ENERGY EFFICIENCY

Electric motors and Power Drive Systems

Bonfiglioli

We engineer dreams

ENERGY AND ENVIRONMENTAL POLICY

THE ADVENT OF THE CULTURE OF ENERGY REDUCTION

Since the end of the second millennium, there has always been great interest in improving the energy efficiency of energy-using devices in European countries. Over the years, the topic of energy savings has become widespread and is growing globally, starting from the industrial sector all the way to the most varied domestic appliances. It's easy to understand the impact that energy consumption and optimization have on industrial growth, structural changes, lifestyle improvements and, simply put, on energy prices.

Initially implemented by individual countries as an attempt to reduce energy consumption, energy efficiency standards and labeling have become a global topic with several international agencies involved. In addition, some countries have formed sub-groups to harmonize their testing and energy efficiency standards (e.g. Australia/New Zealand and Canada/Mexico/USA).

Energy-efficiency labels and standards can be applied to any product that consumes energy, directly or indirectly, as it provides its services.
Energy efficiency standards can be either mandatory or voluntary; they can be in the form of minimum allowable energy efficiency or a maximum allowable energy use.

THE IMPACT OF ELECTRIC MOTORS ON ELECTRIC CONSUMPTION

According to the U.S. Department of Energy (DOE), electric motors are responsible for half the energy used in the U.S. manufacturing sector, and the International Energy Agency (IEA) estimates that electric motor-driven systems account for more than 40 percent of global electricity consumption.

To promote energy savings, increase efficiency, and reduce operating costs for manufacturing operations, many countries and regions around the world have established minimum efficiency performance standards (MEPS) for motors used in industrial, commercial, and residential applications. The ability to establish and enforce MEPS, however, depends on a standardized testing and classification system for motor efficiency.

MINIMUM ENERGY PERFORMANCE STANDARDS (MEPS)

Sometimes also referred to as Minimum Energy Efficiency Requirements (MEER), they are regulatory measures applied in a certain country or region, and specifying performance requirements for energy using devices.
They establish energy efficiency limits that products must meet or exceed before they can be sold. A MEPS generally requires the use of a particular test procedure that specifies how performance is measured.

The EU Ecodesign Directive is the primary means for setting MEPS in the EU. MEPS are usually reviewed, in consultation with the industries concerned, and updated in line with technological advances.
Along with energy rating labeling, MEPS should ideally give the industry the motivation to constantly improve the energy efficiency of products on the market.

ENERGY EFFICIENCY STANDARDS

To harmonize efficiency classifications for motors manufactured and sold in the global market, the International Electrotechnical Commission (IEC) introduced Standard IEC 60034-30:2008, which was updated in 2014 and is now referred to as IEC 60034-30-1:2014, "Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors."

In addition to defining efficiency classes for electric motors, the IEC has also developed a standard that specifies how to determine motor efficiencies and losses based on established testing methods. This standard, IEC 60034-2-1 : 2014, ensures an international common base for electric motor designing and classification, as well as for national legislative activities and provides the basis for defining the efficiency classes in IEC 60034-30-1.

Both standards were developed in conjunction with the National Electrical Manufacturers Association (NEMA), the Japan Electrical Manufacturers Association (JEMA), and the European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP).

In 2017, the IEC published a new standard dealing with the energy efficiency of AC drives and drive-motor systems: IEC 61800-9 "Ecodesign for power drive systems, motor starters, power electronics and their driven applications". The standard IEC 61800-9 is harmonized in Europe as EN 61800-9 and replaces the earlier standard EN 50598 (-1 and -2).

Starting from 2021, the European regulation 2019/1781 is introducing for the first time legally binding energy efficiency standards for frequency inverters.

HISTORY OF ENERGY EFFICIENCY STANDARDS

IEC 60034-2-1: 2007: harmonizes the procedures for the measurement of efficiencies.
IEC 60034-30: 2008: specifies efficiency classes and forms the basis for the various national efficiency requirements.
IEC 60034-2-1: 2014: is intended to establish methods of determining efficiencies from tests, and to specify methods of obtaining specific losses.
IEC 60034-30-1: 2014: takes a step further in widening the scope of motors subject to efficiency classes and introduces the IE4 class. VSD-driven motors are out of the scope of this standard and will be dealt with in a standard of its own.
IEC TS 60034-30-2: 2016: Rotating electrical machines - Part 30-2: Efficiency classes of variable speed AC motors (IE-code)
IEC 60034-2-3 : 2020: Rotating electrical machines - Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC motors

The IE classes are shown in the following table:

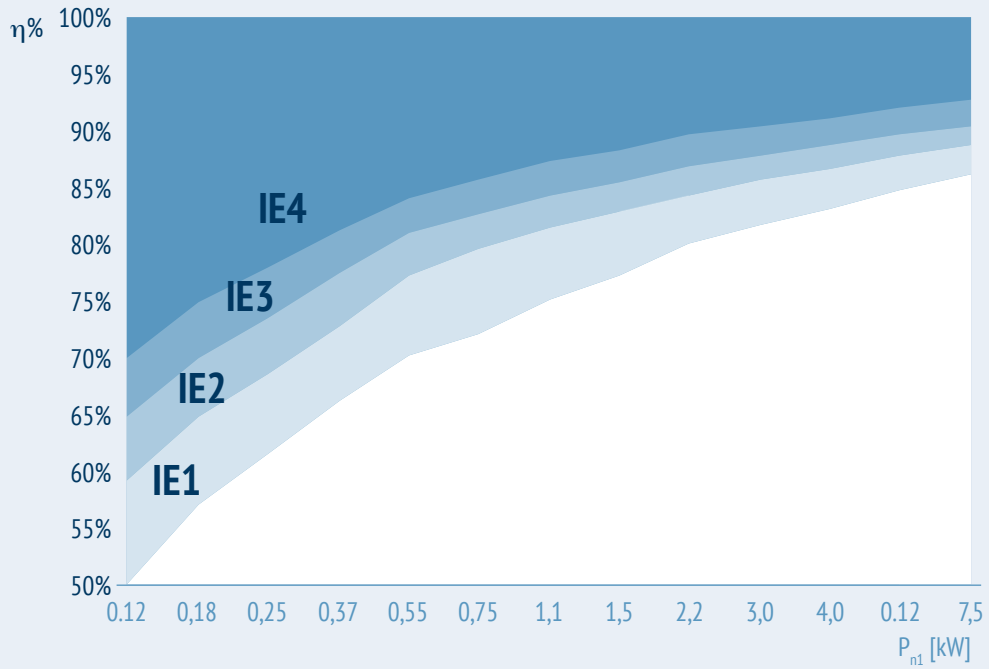
Class type	Class number
Standard efficiency	IE1
High efficiency	IE2
Premium efficiency	IE3
Super premium efficiency	IE4

IEC 61800-9:2017 introduced the extended product approach, which allows us to determine the efficiency of drive + motor + driven equipment (i.e. a pump) under defined load-time profile.
The regulation defines efficiency classes for AC drives and motor-drive systems (called Power Drive Systems or PDS in the standard).
For AC drives, the standard defines three classes: IE0, IE1 and IE2.
For motor-drive systems, there are again three classes: IES0, IES1 and IES2. The 'S' after 'IE' stands for 'system'.
European Regulation 2019/1781: New regulations for the European market for induction motors and electronic motors controls such as frequency inverters.

THE STEP FORWARD - IE4 AND IE5

Motors belonging to efficiency class IE4 achieve an even further improvement of efficiency.
At present, Bonfiglioli is already on track with its synchronous motors for inverter operation and is continuously improving and enhancing the performance of its asynchronous three phase induction motors.
IE5 is to be incorporated in the next edition of IEC 60034-30-1, with the goal to obtain an energy loss reduction of 20% compared to IE4.

IE efficiency classes for 4-pole motors at 50 Hz



Electrical motor efficiency is the ratio between the mechanical output power and the electrical input power:
$\eta = P_{n1} / (V_n \cdot I_n \cdot 1000)$

Parameters:
V_n = Rated voltage [V]
P_{n1} = Motor output power [kW]
I_n = Rated current [A]

A well dimensioned electric motor which operates in its high efficiency region should be chosen in order to obtain a highly efficient system.

ENERGY EFFICIENCY SCHEMES

Though the IEC efficiency standards are internationally relevant, differences in implementation still exist. Notice that IE1, "standard efficiency", has become substandard in basically all the regions mentioned, with the exception of some LATAM countries.
Despite there were no imperative timelines for establishing IE4 regionally until recently, it is important to acknowledge that minor changes are forseen for European countries. Specifically, all the asynchronous three-phase electric motors with a power equal to or greater than 75kW must comply with IE4 standard, starting from July 2023.

ENERGY EFFICIENCY STANDARDS

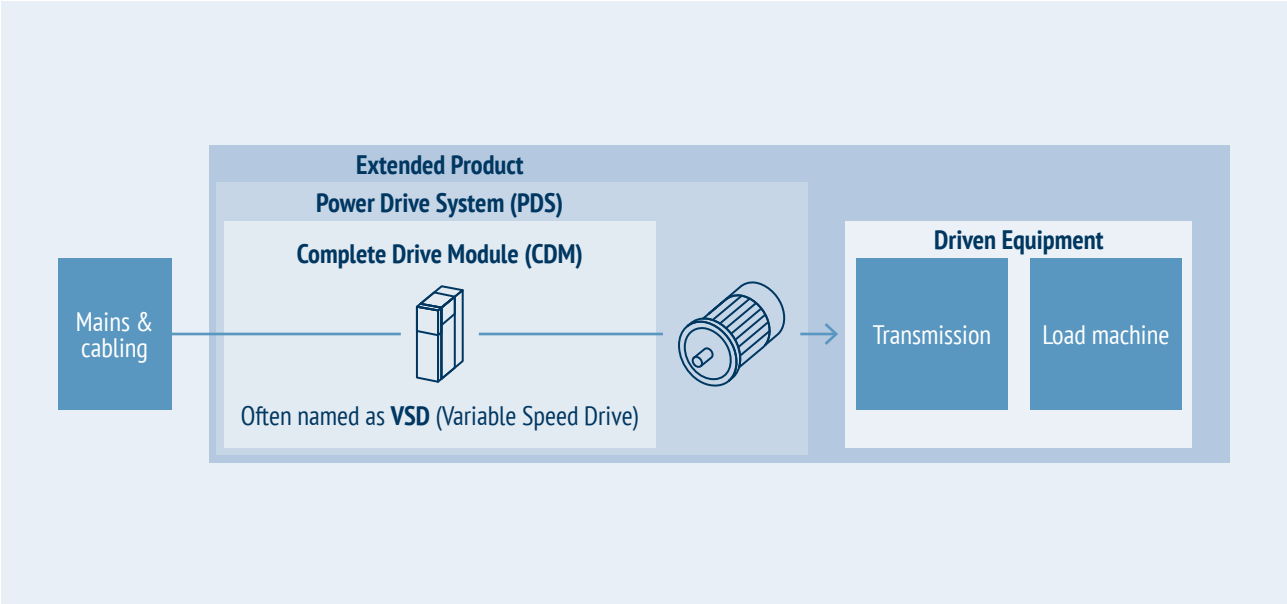
THE EXTENSION OF THE INTERNATIONAL REGULATION TO VARIABLE FREQUENCY DRIVES AND POWER DRIVE SYSTEMS (PDS)

The IEC 61800-9 standard published in 2017 broadened the focus on the efficiency to variable speed drives worldwide, introducing two main elements:

- Extended product approach
- Classification of drives and Power Drive Systems

EXTENDED PRODUCT APPROACH

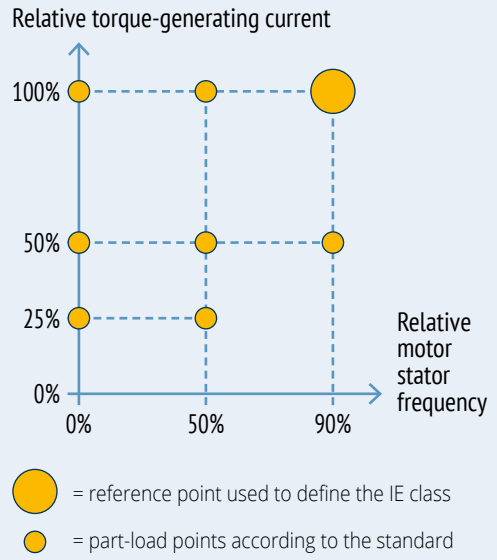
The extended product approach introduced a broader scope for energy efficiency optimization by **combining the efficiency** (or losses – just another way of expressing it) **of the motor with the efficiency of the driven equipment**. The optimization of the entire system, in fact, has proved to have a much greater influence on the overall energy efficiency than the rated efficiency value of the individual components.



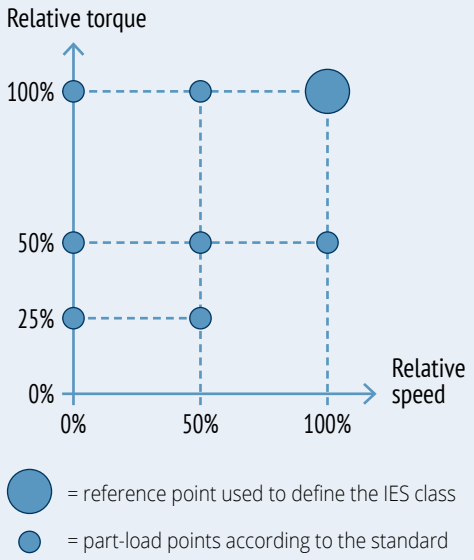
Through this approach it is possible to **rate the efficiency of a complete system**, under defined load-time profile. It allows to compare systems and to perform optimization at system level, by selecting the most efficient drive – motor – driven equipment combination.

CLASSIFICATION OF AC DRIVES AND POWER DRIVE SYSTEMS

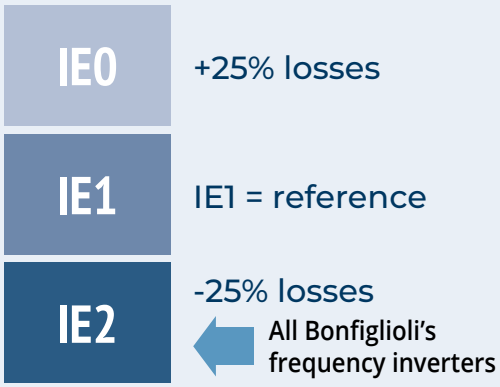
AC DRIVES RATING



POWER DRIVE SYSTEMS RATING

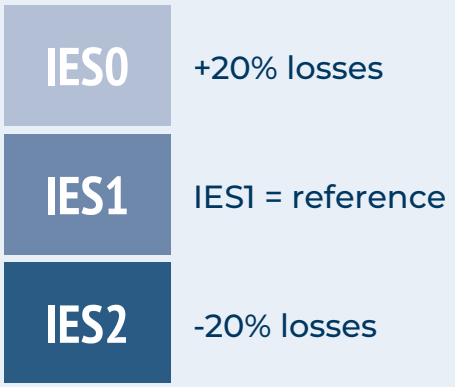


The IEC standard 61800-9-2 specifies the **procedure for determining the losses in 8 application-relevant operating points**, in the power range from 0.12 kW to 1,000 kW, **of both AC drives** and for the **combination of AC drives together with a motor**, defined as **Power Drive Systems** (PDS) in the regulation.



AC DRIVES EFFICIENCY CLASSES

For **AC drives**, the standard defines three classes: IE0, IE1 and IE2. A reference value is defined for each power size. The reference value corresponds to IE1. If the drive has 25% more losses than the reference value, it will be categorized as IE0. If it has at least 25% less losses than the reference, it will become IE2.



POWER DRIVE SYSTEMS EFFICIENCY CLASSES

The IEC EN 61800-9-2 standard also defines the efficiency classes **IES0** to **IES2** for AC drives together with a motor. Losses of the reference power drive system, corresponding to IES1 class, are defined for the 8 specific operating points. If the PDS has 20% more losses than the reference value, it will be categorized as IES0. If it has at least 20% less losses than the reference, it will become IES2.

FIND THE PRODUCT COMBINATION FOR YOUR ENERGY EFFICIENCY OPTIMIZED SYSTEM

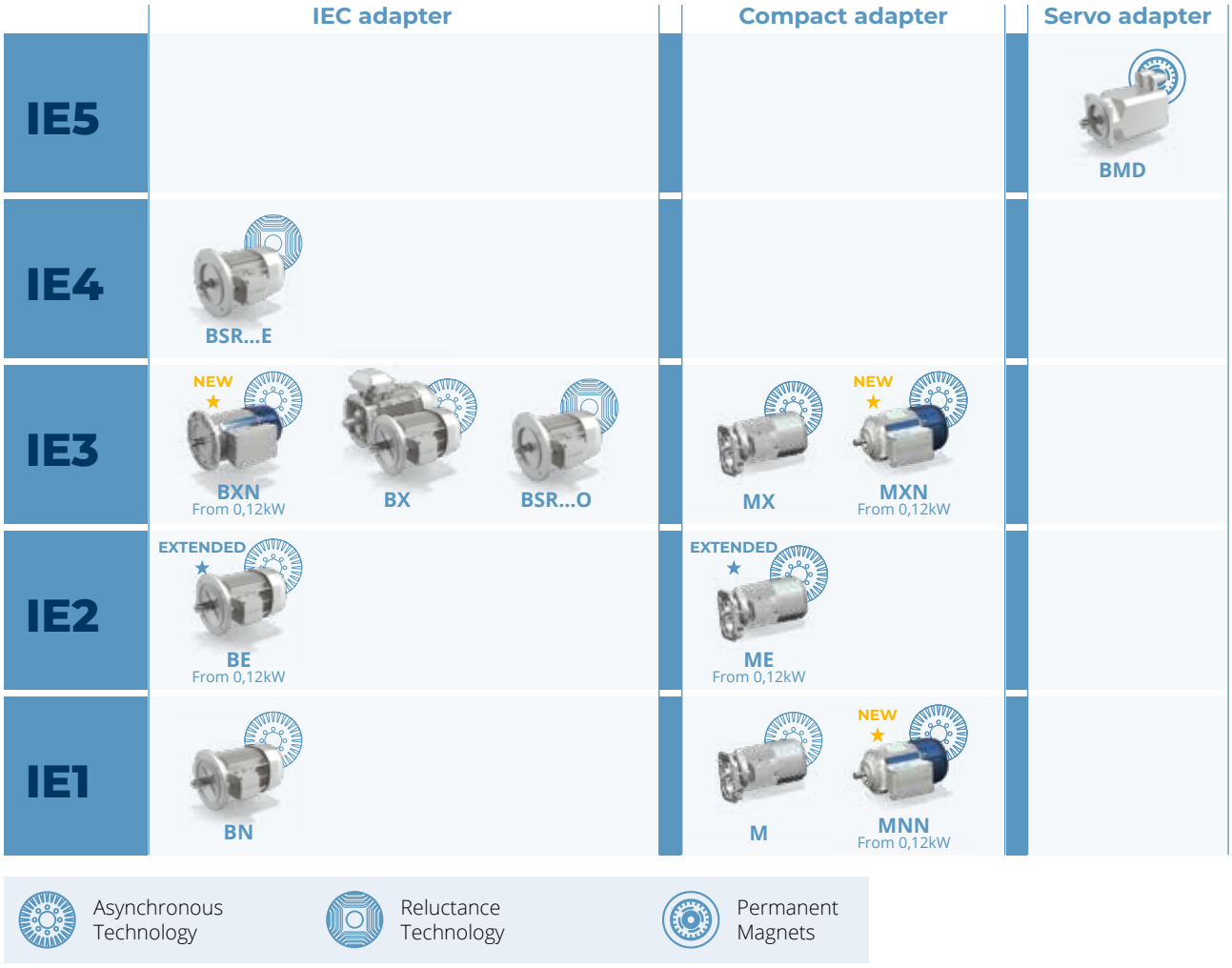
Great potential for energy savings comes from an **efficient overall power drive system**. In Bonfiglioli we recognize this potential, which can only be achieved with a comprehensive approach, supporting you in **developing an energy-optimized drive system based on our great set of product's combinations** to match your application requirements around the world.

Your benefits

- Energy consumption optimization and connected cost saving
- **Optimized solutions** thanks to Bonfilgioli's comprehensive approach based on providing ideal combinations of components covering the entire motion drive train
- **Qualified expertise** to identify and assess your savings potential, whether through new solutions or retrofitting.

MOTORS AND GEARED MOTORS

We offer a wide range of Asynchronous and Synchronous motors for all efficiency levels and compliant with all the different international standards[2].



*2) For the **European countries, new binding requirements** defined as MEPS (Minimum Efficiency Performance Standard), have been introduced according to the European Ecodesign Regulation **2019/1781** starting from **1st July 2021**.*

FREQUENCY INVERTERS

Not only the individual motor, but also **an energy-optimized control by a frequency inverter (CDM: Complete Drive Module)** offers great energy-saving potential.

Our frequency inverters and servo drives portfolio fulfils the **highest IE2 efficiency class** in compliance with the international **EN 61800-9-2** regulation and with the binding requirements established by the Ecodesign Regulation **2019/1781** for Europe, valid from July 2021.
Our drives give a major contribution to **energy consumption optimization and saving** to the entire plant. Several **incorporated functions** are available through parameter setup allowing **to reduce the electrical energy** needed to power motors, such as standby mode and automatic flux reduction.

Complete your solution

Frequency Inverters and Servo drives

POWER DRIVE SYSTEM

The international standard IEC61800-9 deals also with the energy efficiency of **Power Drive Systems (PDS)**, defining the related IES classes: IES0, IES1 and the highest IES2. The standard IEC 61800-9 is harmonized in Europe as EN 61800-9.

In order to ensure a consistent implementation of all the energy-saving factors, Bonfiglioli offers a **comprehensive approach** supporting you in the selection and combination of all the energy-efficient components for the development of the **optimized solution for your application**.

Some IES2 Power Drive Systems examples from our offering:

- BSR SynRM motor + Active Cube inverter (ACU) package
- BSR SynRM motor + DGM Modular decentralized inverter (DGM-MPM) package

BSR

+

Active Cube

DGM-MPM

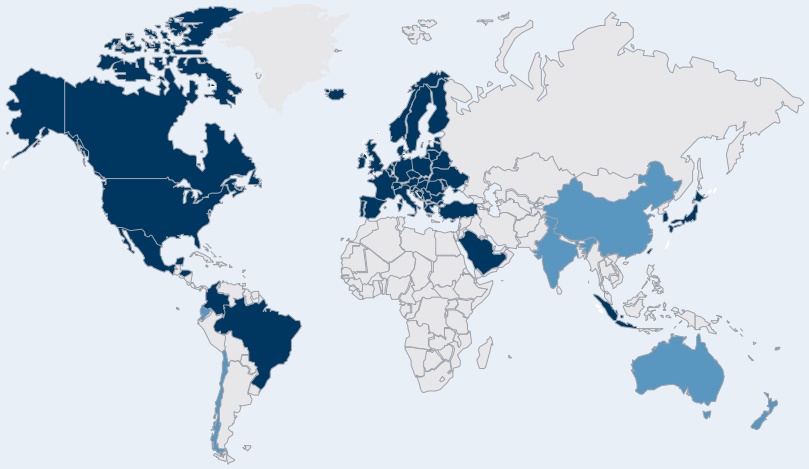
IES2

47%
AVERAGE REDUCTION OF LOSSES VS IES1

Contact us to discover many more opportunities for your high-efficiency solution.

INTERNATIONAL EFFICIENCY REGULATIONS

GLOBAL MINIMUM EFFICIENCY MAP



GLOBAL EFFICIENCY CLASSES

IEC 60034-30-1	IE1	IE2	IE3	IE4	IE5
NEMA MG-1	Standard	High	Premium	Super Premium	
GB 18613		Grade 4	Grade 3	Grade 2	Grade 1
NBR 17094-1		IR2	IR3		
AS/NZS 1359,5	IE1	IE2	IE3		
IS 12615	IE1	IE2	IE3	IE4	
SASO 2893	IE1	IE2	IE3	IE4	
KS C IEC 60034	IE1	IE2	IE3	IE4	
JIS C 4034-30	IE1	IE2	IE3	IE4	

MOTORS EFFICIENCY REQUIREMENTS BY COUNTRIES

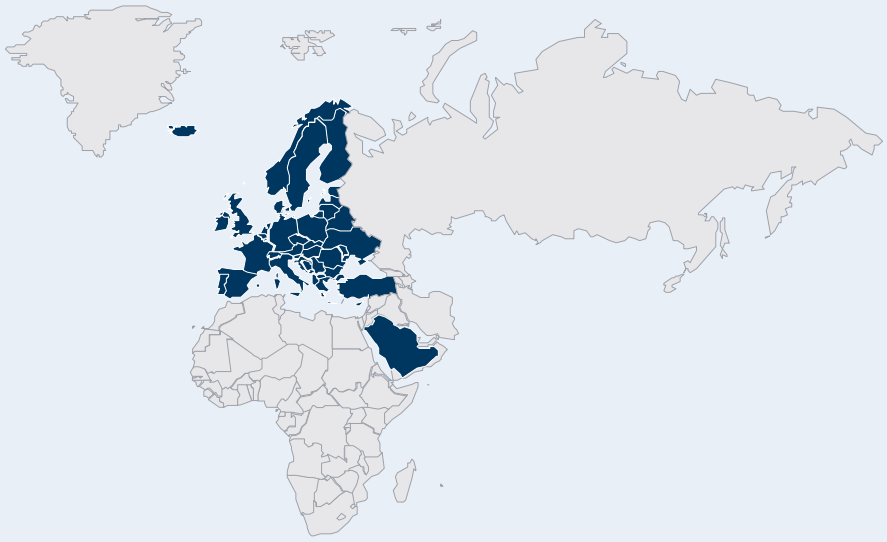
Country	Efficiency class	Required level	Future
Europe*	IEC 60034-30	IE3	01/07/2023: IE4 from 75 to 200kW
U.S.A.	NEMA MG-1	Nema premium	Additional rulings are expected to mandate higher efficiency req. on frame size NEMA 42-48-56
Canada	NEMA MG-1	Nema premium	A regulation for small electric motors (0,25 - 3 HP) with Premium Efficiency (IE3) is planned
Mexico	NEMA MG-1	Nema premium	Mexico orients itself toward US requirements
Brazil	NBR 17094-1	IR3 → IE3	No update planned
South Korea	KS C IEC 60034	IE3	No update planned
Japan	JIS C 4034-30	IE3	No update planned
Singapore	IEC 60034-30	IE3	No update planned
Saudi Arabia	SASO 2893	IE3	No update planned
Taiwan	IEC 60034-30	IE3	No update planned
China**	GB 18613	Grade 3 → IE2	No update planned
India	IS 12615	IE2	India orients itself toward European requirements
Australia	AS/NZS 1359.5	IE2	No update planned
Ecuador	IEC 60034-30	IE2	No update planned
Colombia	IEC 60034-30	IE3	No update planned
Chile	IEC 60034-30	IE2	No update planned
Peru	-	-	No update planned
Argentina	-	-	No update planned

* *From 1st July 2021 onwards, the new rule applies to 3-phase induction motors rated:*
*1) **for continuous duty i.e. duty class S1, S3≥80%, S6≥80%**. All others duty cycle are considered an exception (ex: S3-25%, S2-30min, S9, etc..).*
*2) **as brake motors** so designed that the efficiency of the motor can be determined independently of the brake are no longer exempted.*
*3) **as 2,4,6,8 pole motors**. Multipole are considered an exception.*
*4) **as designed for inverter (VSD) operation**. That means that the actual IE2 + VSD with power rated between 0,75kW ≤ Pw ≤ 375kW need to be at least IE3.*
*5) **with power between 0,12kW ≤ Pw ≤ 1000kW**. In particular, any IE1 motors with a power rated between 0,12kW ≤ Pw ≤ 0,55kW which is not considered exempted from the new regulation need to be shifted at least to a IE2 efficiency class. Any IE1 or IE2 motors with a power rated between 0,75kW ≤ Pw ≤ 1000kW which is not considered exempted from the new regulation need to be shifted at least to a IE3 efficiency class.*

The new rule don't applies to 3-phase induction motors:
1) with an explicit end destination Outside the European Community where the IE1 or IE2 energy efficiency is allowed.
2) with an explicit end destination as exact replacement of a motor that has been placed on the Market before 1st July 2021. These motors can be marketed until 30th June 2029.

** *From 1st June 2021 onwards, the new rule applies to 3-phase induction motors rated:*
*1) **for continuous duty i.e. duty class S1, S3≥80%, S6≥80%**. All others duty cycle are considered an exception (ex: S3-25%, S2-30min, S9, etc..).*
*2) **as 2,4,6,8 pole motors.***
*3) **Multipole**.*
*4) **with power between 0,12kW ≤ Pw ≤ 1000kW** which is not considered exempted from the new regulation need to be shifted at least to a Grade 3 efficiency class. The energy efficiency classification for 3-phase induction motors will be changed as follows: IE2 = Grade 4 (formerly Grade 3) IE3 = Grade 3 (formerly Grade 2) IE4 = Grade 2 (formerly Grade 1) IE5 = Grade 1 (new).*

EXCEPTIONS | EMEA



Country	EU	Switzerland	Turkey	Saudi Arabia
Efficiency	IE3	IE3	IE3	IE3
Non-continuous duty	•	•	•	•
Designed for inverter (VSD) operation				•
Brake motors				
Two speed/Multi-speed/Switchable pole	•	•	•	•
8 pole motor				
Gearmotor				
High-slip/Torque				•
Supplied exclusively for exported equipment				
At altitudes exceeding 4000 meters	•	•	•	•
At altitudes exceeding 1000 meters				
Ambient < -30°C	•	•	•	
Ambient < -20°C				•
Ambient < -15°C				
Ambient > +40°C				
Ambient > +60°C	•	•	•	•
Thermal class H or above				
TENV Totally Enclosed Non-Ventilated	•	•	•	

- This symbol represents an exception to the actual energy regulation. If the e-motor matches with at least one of this characteristics is considered out of the regulation.

We take no responsibility for the information herein is up to date and complete.
Countries that are not yet following the official MEPS, may face strong variations in a short time.

EXCEPTIONS | APAC

Country	India	China	Au/NZ	South Korea	Singapore	Japan	Taiwan
Efficiency	**IE2**	**IE3**	**IE2**	**IE3**	**IE3**	**IE3**	**IE3**
Non-continuous duty	●6	●	●1	●	●7	●	●
Designed for inverter (VSD) operation		●9		●4		●3	●
Brake motors	●5				●		
Two speed/Multi-speed/Switchable pole	●		●	●	●	●	●
8 pole motor					●	●	●
Gearmotor			●8				
High-slip/Torque			●		●	●2	
Supplied exclusively for exported equipment			●		●		
At altitudes exceeding 4000 meters	●		●				
At altitudes exceeding 1000 meters		●			●	●	
Ambient < -30°C					●		
Ambient < -20°C	●	●	●			●	
Ambient < -15°C				●			●
Ambient > +40°C		●		●		●	●
Ambient > +60°C	●		●		●		
Thermal class H or above						●	
TENV Totally Enclosed Non-Ventilated	●	●					

1 Motors rated for duty cycle S2 as stated on Regulation CEI EN 60034- 1 / IEC 34-1
2 0.75 to < 110 kW: ≥ 5%; >110 kW: ≥ 3%
3 Only applies to motors using a forced-cooling fan
4 Not inverter (VSD) motors used in pump, fan or blower applications
5 The motor is integrated with the gear unit so that if it's not possible to test the motor independently, then it is not covered
6 Motors rated for duty cycles S2 and above with an equivalent S1 duty are also covered. These motors must also be marked with the equivalent S1 duty output and its corresponding IE class.
7 Motors rated for duty cycles S6 and S9 must also be marked IE3
8 All gearmotors without motor flange are exempt. All motors for which the gear unit housing constitutes the A-side end shield. (The motor and gear unit form a unit. It means that they cannot be separated without the motor losing its functionality.
9 All induction motors designed "only" for frequency inverter operation are exempt. The nameplate only lists the torque and not the power rating. According to regulation GB 30253 valid from July 1st 2020, PM motors require an IE3 class for the power range 0,55 – 90 kW and for speed from 500 to 3000 rpm.

● This symbol represents an exception to the actual energy regulation. If the e-motor matches with at least one of this characteristics is considered out of the regulation.

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EXCEPTIONS | AME

Country	USA	Canada	Mexico	Brazil	Argentina	Chile	Peru	Ecuador	Colombia
Efficiency	IE3	IE3	IE3	IE3	IE0	IE2	-	IE2	IE3
Non-continuous duty	•	•	•	•	•	•	•	•	•
Designed for inverter (VSD) operation	•	•	•	•	•	•			•
Brake motors			•			•			
Two speed/Multi-speed/Switchable pole	•	•	•	•	•	•	•	•	•
8 pole motor					•	•	•		
Gearmotor					•				
High-slip/Torque	•	•							
Supplied exclusively for exported equipment									
At altitudes exceeding 4000 meters								•	
At altitudes exceeding 1000 meters	•	•		•					•
Ambient < -30°C									
Ambient < -20°C								•	
Ambient < -15°C	•	•		•					•
Ambient > +40°C	•	•		•					•
Ambient > +60°C								•	
Thermal class H or above									
TENV Totally Enclosed Non-Ventilated			•	•	•				

• This symbol represents an exception to the actual energy regulation. If the e-motor matches with at least one of this characteristics is considered out of the regulation.

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Countries that are not yet following the official MEPS, may face strong variations in a short time.

OUR GLOBAL PRESENCE

Thanks to an international network of closely interconnected commercial and production sites, we can guarantee the same high standards of Bonfiglioli quality anywhere at any given time. We know that our direct presence in local markets is the key to long-lasting success, so our family includes 18 production sites, 23 commercial sites and more than 550 distributors around the world.

Our organization is always close by, offering complete and efficient solutions and supporting our customers with dedicated services, co-engineering and after-sales assistance.

18
PRODUCTION SITES

23
COMMERCIAL SITES

80
COUNTRIES

550
DISTRIBUTORS

~4,700
PEOPLE

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