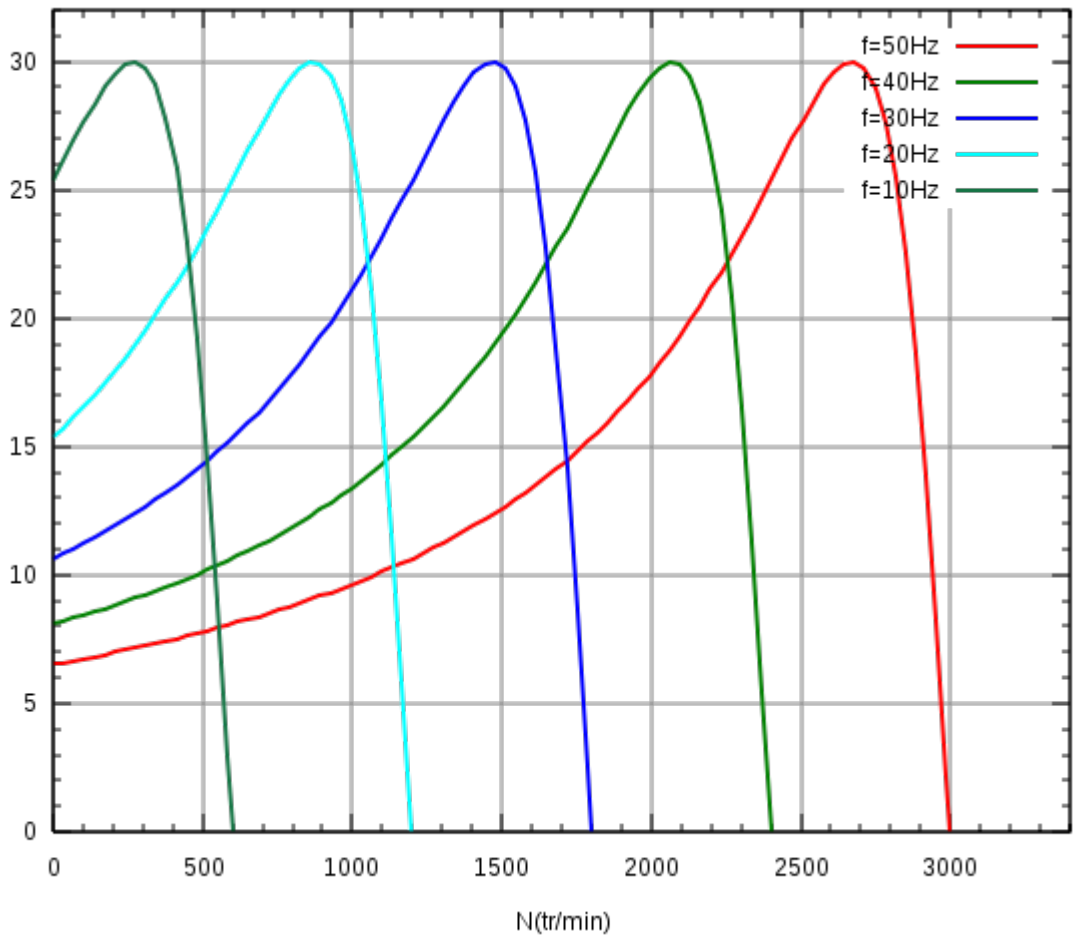


IMPACT OF MOTOR SPEED ON OPERATING POINT

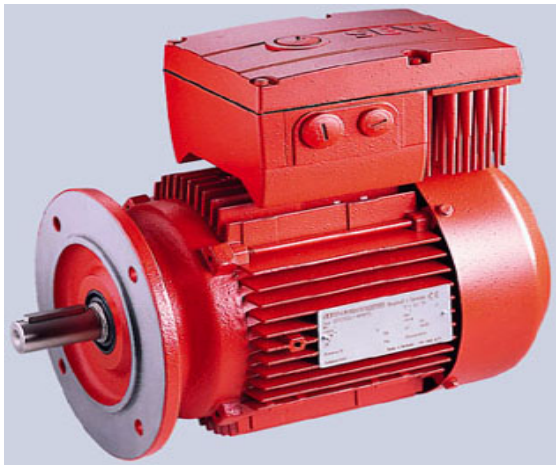


O menor deslizamento pode conduzir a um aumento do consumo !!

Variable Speed Drives – VSDs







VARIABLE SPEED DRIVES - ADVANTAGES

-HIGH EFFICIENCY (96-98%) AND HIGH RELIABILITY;

-HIGH POWER FACTOR (IF CONTROLLED RECTIFIER IS USED);

-SMALL SIZE;

-EASY-TO-USE;

- IMPROVEMENT OF THE DYNAMIC PERFORMANCE OF INDUCTION MOTORS;

- MOTOR-LOAD ADJUSTMENT;

- SOFT STARTING (SAVINGS!) AND CONTROLLED/REGENERATIVE BRAKING;

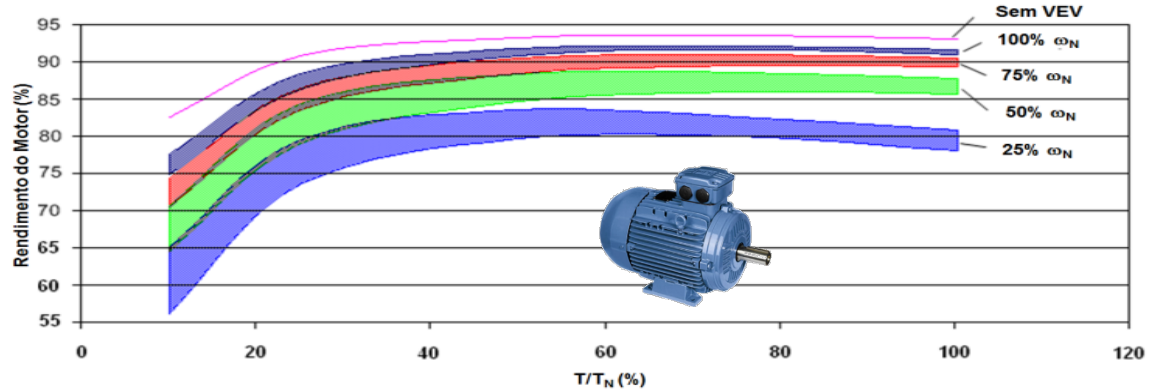
-MOTOR PROTECTION FEATURES;

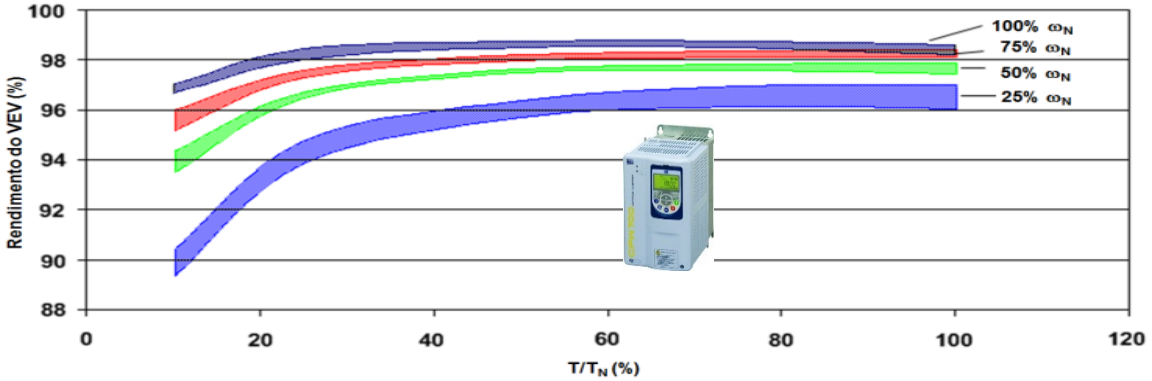
-SAVINGS ASSOCIATED TO THE SPEED CONTROL;

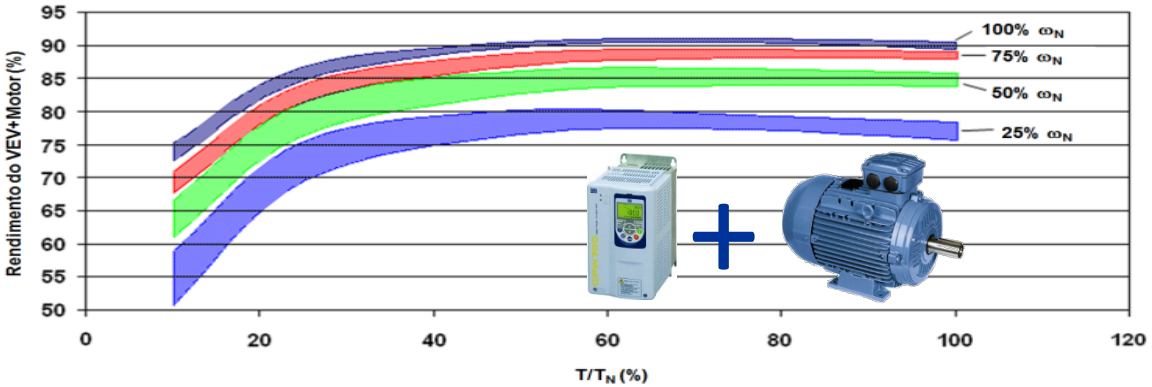
-LOWER ACCUSTIC NOICE AND IMPROVEMENT OF THE PROCESS CONTROL;

-LESS WEAR OF THE MECHANICAL COMPONENTS.

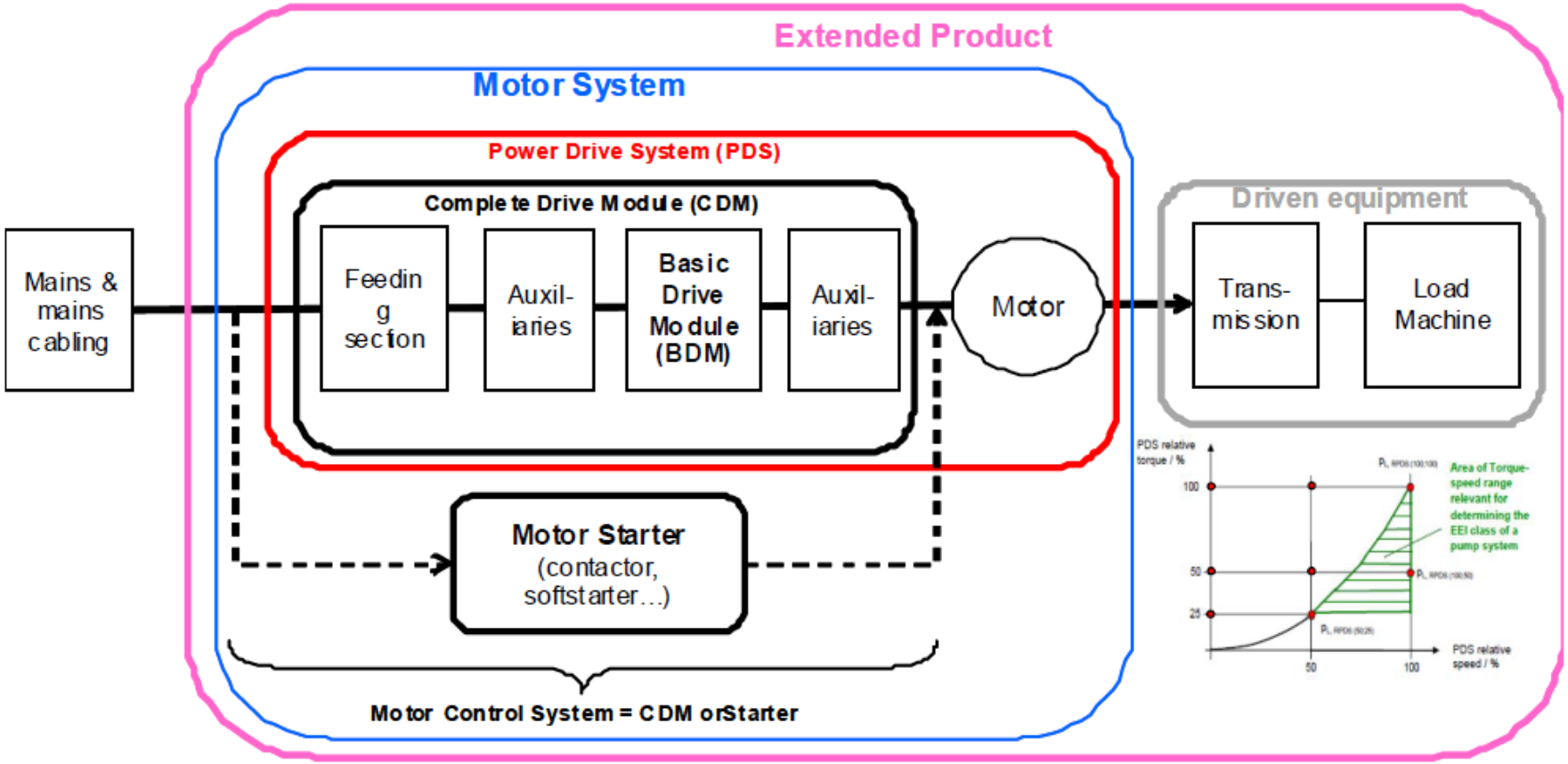
EFFICIENCY OF MOTOR, VSD AND MOTOR+VSD UNITS







Extended Product



EN 50598

New standard being developed by CENELEC TC22X Technical Committee:

EN50598 *Parts 1-2-3: International Standard: Energy efficiency for Power drive systems, motor starters, power electronics and their driven applications.*

EN 50598

- **EN 50598-1**: Procedure for determining the energy efficiency indicators of motor driven applications by using the extended product approach and semi analytical models
- **EN 50598-2:** Energy efficiency indicators for Power drive systems and Motor starters
- **EN 50598-3:** Environmental aspects and product declaration for Power drive systems and Motor starters

Energy Saving VSD Applications

1. Centrifugal pumps, fans and compressors in which torque increases with the square of the rotating speed of the motor.
   The electric power sharply increases with the speed (up to the cube) and a smooth adaptation to the real need can lead to large savings.
2. Conveyors, escalators, hoists, cranes and similar types of equipment where the torque is more or less independent from speed.
   The cost and energy efficiency benefits are smaller compared to the first group of applications because the change of input power is only linear with the speed. Regenerative braking can lead to additional savings.

EUROPEAN GUIDE TO PUMP EFFICIENCY FOR SINGLE STAGE CENTRIFUGAL PUMPS

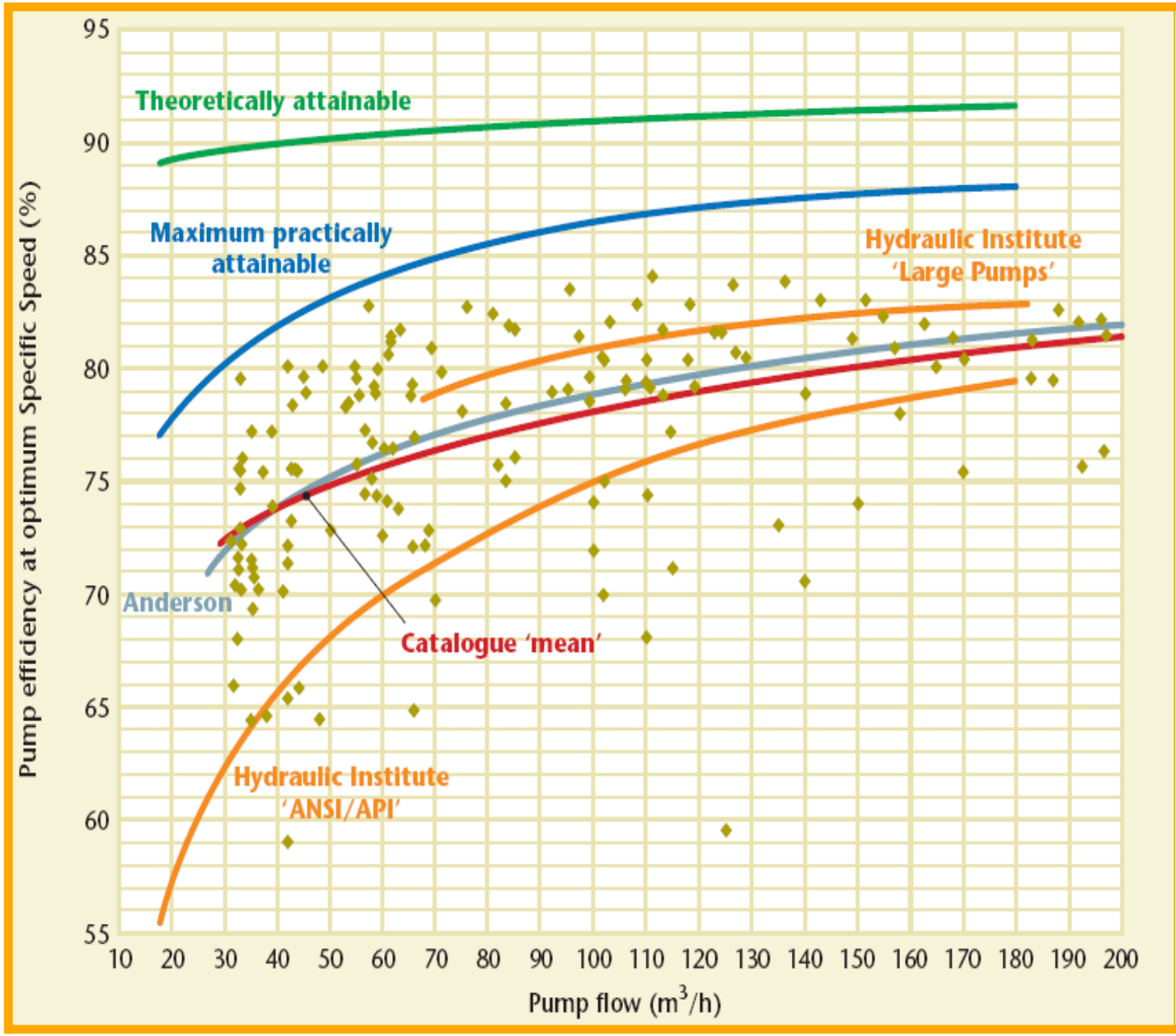


Figure 9: Comparison of efficiencies of end suction pumps from various sources.

PUMPS - Scope and exclusions Regulation 547/2012

Clean water duty only

- End suction water pumps (ESOB, ESCC, ESCCi)



- Vertical multistage water pumps

- Submersible multistage pumps



Pumps with special features excluded







EC Energy Using Products Lot 29: What is in scope?



>150 kW clean water pumps



>150 kW borehole pumps



Swimming pool pumps



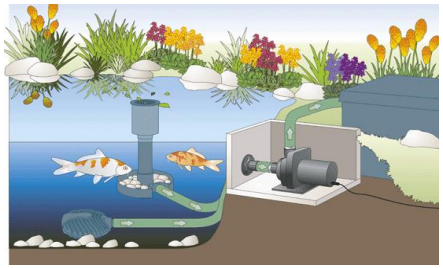
Aquarium air pump



Aquarium water pump

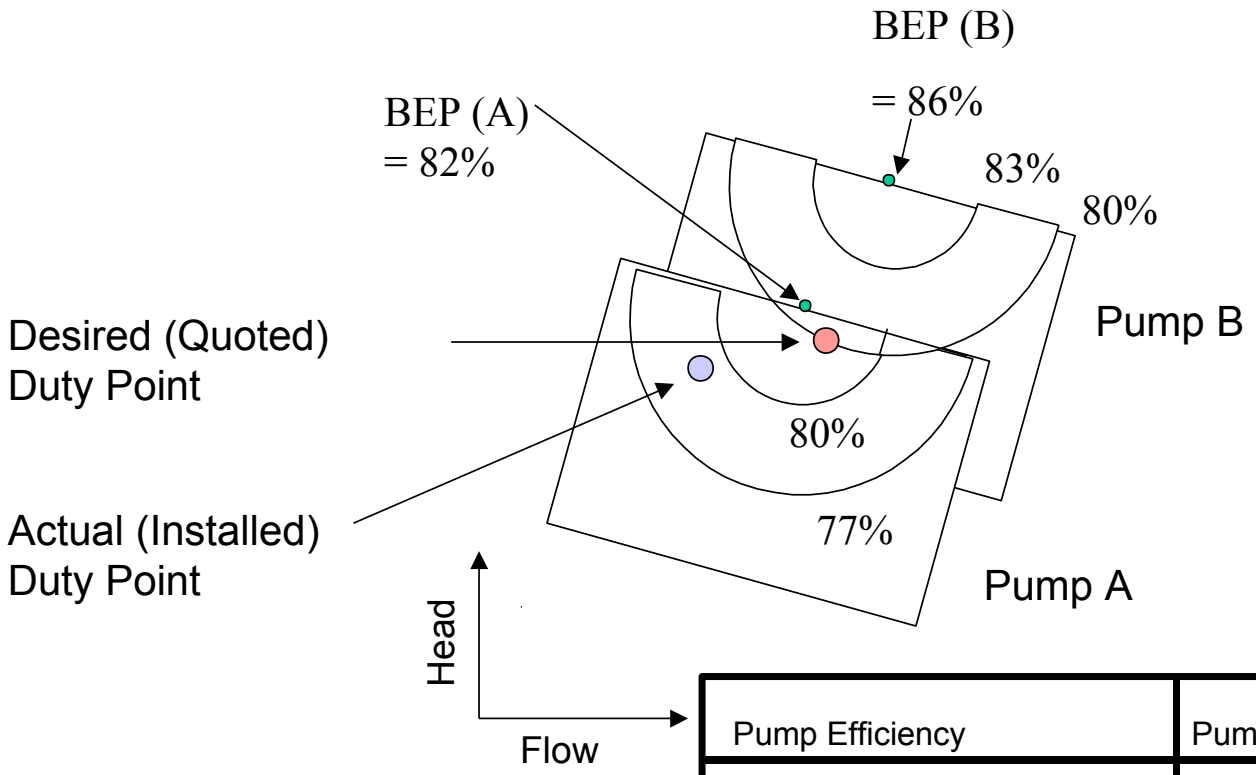


Fountain pump



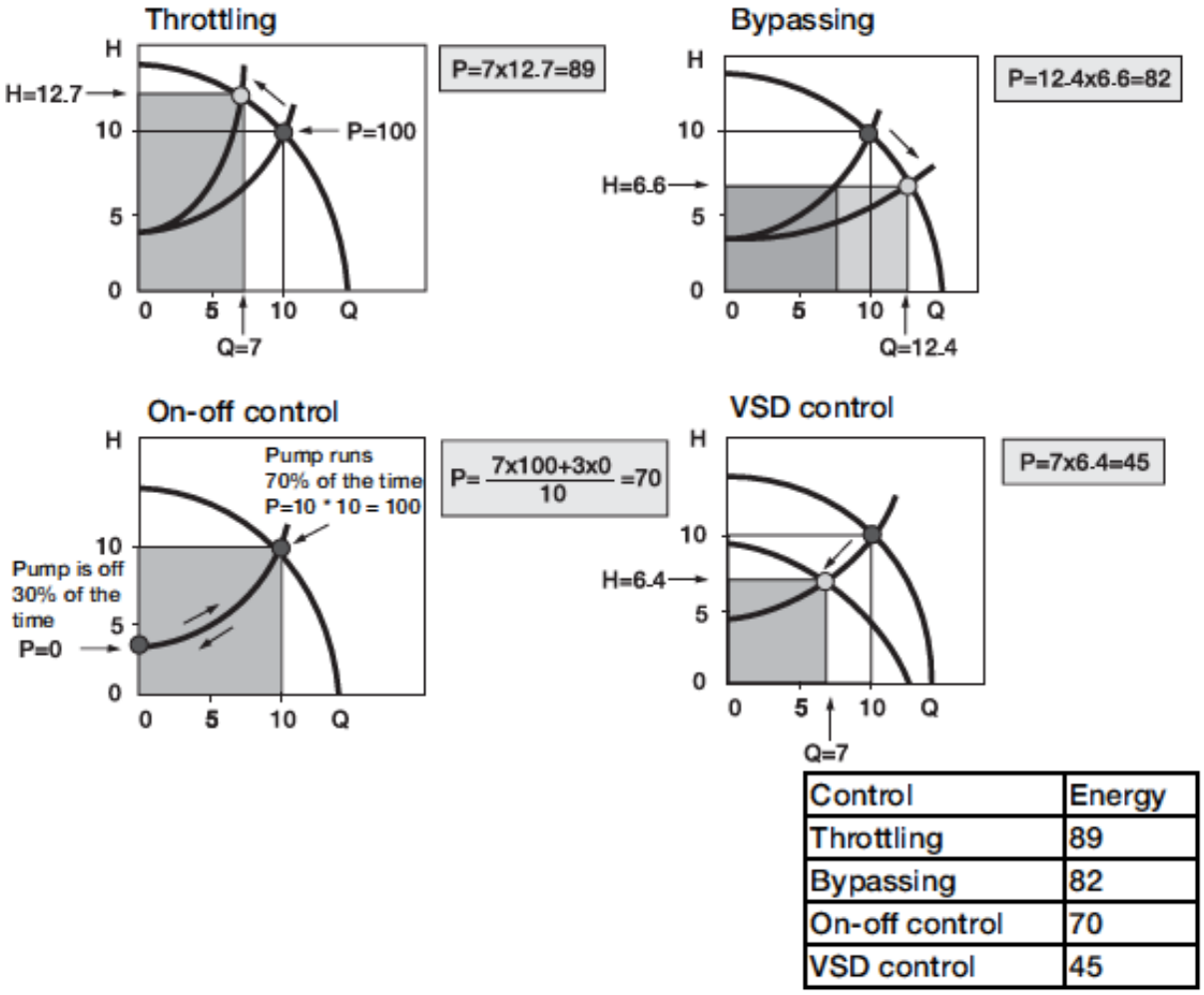
Pond pump

Best Efficiency Point isn't everything



Pump Efficiency	Pump A	Pump B
Peak (BEP)	82%	86%
At desired (quoted) duty point	81.5%	80%
At actual (installed) duty point	79%	<77%

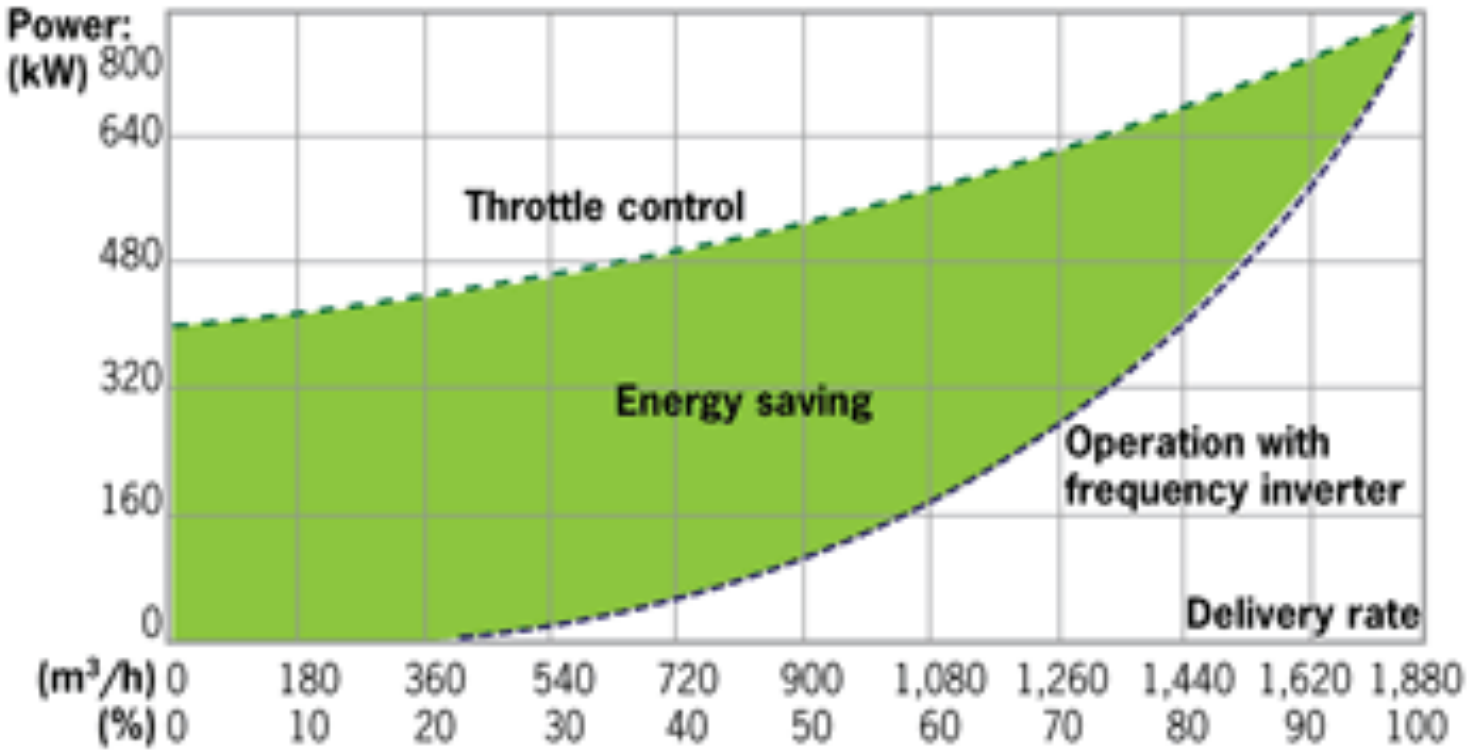
Pump Control Methods



Control	Energy
Throttling	89
Bypassing	82
On-off control	70
VSD control	45

Relative power consumption on an average flow rate of 70% with different control methods.

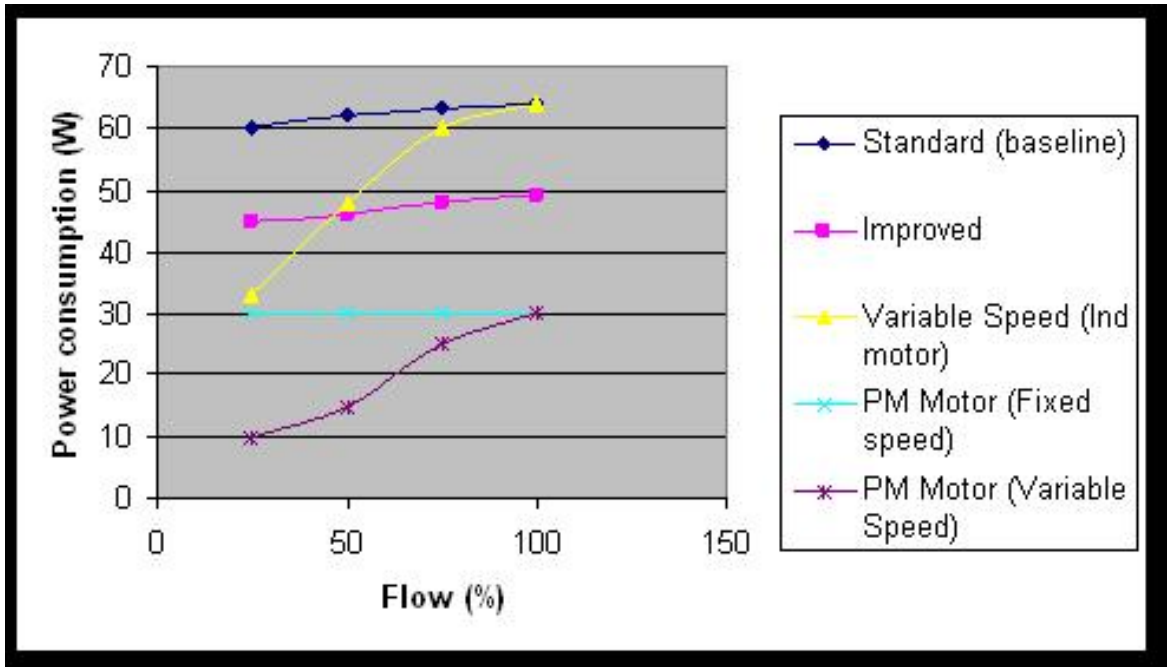
Centrifugal Pumps

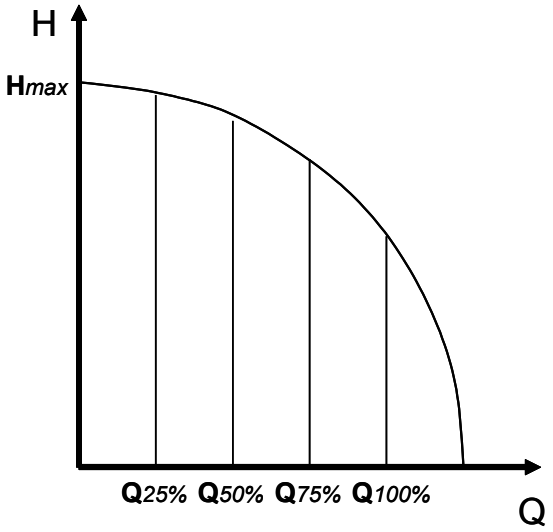


Circulators



Methodology

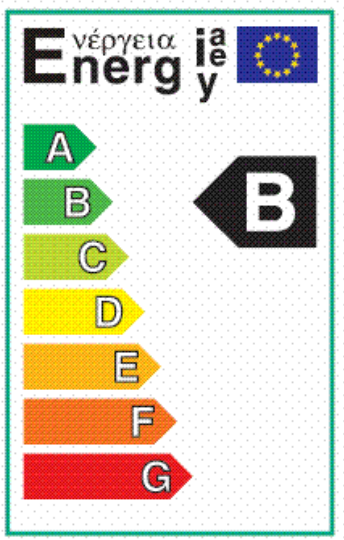




Flow (%)	Time (%)
100	6
75	15
50	35
25	44

Control option	Annual running hours	Flow profile
Continuous	5,000	Blauer Engel
On/Off Thermostatic Radiator Valve (TRV) control	2,300	Blauer Engel
On/Off control	2,300	100% or OFF

New efficiency levels



Now

The future.....

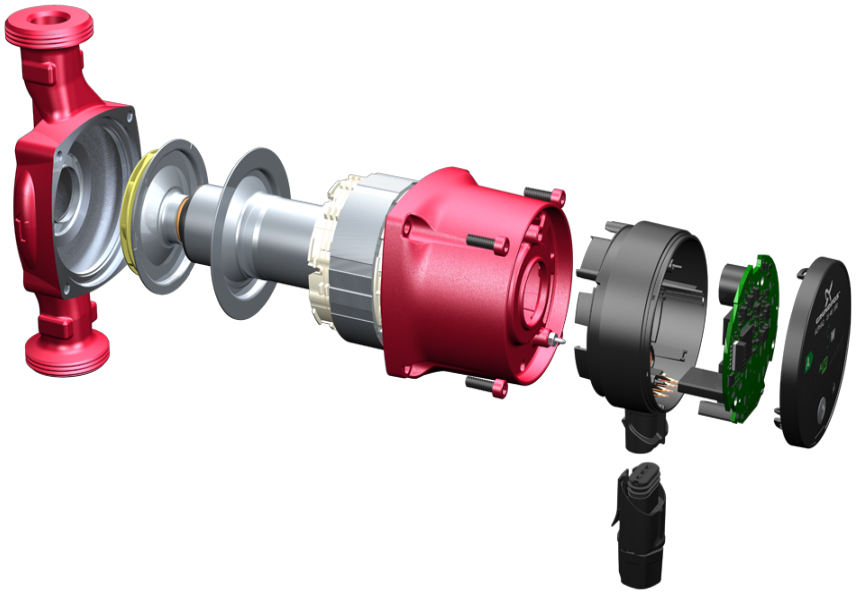
Class	Energy Efficiency Index (EEI)
A	EEI < 0.40
B	0.40 = EEI < 0.60
C	0.60 = EEI < 0.80
D	0.80 = EEI < 1.00
E	1.00 = EEI < 1.20
F	1.20 = EEI < 1.40
G	EEI =1.40

From 2015, all new circulators 1-2,500W shall be A* - effectively a high efficiency variable speed Permanent magnet design.

This will lead to energy savings equivalent to 4 coal fired power stations.

Costs of improved technology

Ref	Design Option	Cost (%)	Cost (Euros)	Additional Cost (Euros)
1	Baseline	100	120	0
2	Speed Control (induction motor)	135	162	42
3	PM/Variable speed	200	240	120
4	Improved design – conventional technology	120	144	24



Changes since the Consultation Forum

- Boiler Integrated circulators also to be included
- Re-alignment of EEI scheme to make MEPS equally challenging for both small and large circulators





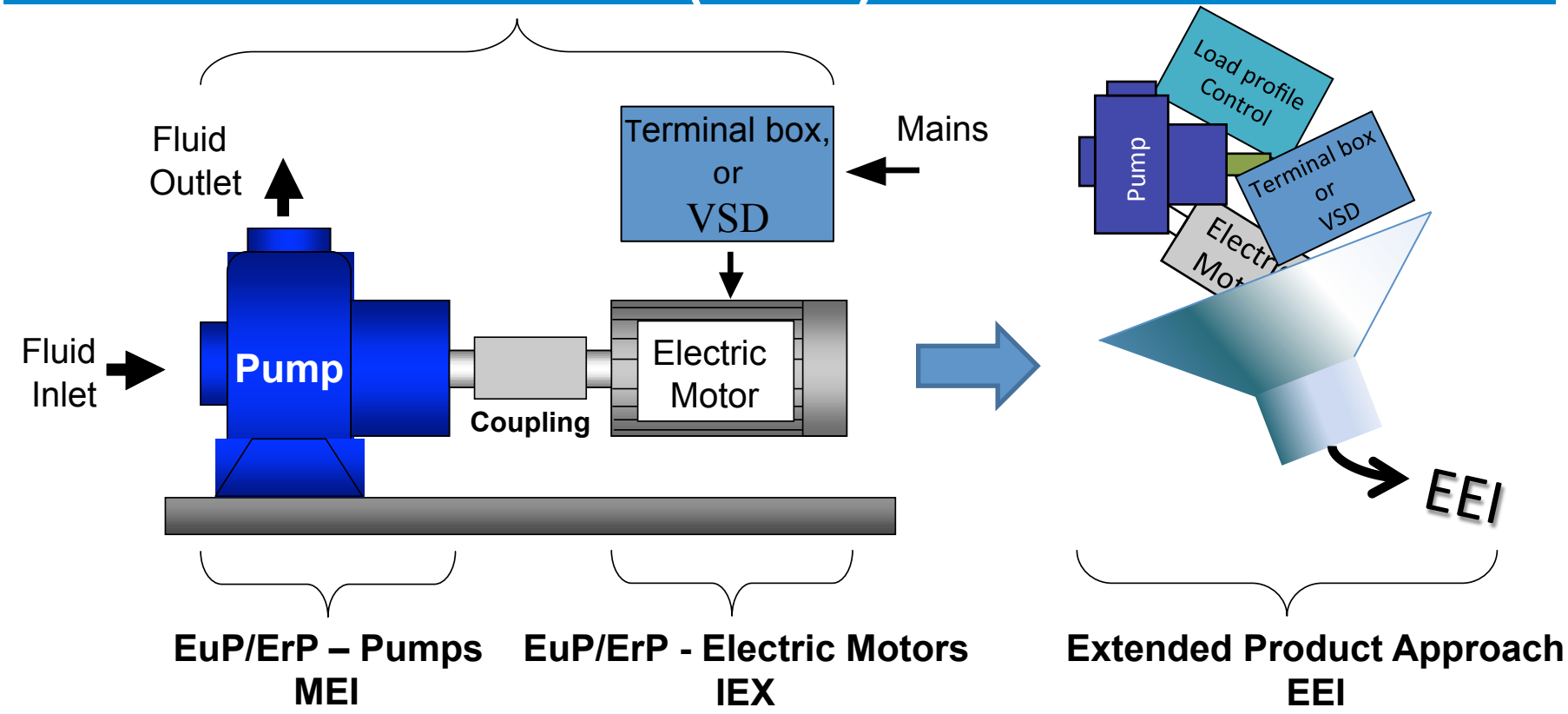
Europumps ecopump initiative

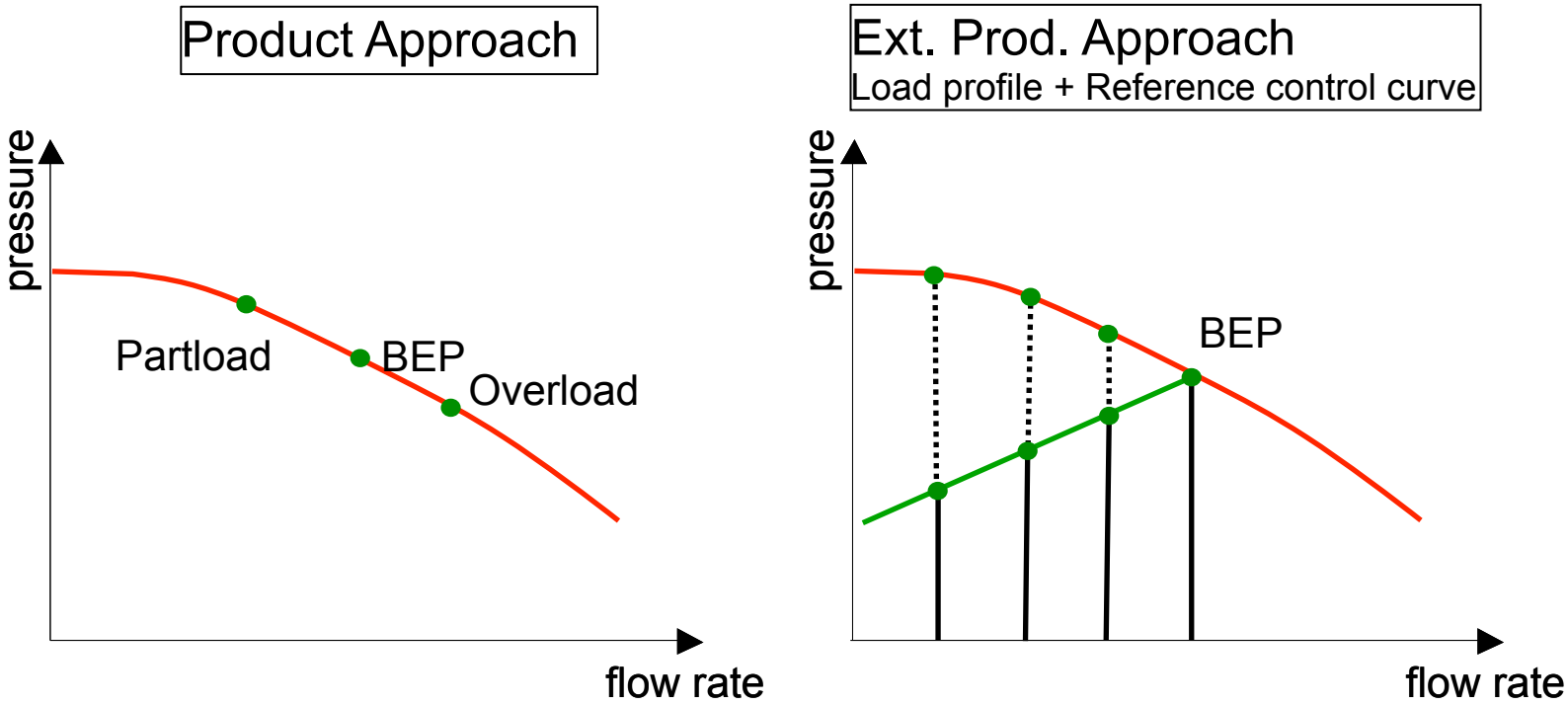
ecopump

The pump industry's answer to the Ecodesign directive !

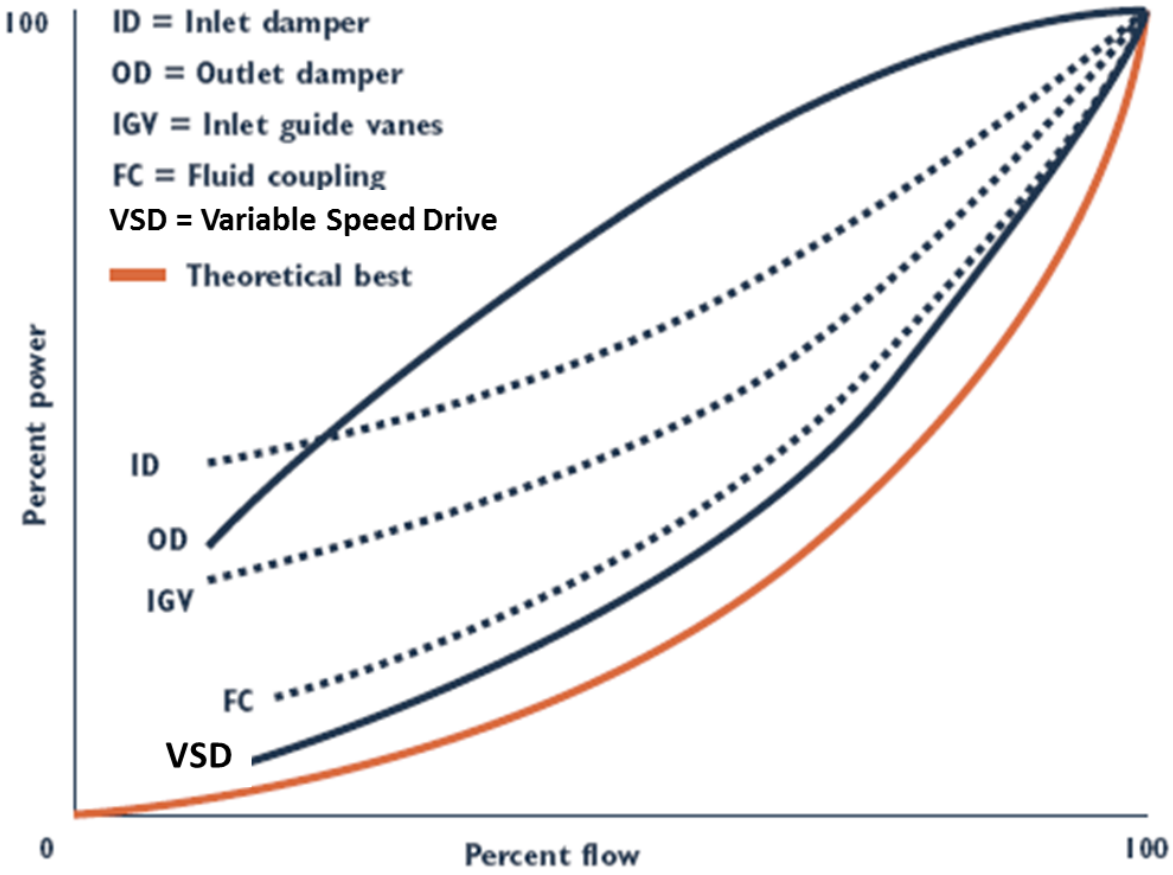
Product (Pump)	**Extended Product** (Pump, PDS, Controls)	**System**

(EPA)


Fluid
Outlet
Terminal box,
or
VSD
Mains
Fluid
Inlet
Pump
Coupling
Electric
Motor
Load profile
Control
Pump
Terminal box
or
VSD
EEI
EuP/ErP – Pumps
MEI
EuP/ErP - Electric Motors
IEX
Extended Product Approach
EEI


Product Approach
pressure
Partload
BEP
Overload
flow rate
Ext. Prod. Approach
Load profile + Reference control curve
pressure
BEP
flow rate

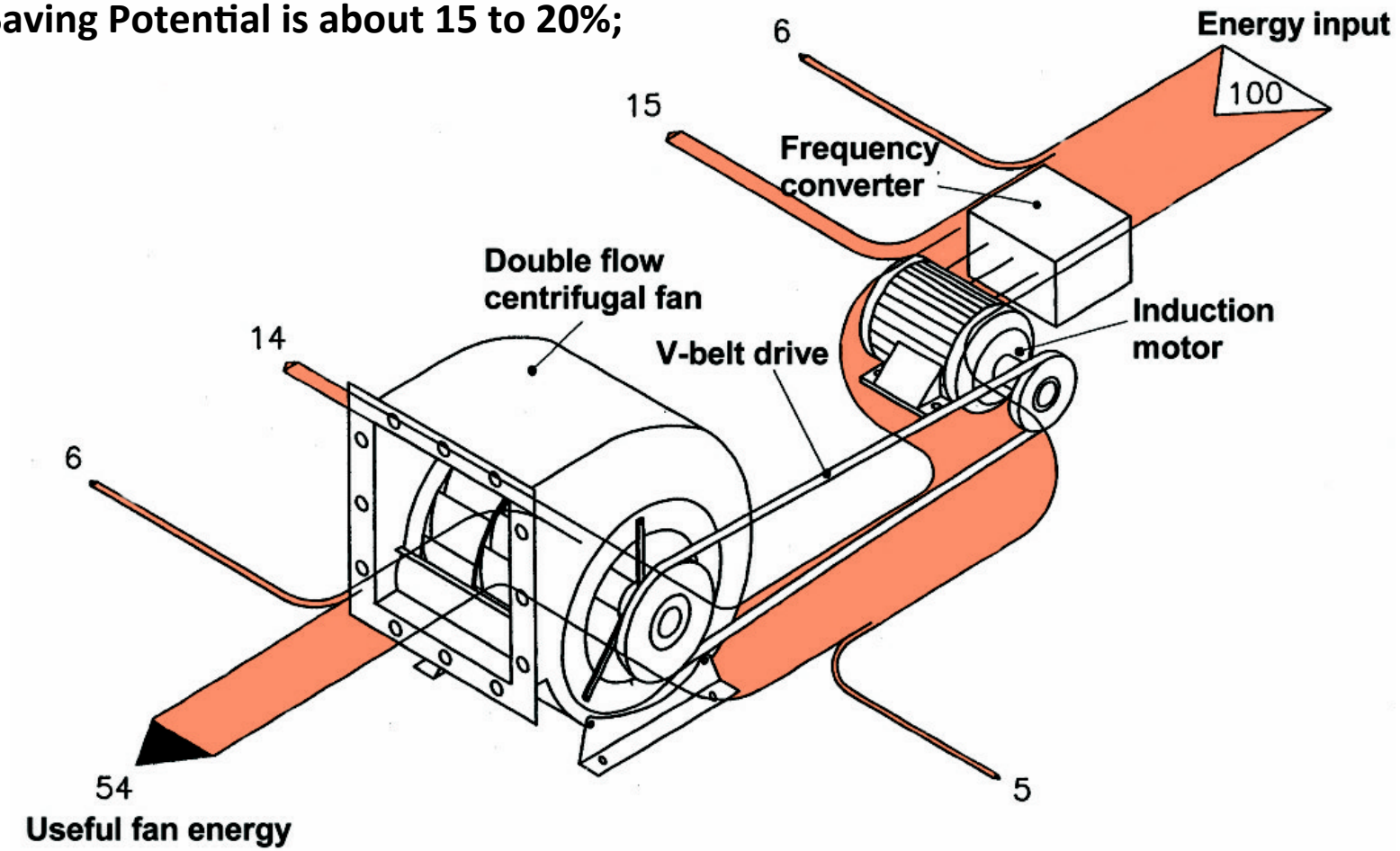
Fan Systems


100
ID = Inlet damper
OD = Outlet damper
IGV = Inlet guide vanes
FC = Fluid coupling
VSD = Variable Speed Drive
Theoretical best
Percent power
ID
OD
IGV
FC
VSD
0
Percent flow
100

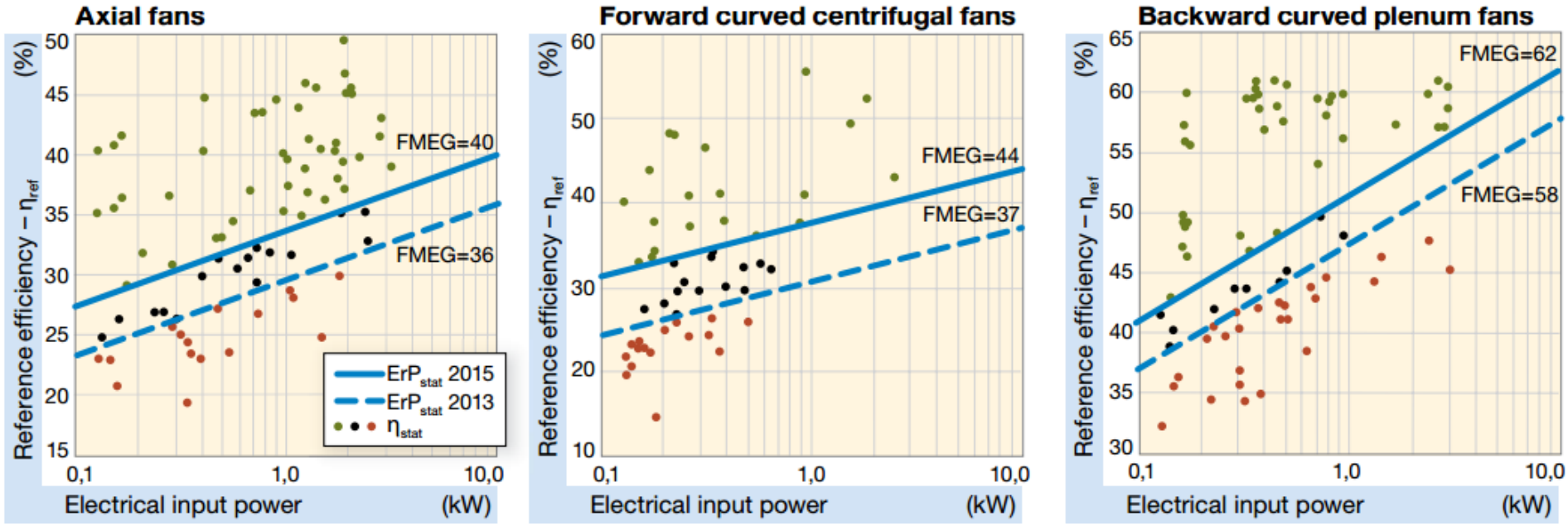
Fan Systems

-Fan Saving Potential is about 5 to 10 %;

-Fan System Saving Potential is about 15 to 20%;



Regulation 327/2011



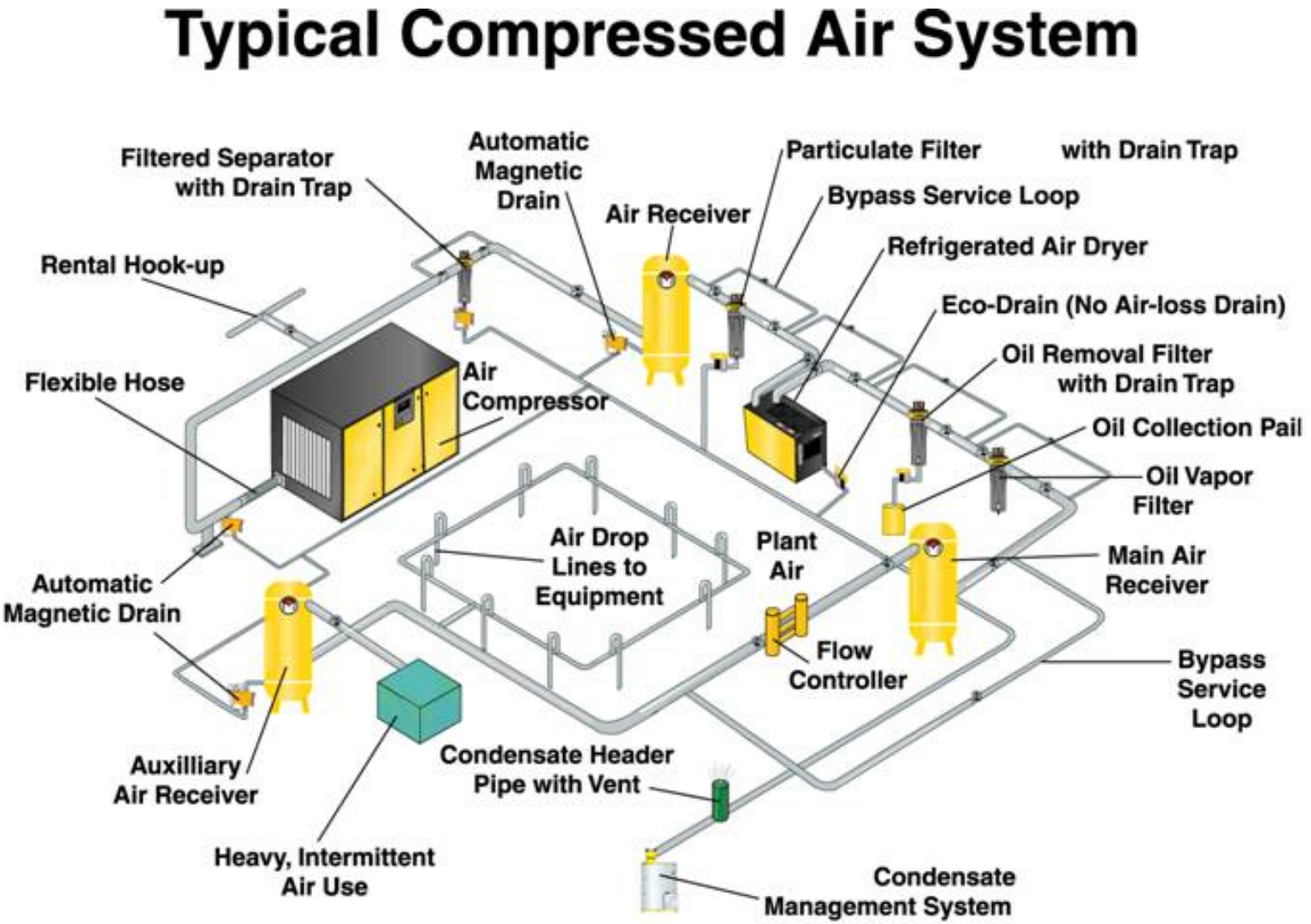
Reference efficiencies based on static pressure for common populations of fan assemblies in the industry today displayed against the 2-tier efficiency limits in Regulation 327/2011.

Source: AMCA

Regulation 327/2011

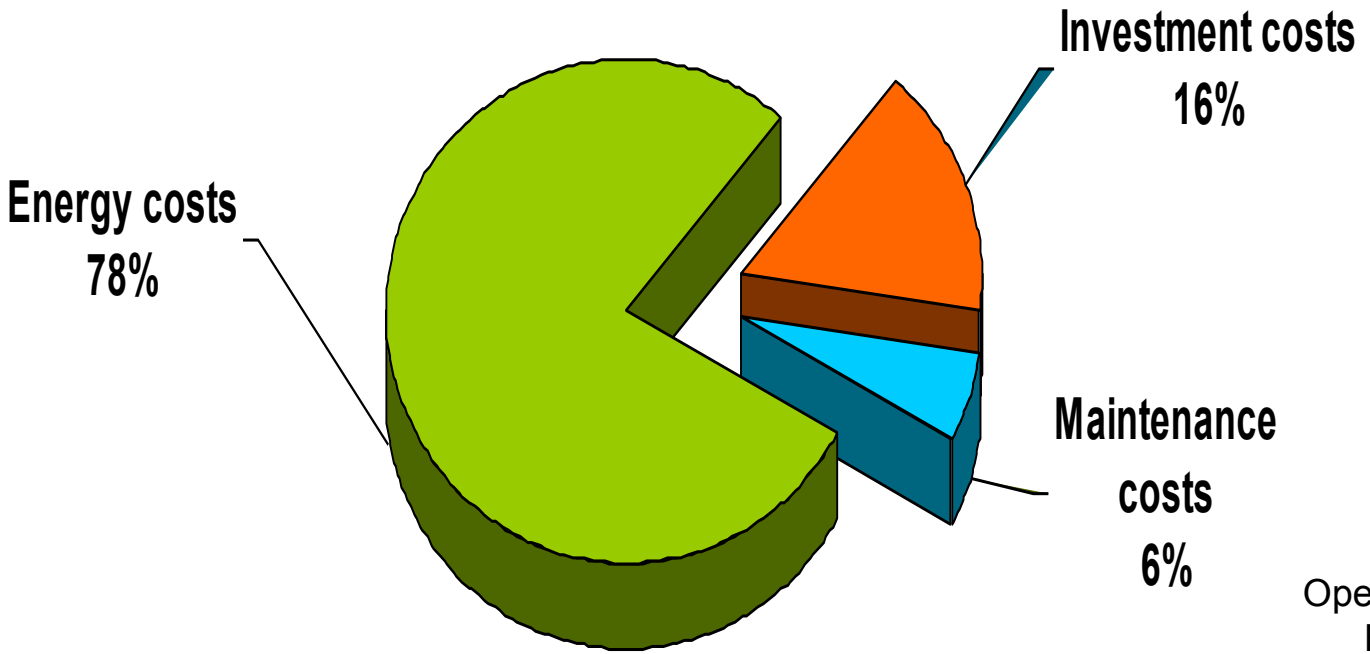
A fan within the scope of this Regulation is designed for use with or equipped with an electrical motor having an electrical input power between 125 W and 500 kW (≥ 125 W and ≤ 500 kW) to drive the impeller at its optimum energy efficiency point.

Compressor Systems



Compressor Systems

Compressed air accounts for 10% of industrial consumption of electricity
Compressed air systems often have poor energy efficiency: possible energy savings are in the range from 5% to 50%…

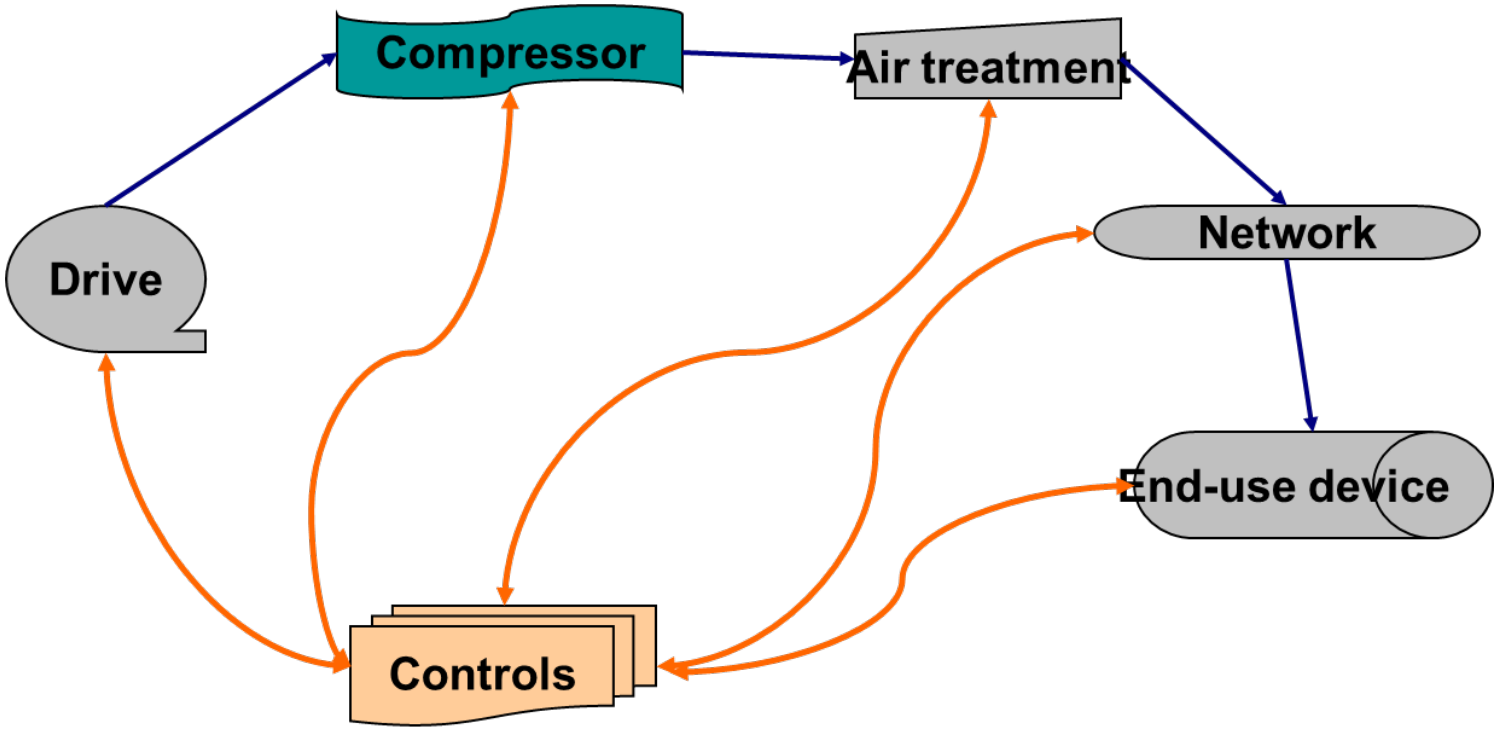


Assumptions

Power 110 kW
Equipment life 15 years
Operating hours 4000 h/year
Electricity price 5 c€/kWh

Compressor Systems

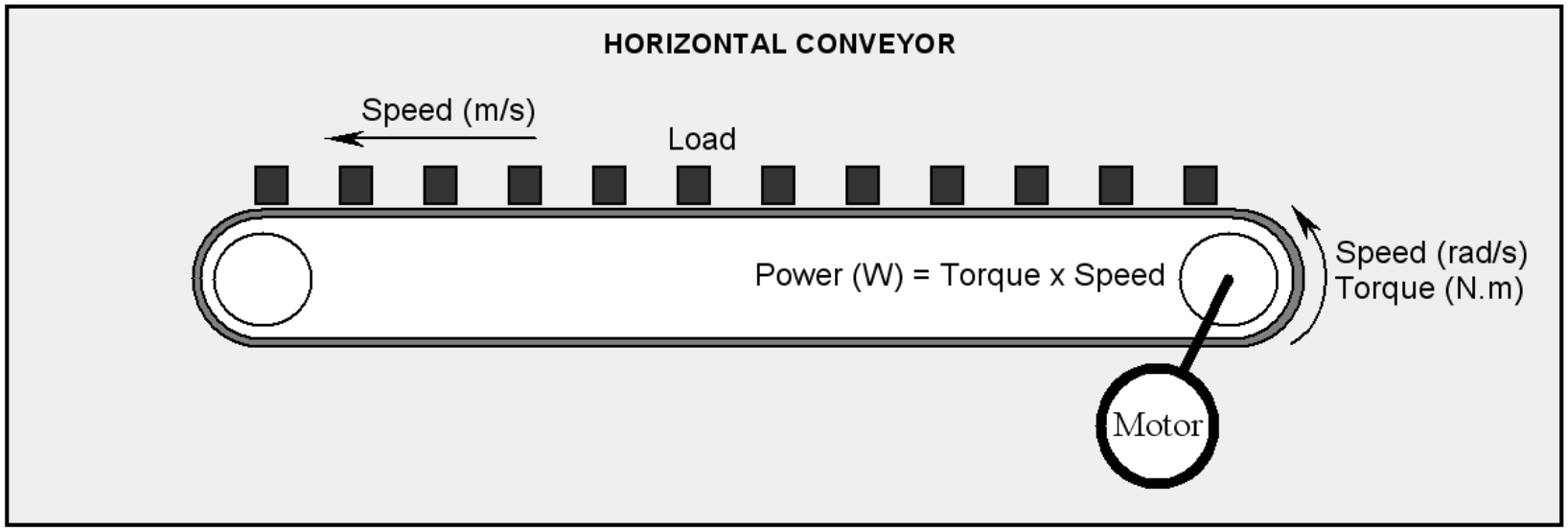
- The maximum overall system energy efficiency is limited by the component with the lowest efficiency in the system.
- The compressor itself is only one element of the system.

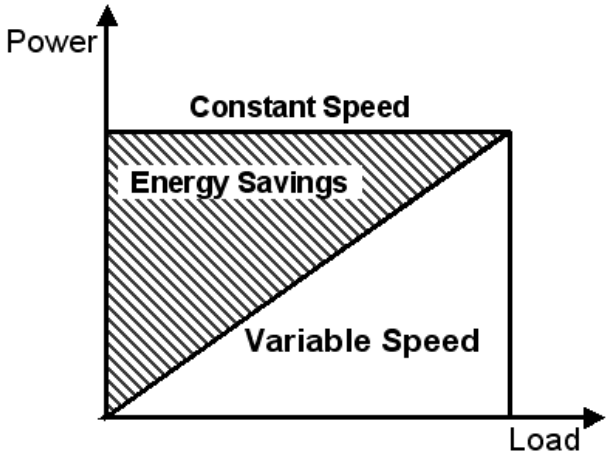


Other Energy Saving VSD Applications

3. Changes in load and speed but can benefit from a VSD in other ways like process control, soft starting and stopping, as well as the requirement of an especially high starting torque or of regenerative braking.
   The cost and energy efficiency benefits are small compared to the first two groups. VSDs allow for voltage optimization to improve motor efficiency if the torque changes.
4. Motion Control – AC drives can now provide high performance torque/speed control, similar to motor servo drives.

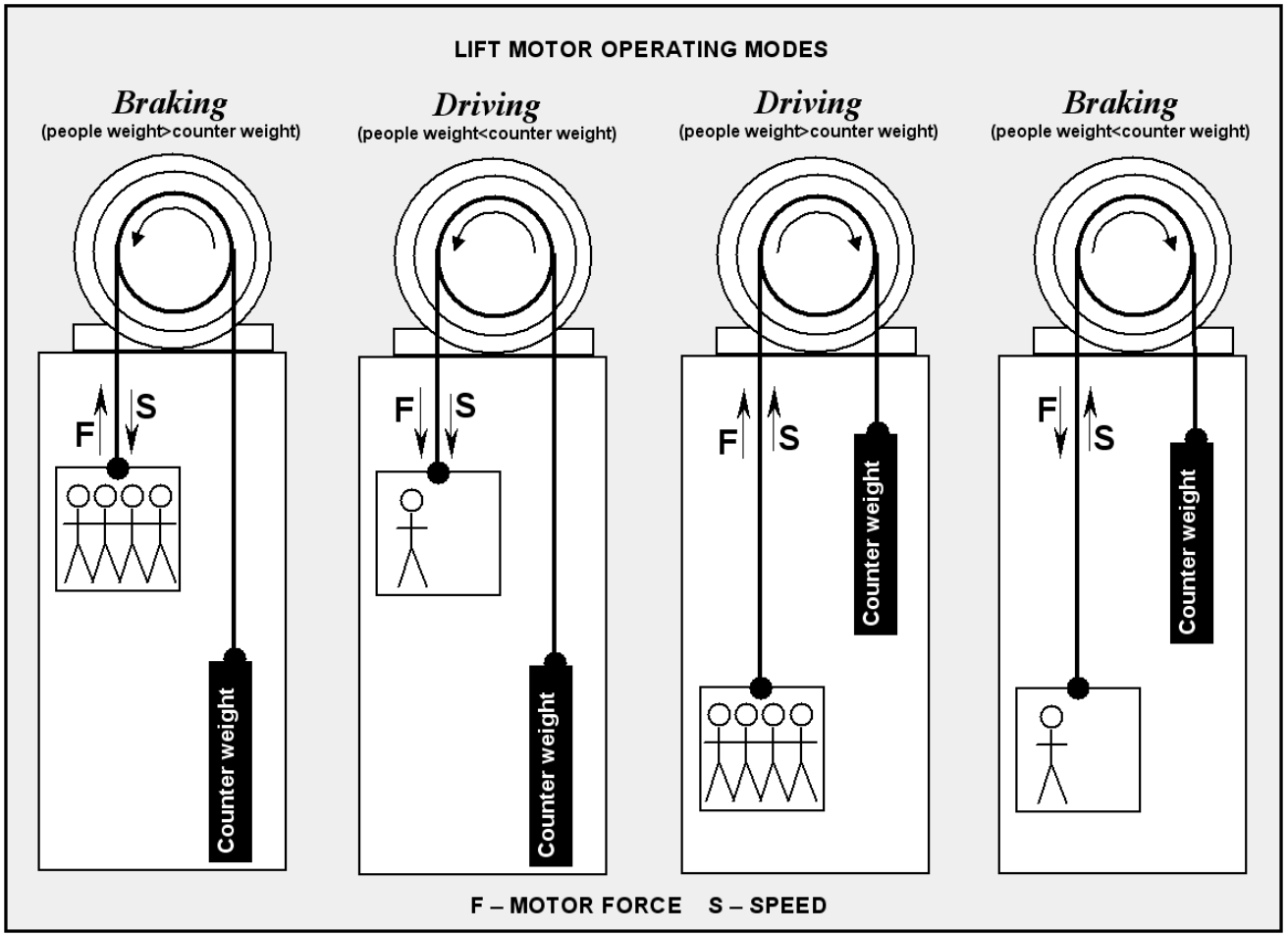
VSDs in conveyors



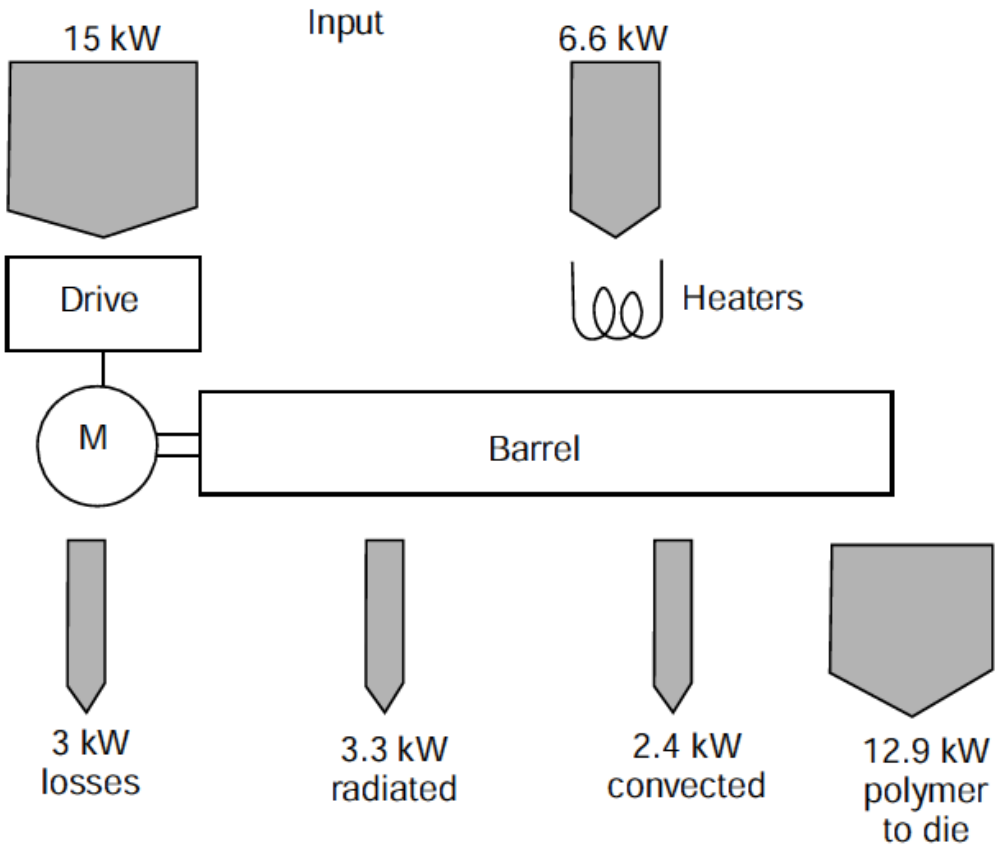


Energy savings in a conveyor using speed control, in relation to the typical constant speed.

VSDs in Lifts-Cranes

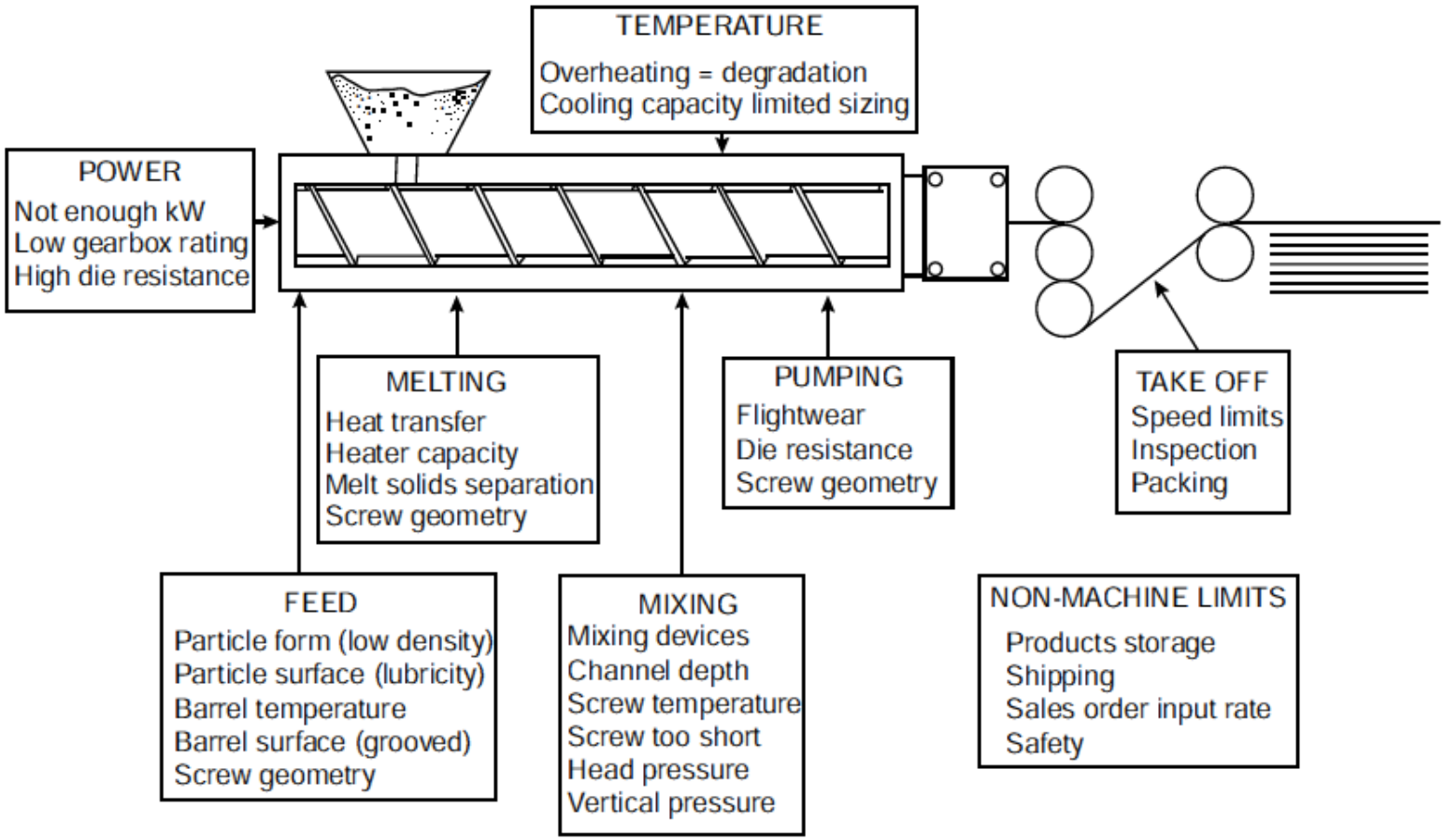


Plastic Extrusion



Typical Extruder Energy Balance

Plastic Extrusion



Factors imposing output limitations

Thank you