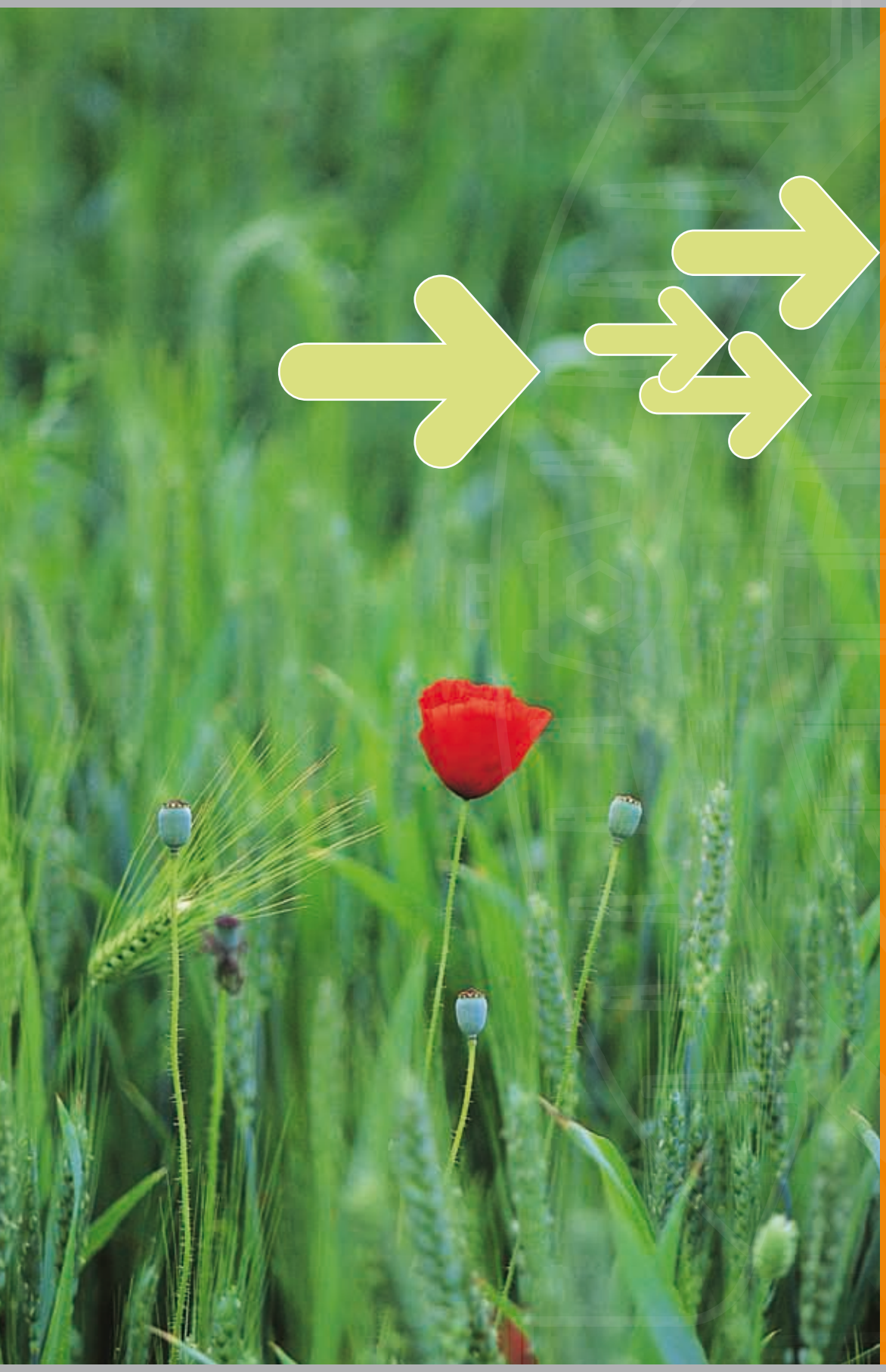
What about controlgear?

Electric motor system efficiency



Guidance concerning "Commission Regulation (EC) N°640/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors".

CAPIEL

European low voltage Switchgear and Controlgear manufacturers association

CAPIEL is the European low voltage Switchgear and Controlgear manufacturers association for products and systems.

CAPIEL and its member associations cover a wide range of low voltage products (maximum voltage rating of 1 kV a.c. or 1,5 kV d.c) and services essential for the operation, protection and control of electrical distribution networks, electrical machinery, and other similar industrial and commercial applications in the EU.

It is a broad-based group that represents many national associations of manufacturers. The members of these national associations include small, medium and large-sized companies that, in total, employ more than 100.000 people in this field in Europe and export a significant part of their EU production to non-EU countries.

CAPIEL promotes and represents the common professional interests of its members in all areas of its competence.

Eckard Eberle
CAPIEL President

Philippe Sauer
CAPIEL Vice-President

A message from the CAPIEL Presidents

The future of Europe and its citizens is intimately linked to the success of our manufacturing industry and its ability to deliver innovative solutions for a greener environment. Ensuring a competitive landscape that will promote our values should be a common goal for all European governments, institutions, employers, employees and their representatives.

The success of ecodesign – an engineering challenge for today – will strongly contribute to ensuring that we leave a better planet for following generations.

It is our duty, as CAPIEL, to work with regulators to make sure that regulations are consistent with our common objective of more energy efficient systems. It is also our responsibility to make sure that these regulations are well understood and correctly interpreted by all users of electrical products, systems and solutions.

As a first initiative, this brochure will provide you guidance about how to implement the recent EU regulation related to efficient motor applications. We hope that you will find it of interest.

Yours sincerely

Eckard Eberle & Philippe Sauer

National organisations

Austria	FEEI
Belgium	AGORIA
France	GIMELEC
Germany	ZVEI
Italy	ANIE
Netherlands	FME
Spain	AFBEL
Spain	AFME
UK	GAMBICA
UK	BEAMA
Sweden	Teknikföretagen

EU Regulation for ecodesign of electric motors

The Ecodesign Regulatory Committee, composed of representatives of the Member States of the EU, has endorsed the new EU Commission Regulation (EC) No.640/2009, Ecodesign Requirements for Electric Motors. This regulation imposes mandatory minimum efficiencies for many types of three-phase, low voltage electric induction motors.

The voluntary agreement of the European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP) defined three possible efficiency classes for motors based on IEC 60034-2:

- EFF3 Low-efficiency motors
- EFF2 Improved-efficiency motors
- EFF1 High-efficiency motors

New efficiency classes have been defined in IEC 60034-30 for induction motors (IE = International Efficiency):

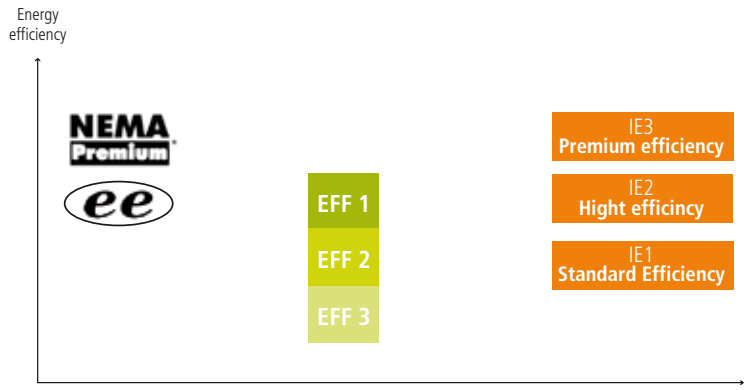
- IE1 (Standard Efficiency)
- IE2 (High Efficiency)
- IE3 (Premium Efficiency

Ecodesign is by principle product oriented, but energy efficiency improvement is necessarily a combination of an energy related product approach (ErP) and a system approach. This new regulation also introduces the option of using a Variable Speed Drive (VSD) in some circumstances.

Whilst, there may be some applications in which variable speed drives (VSD) are the better alternative, it is also clear that motor starters offer the most energy efficient solution for fixed speed or fixed load applications, independently from the efficiency class of the motor (IE2/IE3).

Therefore, an IE2 motor equipped with variable speed drive is not equivalent to an IE3 motor. Instead, it is always necessary to consider the speed and load requirements of the application in order to choose the best solution.

CAPIEL fully supports the goal of energy saving by using energy efficient components. However, it should not be forgotten that the ultimate objective is to ensure the best energy efficiency of the complete system or solution. The design of the overall system is therefore critical, and it is important to understand how this regulation (which essentially addresses only one aspect of system efficiency i.e. the efficiency of the electric motor) fits in with an overall system design strategy intended to optimise the energy efficiency of the complete system.



EC 640/2009 (extract of Article 3)

❶ From 16 June 2011

motors shall not be less efficient than the IE2 efficiency level, as defined in Annex I, point 1.

❷ From 1 January 2015

(i) motors with a rated output of 7,5-375 kW shall not be less efficient than the IE3 efficiency level, as defined in Annex I, point 1, or meet the IE2 efficiency level, as defined in Annex I, point 1, and be equipped with a variable speed drive.

❸ From 1 January 2017

(i) all motors with a rated output of 0,75-375 kW shall not be less efficient than the IE3 efficiency level, as defined in Annex I, point 1, or meet the IE2 efficiency level, as defined in Annex I, point 1, and be equipped with a variable speed drive.

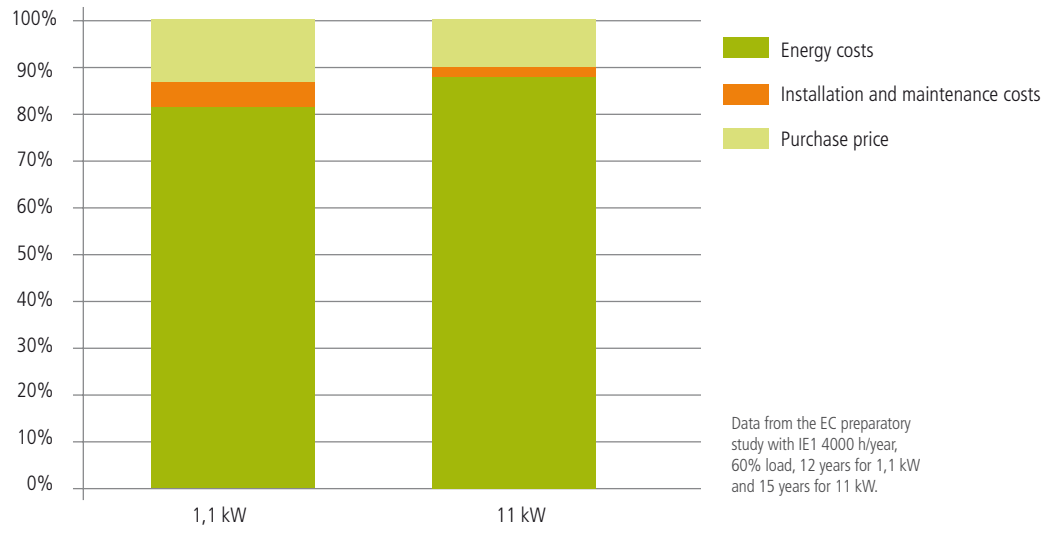
Does the new regulation influence the purchasing of an electric motor?

The main purpose of the ecodesign regulation is, of course, to reduce the electricity consumption of the electric motor. It achieves this by prohibiting the selling of low efficiency motors.

However, whilst the initial purchase price of the motor might increase, any increase should always be compared to the energy cost savings that will be realised during the life of the motor.

Energy costs account for over 80% of the life cycle costs of motors, whereas procurement and installation account for less than 20%.

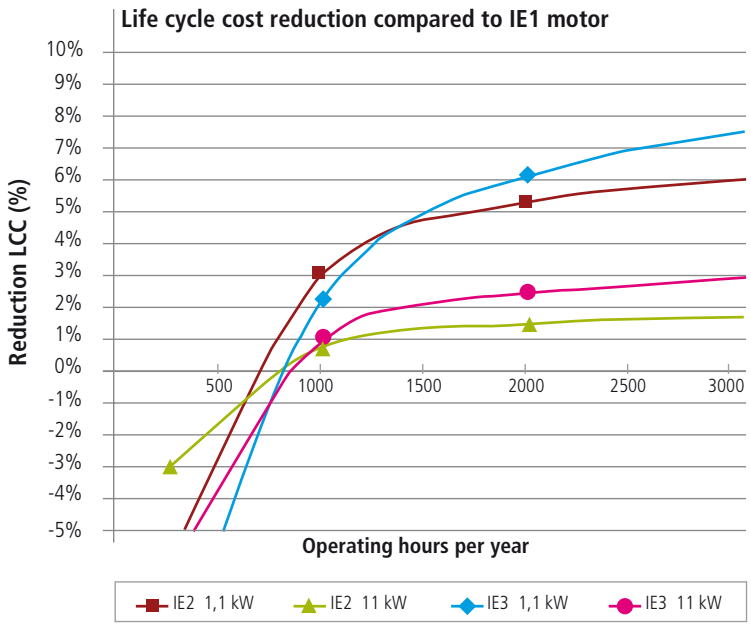
As the energy consumed during the use-phase of a motor is also the main contributor to its environmental impact, high efficiency motors clearly benefit the environment as well as offering a life cycle cost reduction.



Data from the EC preparatory study with IE1 4000 h/year, 60% load, 12 years for 1,1 kW and 15 years for 11 kW.

The correct sizing of motors (in particular, avoiding oversizing) is of the utmost importance in order to maximise the environmental benefit at the same time as minimizing the investment.

Studies with higher efficiency motors have demonstrated that the life cycle cost is reduced such that the additional purchase cost, compared to an IE1 motor, is paid back over its average life time for a duty higher than 800h/year.



Data from the EC preparatory study with 0,075/kWh, 60% load 12 years for 1,1 kW and 15 years for 11 kW.

ANSWER: Yes, the regulation requires the selection of a higher efficiency (preferably IE3) motor. This reduces the environmental impact, and can also reduce the life cycle cost.

Does the new regulation change the criteria to use a variable speed drive?

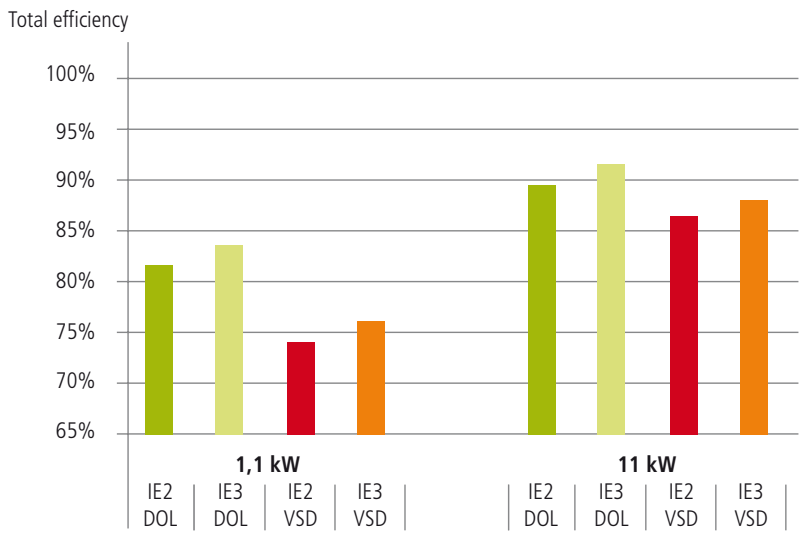
The Regulation introduces the option of an IE2 motor equipped with a variable speed drive as an alternative to an IE3 motor. However, as discussed earlier in this document, these two options are not directly comparable - the VSD solution may be a suitable energy efficiency solution for some applications but may be totally unsuitable for others.

Furthermore, from a system standpoint, the overall energy efficiency is determined by the application and the chosen system solution, not the individual system components alone.

Fixed speed	Changing loads depending on application requirements	Variable speed
• pumps in water storage • stirring units in waste water treatment • conveyors for constant loads • ventilation	• HVAC of buildings • transportation of goods • public water supply	• hoisting • positioner in machine tools • closed-loop pumping or blowing (without throttle)
Typical control approach • switching devices such as contactor or softstarters	**Typical control approach** • switching devices and/or VSD with an appropriate control strategy	**Typical control approach** • variable speed drive • complex control electronics

This table and the following graph shows that for a constant speed application, a motor controlled by a variable speed drive will be less efficient than a motor controlled by a direct on line starter.

MECHANICAL POWER		1.1 kW				11 kW			
Motor efficiency class		IE 2		IE 3		IE 2		IE 3	
Motor efficiency	%	81,4		84,1		89,8		91,4	
Power consumption of the motor	kW	1,35		1,31		12,25		12,04	
		DOL	VSD	DOL	VSD	DOL	VSD	DOL	VSD
Power loss of the control equipment	W	5,3	138	5,3	138	10,7	426	10,7	426
Total cosumption of the motor system	kW	1,36	1,49	1,31	1,45	12,26	12,68	12,05	12,46
Total efficiency	%	81,1	73,9	83,8	76,1	89,7	86,8	91,3	88,3



ANSWER: No, because the selection of a variable speed drive should always be the result of a system analysis. As shown above, many applications will achieve a higher energy efficiency using a motor starter solution.

Does it change the way to select a motor starter?

Each motor control project has specific requirements and constraints that help determine the most appropriate control solution.

In addition to the variable speed drive solution, the following options can also be used for starting and controlling three phase AC induction motors.

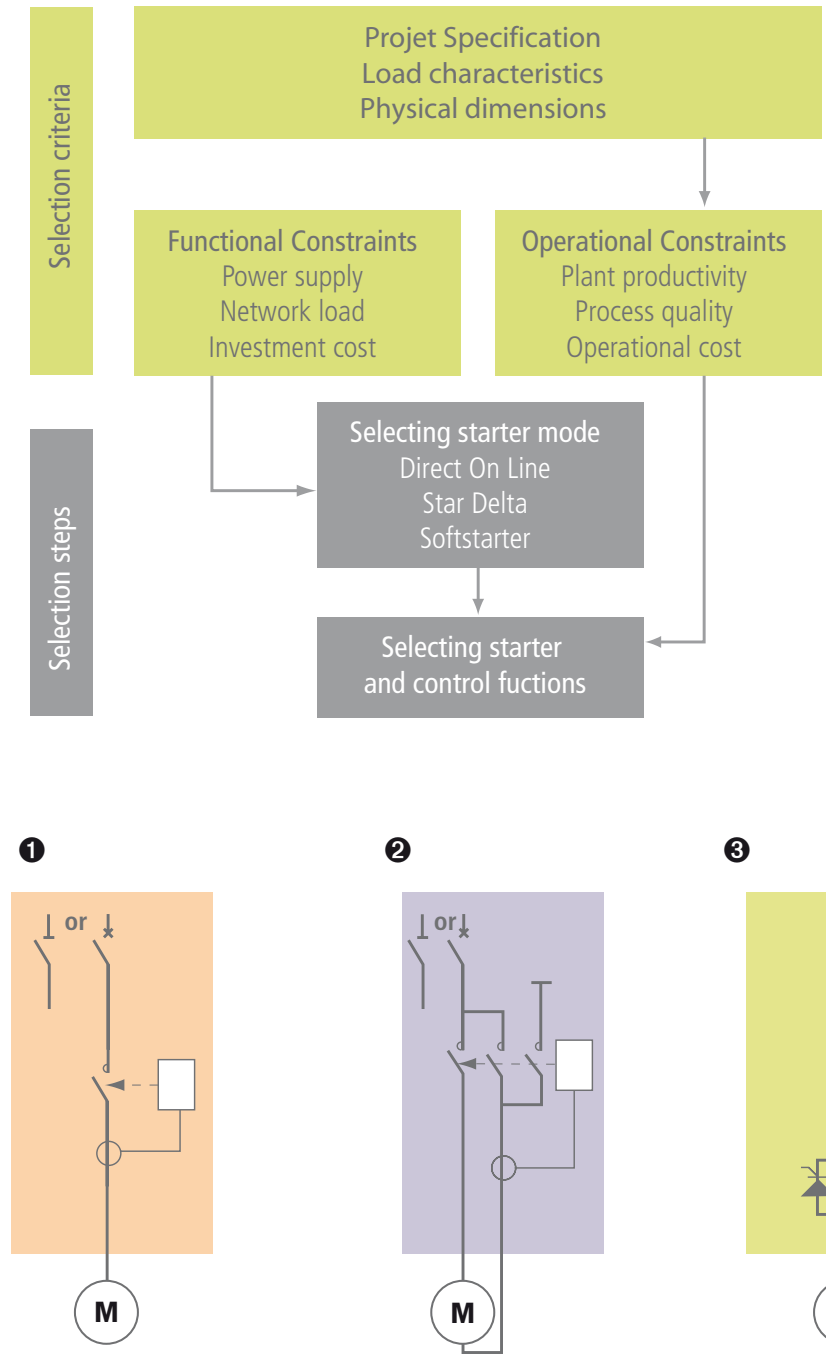
- Direct on line starters/reversers provide an economical and reliable solution to control motors.

- Star Delta starters or softstarters offer reduced starting current and therefore reduce the demand on the electrical supply (transformers or generators).

❶ Direct on line
This is the simplest and most economical starting mode

❷ Star Delta
A simple and economical way to reduce the starting current if the load allows a starting torque of 1/3 nominal torque.

❸ Softstarter
A performance starting mode enabling gentle starting and stopping.



ANSWER: No, because the selection of the starting mode is the result of a system approach and not a product approach.

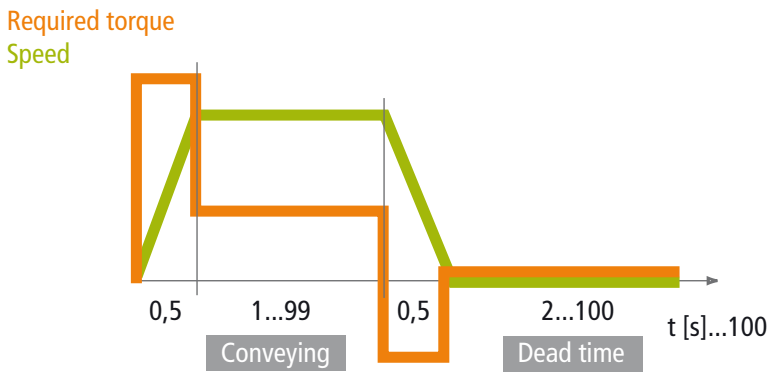
Does it change the way to design a system?

Example of handling equipment - Airport Belt conveyors

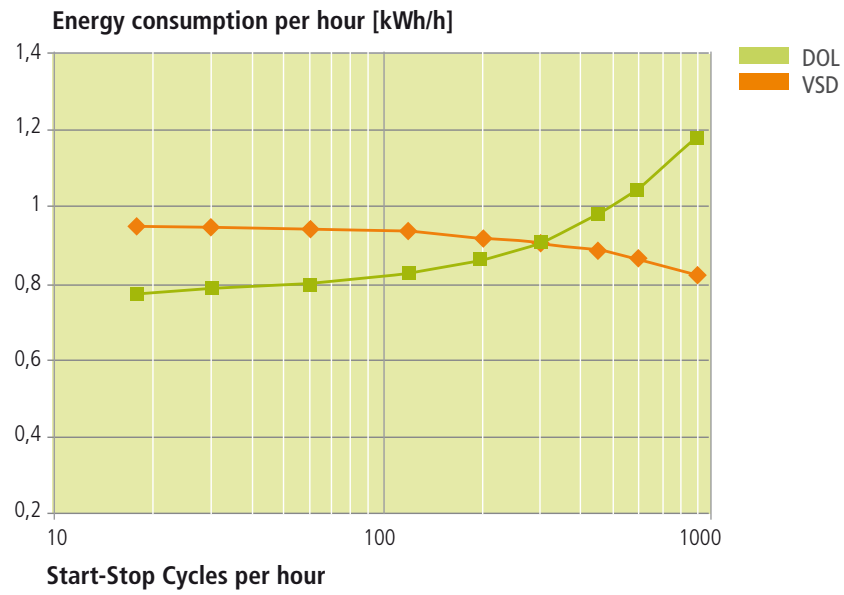
Comparison of the energy consumption of a system controlled by direct on line (DOL) versus variable speed drive (VSD) for different number of start-stop-cycles per hour.

Characteristics
- Horizontal conveyor section
- 4,5 m length
- Conveyed load 105 kg
- Gear ratio 3,84 (1420 to 370 min^{-1})
- Geared motor with mechanical holding brake 2,2 kW, 4 poles Y 400 V, IE1

Load profile: 50% ON (conveying) and 50% OFF (dead time)
- Starting: 0,5 sec run-up period with VSD or self-regulating (load dependent) with DOL
- Conveying from 0,5 up to 99 s
- Deceleration: 0,5 sec braking rate with VSD or by mechanical brake with DOL
- Dead time: from 2 up to 100 s depending on the number of start-stops/hour, mechanical holding brake, VSD not active during this period.



Comparison of the energy consumption between Direct on Line (DOL) control and variable speed drive (VSD) control for different start-stop cycle durations per hour.



- **DOL is better for up to 300 start-stop-cycles per hour**
  - Lower energy consumption at constant speed, higher energy consumption during starting
- **The VSD has a highly dynamic process capability**

ANSWER: No, the design of a system should address energy efficiency together with functionality, availability, maintainability and life cycle cost.

Summary

Comprehensive legislation is being implemented in the European Union with the objective of reducing energy consumption and therefore CO_2 emissions. The efficiency of induction motors in the industrial environment is regulated by EU Commission Regulation (EC) No. 640/2009.

The standard EN 60034-30: 2009 defines efficiency classes for 50 and 60 Hz motors and stipulates which types of motor are covered and which exceptions apply. The technical requirements of the EU Regulation are based on this standard.

EU ecodesign legislation targets the efficiency of individual products, but for overall energy efficiency improvement it is necessary to take into account both the product efficiency and the system efficiency.

Our recommendations

- Consider IE3 motors for high duty applications today even before they become mandatory. This will help future compliance of your design.
- Focus on energy consumption and use motor starters where they provide the most efficient solution. For example, use motor starters in fixed speed, constant load or low duty applications.
- Apply variable speed drives in applications where they bring an added value or a significant energy saving.
- Be aware of the future CENELEC technical specification "Energy efficiency and Eco-design requirements for Power electronics, Switchgear, Controlgear, and Power drive systems and their industrial applications" being developed by CENELEC TC22X WG6.

All applications should undergo a detailed energy performance analysis in order to maximise the energy efficiency. All system components and auxiliary equipment should be considered as part of this analysis.

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