

ENGINEERING  
TOMORROW

*Danfoss*

# Ecodesign and energy efficiency intelligently combined

## IEC 61800-9-2

defines efficiency  
classes for your  
AC drives and  
drive-motor systems

[drives.danfoss.com](http://drives.danfoss.com)

**VLT** | **VACON**

# Ecodesign made simple: motors are the basis - drives make the difference

Efficiency classes enable energy comparisons of various combinations of motors and AC drives. On the basis of the defined efficiency classes, the use of energy-efficient products is assured worldwide through statutory provisions. In Europe, this legal framework is referred to as Ecodesign. This brochure describes the most important features of the efficiency classes relevant to electric drive systems and their legal relevancy. Of course, efficiency is an important factor for the optimal design of a drive-motor system. The user, however, must consider more than just the efficiency classes for an effective and economic overall system: The compatibility of all components as a system solution is what decides the efficiency of an application.



# The Danfoss elements

## Efficient

The prefabricated products offered on the market consist of a motor and an AC drive optimized for a specific range. Danfoss AC drives ensure the optimal operation of any kind of motor – regardless of motor manufacturer – with the right drives for all your applications. Easy, flexible, and independent!

- High efficiency AC drives
- Efficient operation of all common motor technologies, including synchronous reluctance motors.
- Coordinated plant operations
- AEO – Automatic Energy Optimization, which optimizes energy costs
- AMA – Automatic Motor Adaptation for the actual installation
- MyDrive® ecoSmart – Determining the IES class of the system

## Operational reliability

Unforeseen machine down time is critical in every production process and should be avoided.

- Drive optimized to the application
- Worldwide drive availability through regional presence
- Reduced number of motor and drive variants for optimized warehousing operations
- Fewer components that require repair and set-up know-how
- Enclosure rating appropriate to application
- Specially coated circuit boards
- Long service life
- Secure investment since all common motor technologies are supported
- If one motor technology is unavailable locally, simply choose another.

## Simple

Every drive-motor system must be planned and put into operation. Clear selection and simple operation ensure optimal results.

- Intuitive HMI
- The wizard guides the user through the necessary set-up.
- Clear set-up software
- Corresponding EMC filters for your application
- Same operation and parameter structure
- Local language packages
- No influence on motor service life or guarantee

## Cost-effective

A holistic approach must consider the costs involved in acquisition, energy, maintenance and disposal, which all influence the economy of the system.

- Motor prices are dependent on technology and protection class
- Raw material costs (for example, copper) affect the price
- Production costs of new motor technologies are often higher
- Transportation costs (weight and route)
- Number of available manufacturers determines price level
- Manufacturer dependence through special designs
- Savings through energy efficiency
- Danfoss provides the optimal drive configuration for your requirements



### Motor technology

High efficiency can be achieved with a wide variety of technologies. The Danfoss brochure describes the most widely used motor technologies, including their advantages and disadvantages.

[Read more >](#)



### MyDrive® ecoSmart

The web-based tool enables simple determination of the IES class of Danfoss AC drives with a motor.

[Read more >](#)



### Motor independent

See for yourself how easy it is to set up IM, PM, and SynRM motors with Danfoss AC drives.

[Read more >](#)



# Definitions and scope of IEC 61800-9-2

The IEC 61800-9-2 standard defines efficiency classes for motor systems. The class descriptions use terms which may not yet be widely known.

## Complete Drive Module (CDM)

Describes the AC drive consisting of power electronics (rectifier and inverter) between the grid and the motor, including all necessary auxiliary components such as in-built protective devices, control transformers, cooling fans and auxiliary equipment.

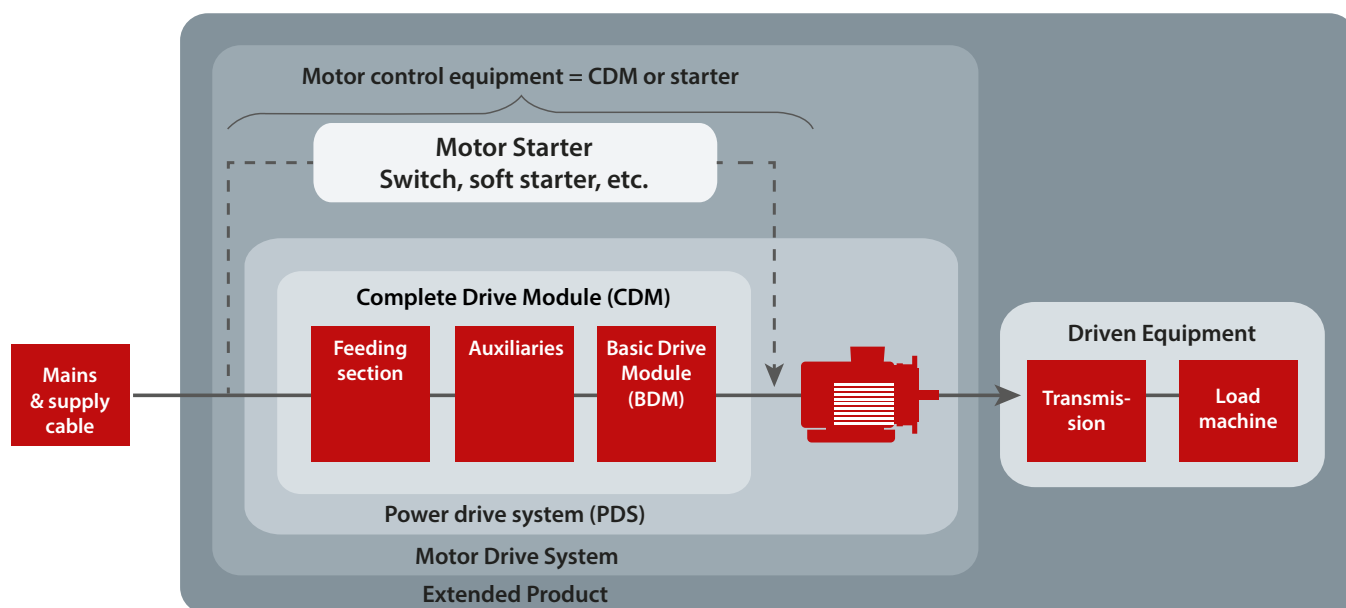
Note: Components like EMC filters can be integrated into the CDM, but do not have to be.

## PDS

The combined drive and motor are known as the Power Drive System (PDS). This consists of the Complete Drive Module, the motor cable and the motor. There is no distinction between different motor technologies.

## Driven Equipment

The standard defines the actual machine, including a mechanical transmission stage such as a belt or a gearbox, as the Driven Equipment.



## Extended Product

In actual practice, systems rather than components save energy. This is why the Extended Product approach considers the interactions between the motor system and the driven machine. The system

should thus be assessed according to a load/time profile in actual use, resulting in an energy efficiency index (EEI).

The concept is described in EN 17038 using centrifugal pumps as an example.

## Motor Drive System

An electric motor always needs a controller to supply it with power. In the simplest case, a switch provides mains voltage directly to the motor. The PDS is a subset of the Motor Drive System.

# We fulfill the Ecodesign requirements

Driven by the Ecodesign Directive, the requirements for energy efficiency in drive technology are becoming increasingly stringent. For example, since 2011 the EU has introduced minimum requirements for the efficiency of three-phase motors and gradually tightened them.



In line with the IE classification system for electric motors, the European standard IEC 61800-9-2 has been developed over the past few years. It defines IE efficiency classes for drives and IES classes for drive-motor systems.

Danfoss drives comply with the highest class: IE2. Of course, they also comply if the drive includes EMC filters.

If a VLT® or VACON® drive is used with a good IE2 motor or a motor in class IE3 or IE4, the combination will usually

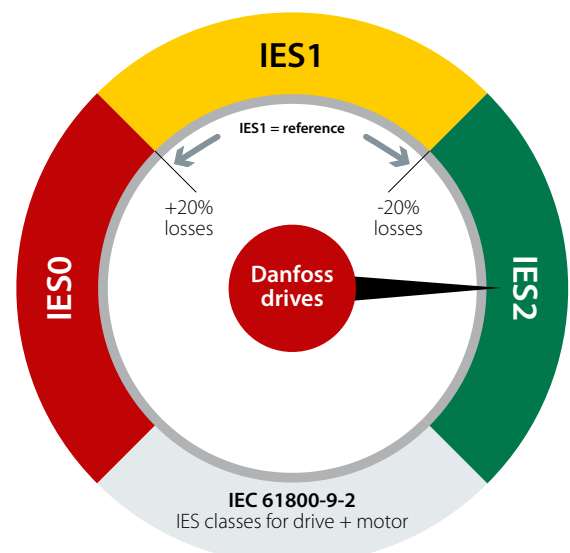
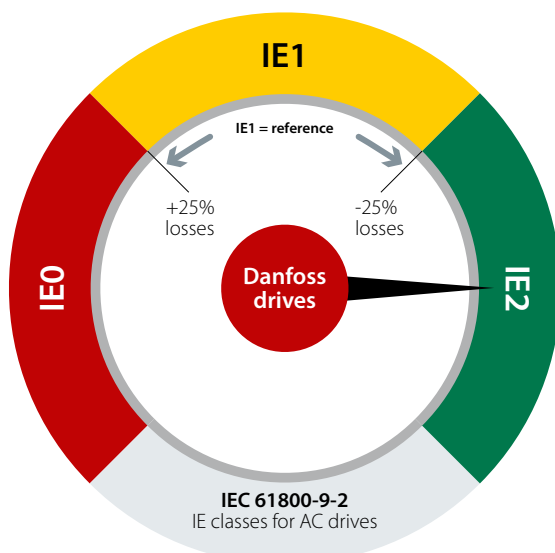
also meet the requirements of the highest combination class IES2.

Danfoss is gradually publishing all necessary information on the IE/IES classes in its manuals and on its website.

In addition, the part-load efficiencies according to IEC 61800-9-2 are gradually being published online.

You can also read more about the different efficiency classes on the following pages. As well

as the definitions, you will also learn how much this new label ensures comparability between different products, systems and solutions and what you should watch out for, as well as the legal requirements for compliance.

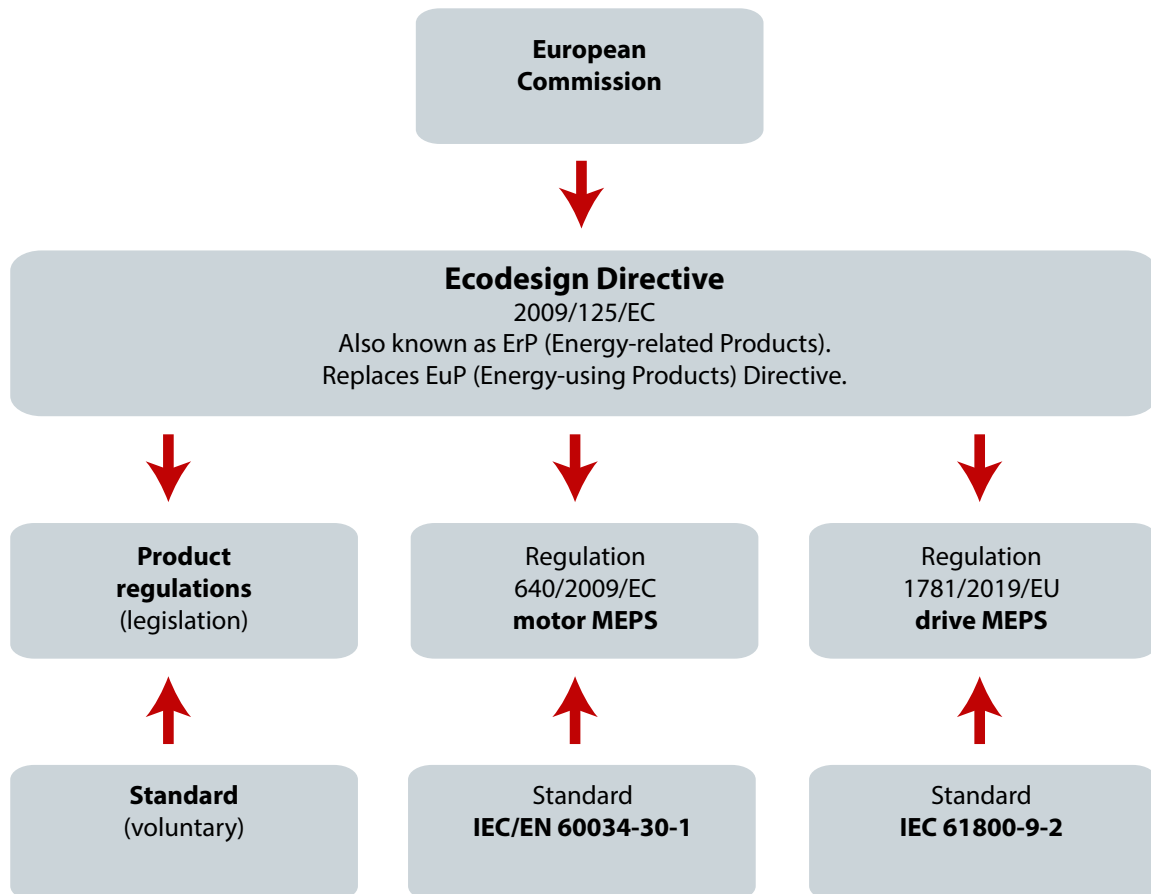




# The Ecodesign Directive

“The aim of the Ecodesign Directive is to reduce the environmental impact of energy-related products over their entire lifetime. It defines requirements for product design.”

Quote from the German Federal Environment Agency (<http://www.umweltbundesamt.de/>)



**Note: Not all aspects of a standard are incorporated in regulations.**

The Ecodesign Directive is Directive 2009/125/EC. It is also known as the ErP (Energy Related Products) Directive, as all products related to energy consumption with a certain savings potential fall under this directive.

The previous Directive 2005/32/EC only considered the energy consumption of devices (EuP = Energy-using Products). The ErP Directive has replaced the EuP Directive.

Regulations relating to the Ecodesign Directive set out the specific energy requirements for the products concerned. For example, they define the minimum requirements in each case, also known as the Minimum Efficiency Performance Standards (MEPS).

### Principle and scope

Across the globe, the legally binding directives and regulations for greater energy efficiency mostly rely on the same, internationally valid

technical standards. However, the defined efficiency limits and the time frames for local introduction vary from region to region or from country to country.

This means that the Ecodesign specifications, which are naturally only legally binding for Europe at this stage, are easy to compare to the requirements in North America or Australia, for example.

# Ecodesign requirements for motors

EU regulation 640/2009 defines minimum efficiency classes for motors. These regulations were strengthened in 2014, and further changes will come into force from mid-2021.

## Efficiency classes

The efficiency classes are based on the IEC/EN 60034-30-1 standard, which defines classes IE0 to IE4 for electric motors.

## Scope of the legal requirements

Compliance with the minimum efficiency classes for motors is prescribed for most electric motors:

Changes from 1 July 2021:

- Operating mode S1, S3 (ED>80%), S6 (ED > 80%)
- Pole number 2 to 8
- Power range 0.12 -1000 kW
- Rated voltage up to 1000 V, 1~ & 3~

Exceptions include brake motors or motors that are entirely incorporated into a product (for example, a gearbox

or a pump), where energy efficiency cannot be determined independently of the product.

## Phased intensification of requirements

Year introduced	Minimum Efficiency Performance Standard in Europe			
	Motors <sup>[1], [2]</sup>		Drives	
	Class	Power range	Class	Power range
2017	IE3/IE2 and VSD <sup>[3]</sup>	3~ 0.75-375 kW	No requirement	0.12-1000 kW
2021	IE2	3~ 0.12-0.75 kW	IE2	0.12-1000 kW
	IE3	3-phase: 0.75-1000 kW		
2023	IE2	single-phase: ≥0.12 kW	IE2	0.12-1000 kW
	IE3	3-phase: 0.75-75 kW and 200-1000 kW		
	IE4	3~ 75-200 kW		

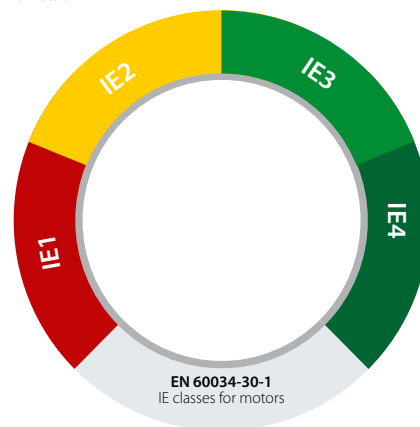
[1] For 3-phase motors (2/4/6 pole). Also 8-pole motors from 2021 onwards. Class IE2 will apply to single-phase and Ex eb motors from 2023. IE4 only for 2-, 4- and 6-pole motors.

[2] Part-load losses for AC drive operation must be provided from 1 July 2022 onward.

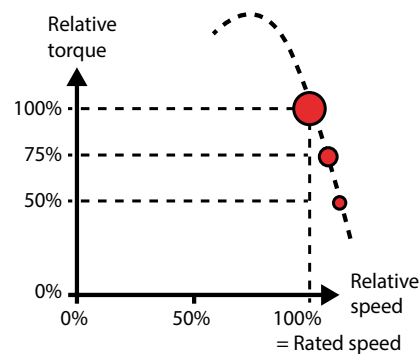
[3] IE2 + AC drive as an alternative to IE3 motors

## Comparability: Good

Motors are easily compared based on MEPS. However, note that each of the respective classes has its own efficiency range.



## IE classes for motors according to EN 60034-30-1



- = reference point used to define the IE class
- = part-load points according to the standard

- IE classes relate to the rated operating point of the motor.
- The efficiency for 50% and 75% part load at the mains frequency must be stated in the documentation.
- The classes apply to motors operating directly from the mains, with no differentiation between technologies.
- Induction motors with a higher efficiency typically have a higher speed. Keep this in mind when replacing them.
- The mounting dimensions of motors can differ depending on the technology and the IE class.

# Ecodesign requirements for drives

EU Regulation 1781/2019 defines minimum efficiency classes for AC drives. These will be enforced from mid-2021.

## Efficiency classes

The IEC EN 61800-9-2 standard defines the efficiency classes IE0 to IE2 according to the actual efficiency of the AC drive.

For example, a 7.5 kW drive with an efficiency of 95% or higher achieves efficiency class IE2. If the efficiency is below 91%, it is classed as IE0.

### IEC EN 61800-9-1:

Defines the efficiency classes of drives and motors in extended products (for example, motor + drive + pump)

### IEC 61800-9-2:

Defines the efficiency classes IE (drive) and IES (drive + motor)

## Scope

The IEC EN 61800-9-2 standard applies to AC drives meeting the following conditions:

- Power range: 0.12-1000 kW
- Voltage range: 100-1000 V
- Single-axle AC/AC drive-motor systems

Drives with active front ends are excluded from classification because they often have relatively high losses.

## Legal requirements

From 1 July 2021, drives must at minimum comply with class IE2 efficiency:

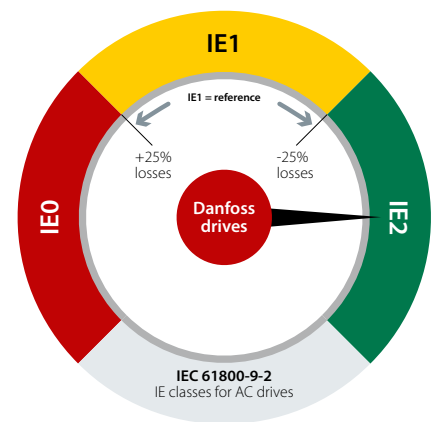
- 1x 3-phase output
- Power range: 0.12-1000 kW
- Rated voltage: 3~ 100-1000 V

Exemptions:

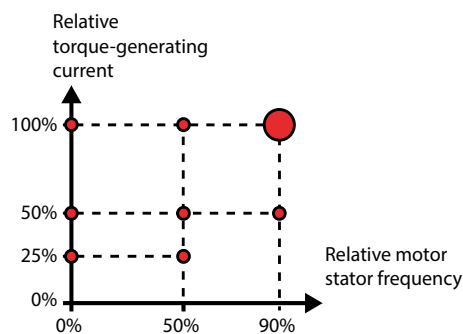
- Integrated drives where measurement is not possible
- Devices for nuclear applications
- Drives with sinusoidal input voltage (THDi < 10%)
- Regenerative drives

## Comparability: Good

IE classification with a defined load ( $\cos \phi$  and current) makes it easy to compare devices using the classes. However, the device designs must be comparable.



## IEC 61800-9-2 IE classes for AC drives



- = reference point used to define the IE class
- = part-load points according to the standard

- The IE class is defined at 90% of the frequency and 100% of the torque-generating current.
- Special test modes are not allowed.
- The efficiency class covers the supplied device, including all integrated options. For non-integrated options (EMC filters, line chokes, etc.), losses must be stated in the documentation if they exceed the following values:
  - >0.1% of drive power or
  - 5 W in total
- Part-load losses can be documented, but do not have to be.



# Ecodesign requirements for drive-motor systems

The IEC 61800-9-2 standard defines the IES efficiency classes for combinations of AC drives and motors.

All combinations are covered by this standard, regardless of whether the user:

- purchases the drive and the motor as individual components;
- purchases the drive and the motor as a package; or
- deploys a compact unit.

## Efficiency classes

The IEC EN 61800-9-2 standard defines the efficiency classes IES0 to IES2 for AC drives together with a motor.

## Scope

The scope is identical to the IE classes for drives:

- Power range: 0.12-1000 kW
- Voltage range: 100-1000 V
- Single-axle AC/AC drive-motor systems

## Comparability: Limited

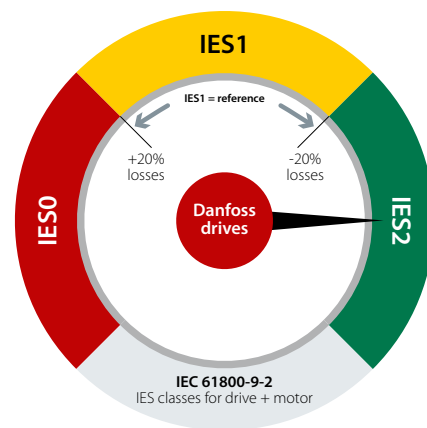
While the standard defines framework conditions for measuring device combinations, it permits deviation from these specifications so long as this is documented by



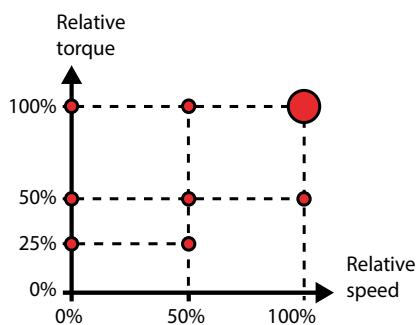
the manufacturer. This means that, for example, cable lengths, filters and motor types may differ. Objective comparison is possible if these framework conditions are observed.

## Legal requirements

No legal regulations are expected before 2025.



## IES classes for AC drives and motors according to IEC 61800-9-2



- = reference point used to define the IES class
- = part-load points according to the standard

- The IES class applies to the drive-motor system.
- The IES class is defined at 100% speed and 100% torque.
- The cable length between the motor and the drive is defined in the standard.
- Changes in cable length, switching frequency, etc. are permitted, but must be documented.
- Part-load losses can be documented, but do not have to be.

# Manufacturer-independent IES class determination

For many applications, the best solution is to combine drives and motors from different manufacturers. If the losses of the drive and the motor are known at the rated operating point, they only need to be aligned

and added to find the system losses. These system losses can then be used to determine the IES class. Similarly, it is also possible to calculate the losses at various partial load points that are relevant to the application concerned.

## Reference motor and drive

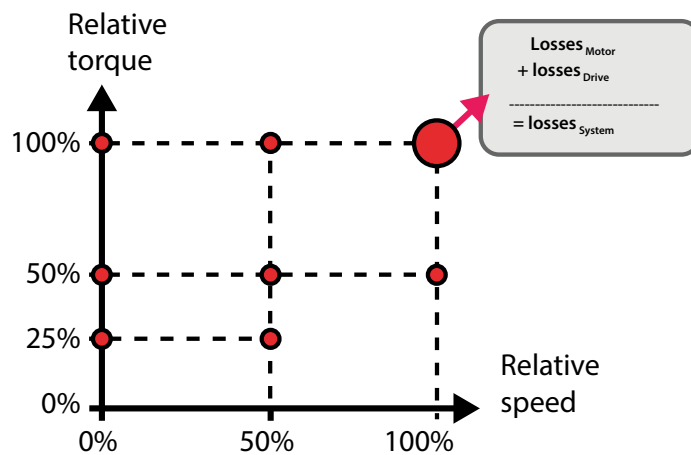
The IEC 61800-9-2 standard defines loss values for reference motors and drives. This reference data can be used as an alternative to real data to estimate IES classes.

## Example calculation:


7.5 kW drive (IE1) and motor (IE2)

Drive losses:	675 W
Motor losses:	1032 W
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System losses:	1707 W

The IES class can be derived from the table below, which is an excerpt from the overall table in the standard.



In the example, the system achieves efficiency class IES1 with 1707 W losses.



## MyDrive<sup>®</sup> ecoSmart does the calculations for you

You can determine the IE class and the efficiency of Danfoss drives under various loads with the MyDrive<sup>®</sup> ecoSmart tool. You can also determine the efficiency and the protection class of any motor drive system controlled by a Danfoss drive.

**<http://ecosmart.danfoss.com>**

# What does Ecodesign mean for my drive systems?



## Reduced energy costs

The aim of the requirements and standards covered by Ecodesign is to reduce energy consumption in your plant.



## Global acceptance

The IEC 61800-9 standard is valid worldwide.



## Increased transparency

It makes the energy requirements of the individual components more transparent. This will gradually eliminate inefficient drive systems from the market. Allocation to efficiency classes helps users to assess their options.



## Improved competitiveness

Through the combination of documented efficiency and the optimal components for your application needs, many opportunities for market differentiation are possible. By contrast, pre-defined packages or bundled solutions offered by manufacturers provide only limited potential for differentiation in regional and global markets, in both technical and commercial terms.



## What do I need to comply with?

Users often need to know which stipulations are legally mandatory, and which are voluntary. In specific cases, these questions require a legal expert. Regardless of this, users and manufacturers can of course agree to take standards like IEC 61800-9-2 into account even if this is not required by law.

## Factors influencing the choice of motor and drive or a combination of the two

Technical specifications	Logistical reasons	Economic reasons	Service and maintenance
<ul style="list-style-type: none"> <li>■ Compliance with the required efficiency class</li> <li>■ Footprint and frame size of the motor</li> <li>■ Operating characteristics (startup, load, mains voltage)</li> <li>■ Customer requirements</li> </ul>	<ul style="list-style-type: none"> <li>■ Motor and drive stock holding</li> <li>■ Motor frame sizes (not IE1-compatible)</li> <li>■ Regional availability</li> <li>■ Delivery time</li> </ul>	<ul style="list-style-type: none"> <li>■ Total cost of ownership</li> <li>■ Motor prices</li> <li>■ Raw material surcharges (e.g. copper)</li> <li>■ Transportation costs</li> <li>■ Savings through energy efficiency</li> </ul>	<ul style="list-style-type: none"> <li>■ Regional/worldwide availability</li> <li>■ Number of motor and drive variants</li> <li>■ Repair and commissioning expertise</li> <li>■ Training expense</li> </ul>



# A better tomorrow is **driven by drives**

**Danfoss Drives is a world leader in variable speed control of electric motors.**

We offer you unparalleled competitive edge through quality, application-optimized products and a comprehensive range of product lifecycle services.

You can rely on us to share your goals. Striving for the best possible performance in your applications is our focus. We achieve this by providing the innovative products and application know-how required to optimize efficiency, enhance usability, and reduce complexity.

From supplying individual drive components to planning and delivering complete drive systems; our experts are ready to support you all the way.

You will find it easy to do business with us. Online, and locally in more than 50 countries, our experts are never far away, reacting fast when you need them.

You gain the benefit of decades of experience, since 1968. Our low voltage and medium voltage AC drives are used with all major motor brands and technologies in power sizes from small to large.

**VACON® drives** combine innovation and high durability for the sustainable industries of tomorrow.

For long lifetime, top performance, and full-throttle process throughput, equip your demanding process industries and marine applications with VACON® single or system drives.

- Marine and Offshore
- Oil and Gas
- Metals
- Mining and Minerals
- Pulp and Paper

- Energy
- Elevators and Escalators
- Chemical
- Other heavy-duty industries

**VLT® drives** play a key role in rapid urbanization through an uninterrupted cold chain, fresh food supply, building comfort, clean water and environmental protection.

Outmaneuvering other precision drives, they excel, with remarkable fit, functionality and diverse connectivity.

- Food and Beverage
- Water and Wastewater
- HVAC
- Refrigeration
- Material Handling
- Textile

## VLT® | VAGON®

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