SCOoPE Saving Cooperative Energy

Energy Efficiency in electric motors driven industrial systems

Webinar nº 6

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FOR ENERGY RESOURCES
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Classification of electric motors

They are classified according to the type of current that is necessary to ignite them

- *Direct Current (DC)*
- *Alternating Current (AC)*

In the electric motors of alternative current the electromagnetic field can be generated of two ways:

a) By means of alternating current (asynchronous machines)

b) By means of direct current (synchronous machines)

The most commonly used motors are asynchronous AC

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Saving Cooperative Energy

Energy Efficiency in Engines

In general the induction engines are lighter and have less inertia so it is easier to adapt the speed of rotation according to the demand. In addition, these kind of engines are cheaper and their performance is higher.

On the other hand, DC engines have been commonly easier to control, however in recent years advances in power electronics have made it possible for the speed of rotation of AC engines to be controlled.

PROPERTY	COMPARATION
Weight	Induction Engines < Direct Current Engines
Inertia	Induction Engines < Direct Current Engines
Maintenance	Induction Engines < Direct Current Engines
Performance	Induction Engines > Direct Current Engines
Control	Usually easier in M.C.C but power electronics made it will be possible in M.I
Cost	Induction Engines < Direct Current Engines

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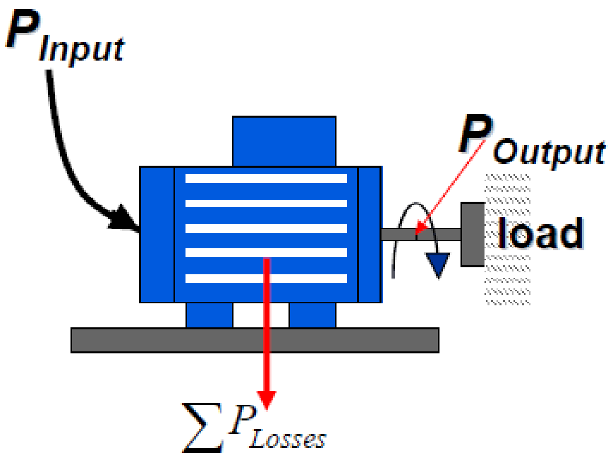
Performance definition:

The performance of an electric engine is defined as the result of dividing the mechanic output power between the electric input power.



$$\eta = \frac{P_{Output}}{P_{Input}}$$

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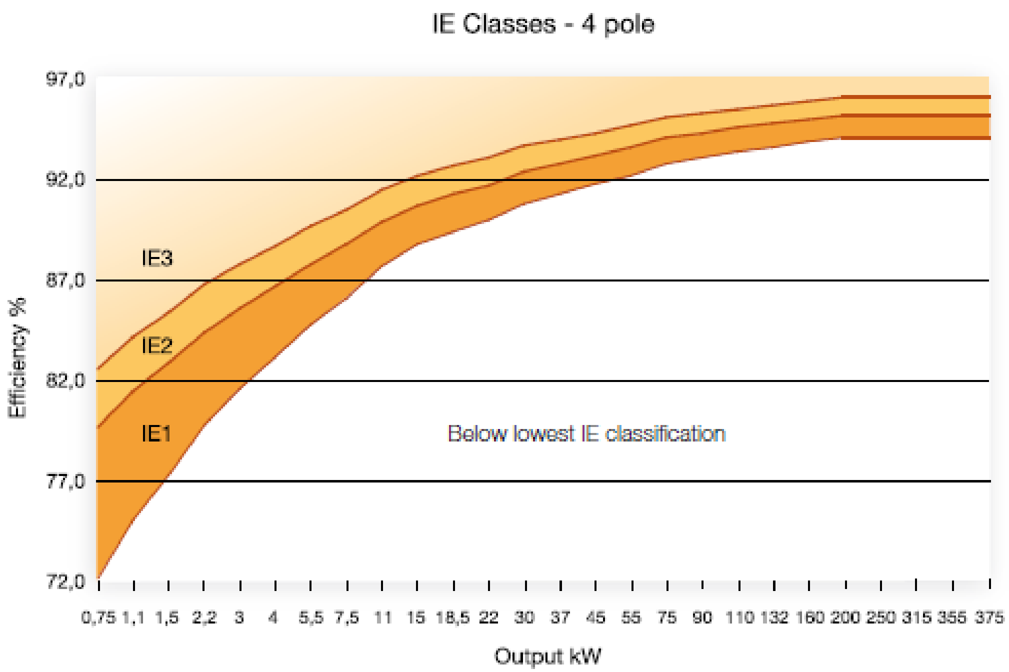
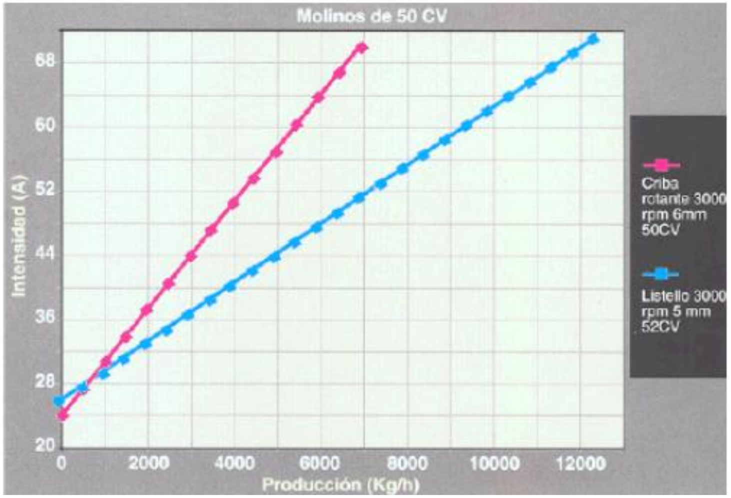
Energy Efficiency in Engines

Performance definition:





The performance is not constant and will be greater the higher the output power

But the higher the output power will also be higher energy consumption

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What are the opportunities to save energy in electric engines?

1.- Make an inventory of the electric engines installed in the cooperative with the following methodology:

a) Identify the engines and the associated process (pumping, ventilation, drives…)

b) Identify the electric characteristics: Power, demand current, voltage, power factor, operation regime.

c) Knowledge of the number of hours the engine operates

d) Load or demand factor

e) Maintenance program

f) Consumption as possible (meter or grid analyzer for measurement)

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What are the opportunities to save energy in electric engines?

2.- Correct selection of the engines:

a) It is very common to see oversized engines, which causes the nominal power to be too high compared to what it is needed to cover the needs

An oversizing causes:

- An increase in losses
- An increase in installed power
- A reduction in the electric power factor (cos φ)
- An overall reduction in energy efficiency in processes

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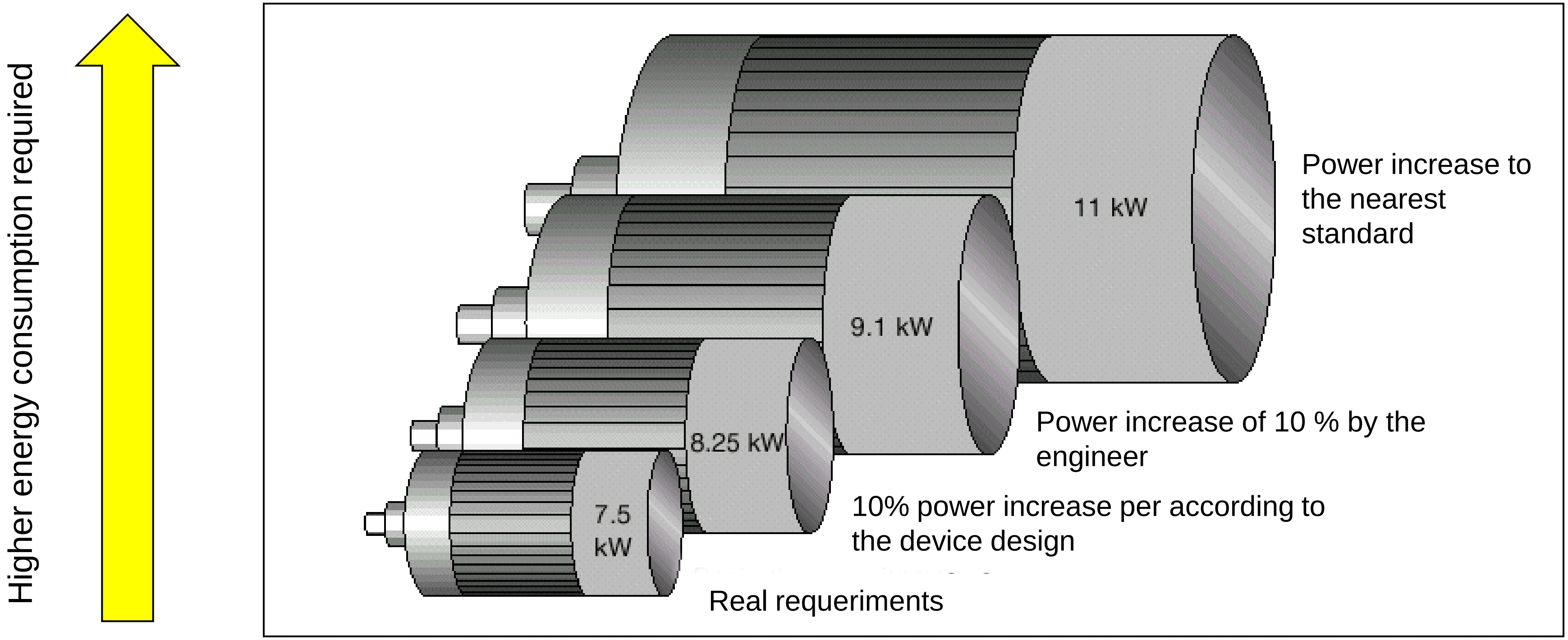
Energy Efficiency in Engines

What are the opportunities to save energy in electric engines?

2.- Correct selection of the engines:



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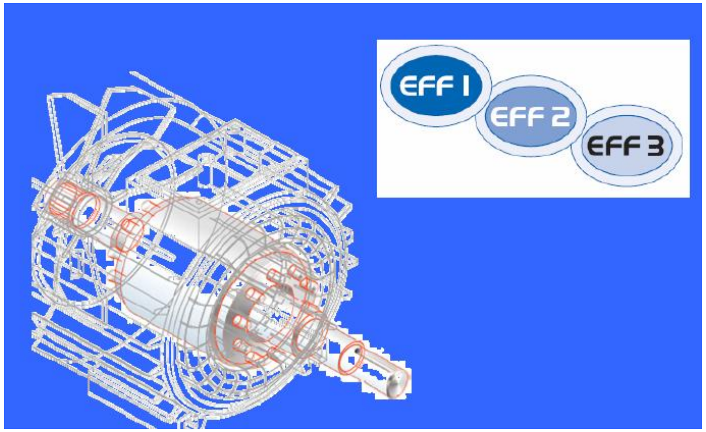
Energy Efficiency in Engines

What are the opportunities to save energy in electric engines?

3.- Replace old engines with new ones with high efficiency.

Classification

- EFF1: High efficiency engines
- EFF2: Improved efficiency engines
- EFF3: Standard engines



Manufacturers agreement to differentiate their devices from others

Europe: EN-IEC 60034-2 for powers in the range of (1,1 kW – 90 kW) for 2 and 4 poles with voltage 400 V and 50 Hz

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Energy Efficiency in Engines

What are the opportunities to save energy in electric engines?

3.- Replace old engines by new ones with high efficiency.

At present, the requirements of the EN 60024-30 published by the European Commission classify the energy efficiency in engines of 0,75 kW – 375 kW of 2, 4 and 6 poles

Classification:

- IE1: Engines with a standard efficiency. Similar to EFF2
- IE2: High efficiency engines, similar to EFF1
- IE3 : More energy efficient motors. Losses are reduced by 15 %.
- IE4 : Super premium efficiency motors.

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Energy Efficiency in Engines

Legislation:

- EU MEPS (European Minimum Energy Performance Standard)
- In July 2009 the European Commission's legislation was published, which establishes the eco-design requirements for engines
- In June 2011, engines from 0,75 kW to 375 kW will be required to be of minimum efficiency of IE2
- From 2015 the minimum performance of engines from 7,5 kW to 375 kW will be IE3
- From 2017 this obligation will be extended to engines from 0,75 kW to 5,5 kW

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Energy Efficiency in Engines

Legislation:

IEC 60034	CEMEP
IE4 Super premium efficiency	
IE3 premium efficiency	
IE2 high efficiency	EFF1
IE1 standard efficiency	EFF2

The IEC 60034 legislation is broader than EU MEPS because it includes all types of engines (explosive atmosphere, brake engines)

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Energy Efficiency in Engines

What are the opportunities to save energy in electric engines?

3.- Replace old engines by new ones with high efficiency.

Characteristics of the motors of high energy efficiency:

- More surface conductors so the resistance is lower, and losses by Joule effect (Losses = I^2*R) will decrease
- Use of steel with better magnetic properties.
- Ventilation losses are reduced due to better design.
- They operate at lower temperatures
- They better resist the voltage variance and the existence of harmonics
- The power factor is higher
- They are quieter
- The duration of the operation is greater

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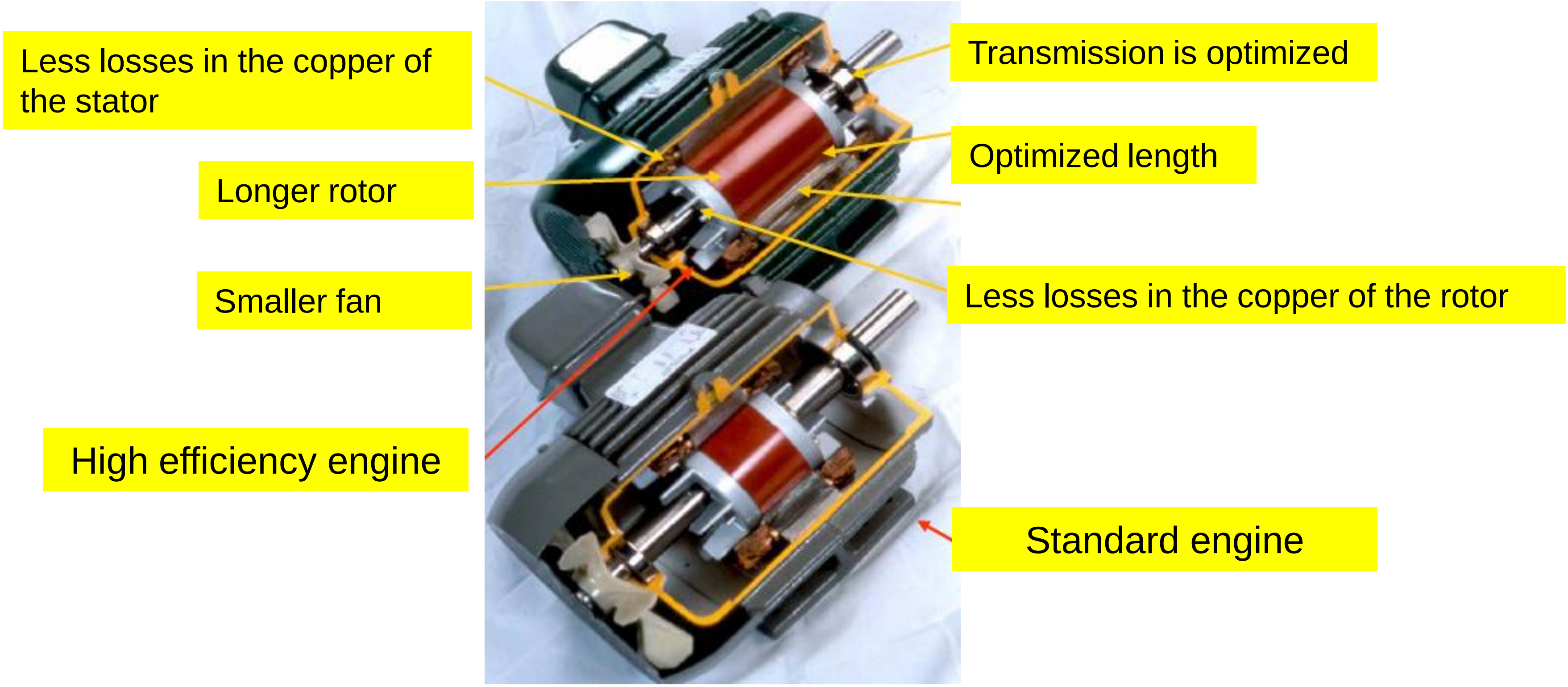

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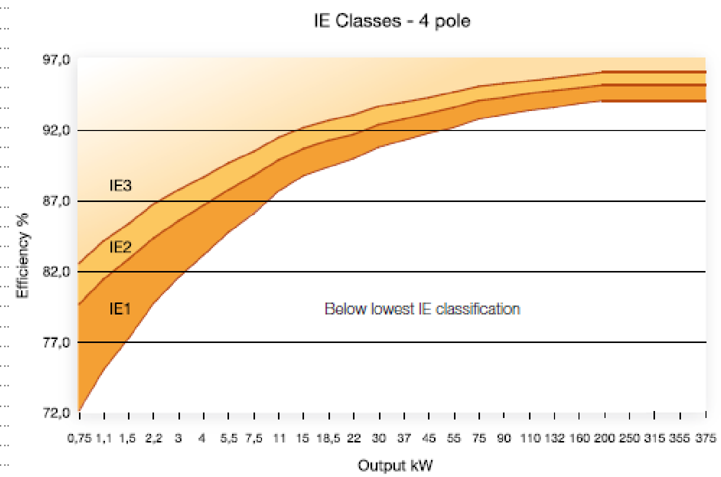
Energy Efficiency in Engines

What are the opportunities to save energy in electric engines?

3.- Replace old engines by new ones with high efficiency.

Table 1 Table with efficiency classes: IE 60034-30 (2008)

kW	HP	IE-1 - Standard efficiency						IE2 - High efficiency						IE3 - Premium efficiency					
		2 pole		4 pole		6 pole		2 pole		4 pole		6 pole		2 pole		4 pole		6 pole	
		50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz	50 Hz	60 Hz
0.75	1	72.1	77.0	72.1	78.0	70.0	73.0	77.4	75.5	79.6	82.5	75.9	80.0	80.7	77.0	82.5	85.5	78.9	82.5
1.1	1.5	75.0	78.5	75.0	79.0	72.9	75.0	79.6	82.5	81.4	84.0	78.1	85.5	82.7	84.0	84.1	86.5	81.0	87.5
1.5	2	77.2	81.0	77.2	81.5	75.2	77.0	81.3	84.0	82.8	84.0	79.8	86.5	84.2	85.5	85.3	86.5	82.5	88.5
2.2	3	79.7	81.5	79.7	83.0	77.7	78.5	83.2	85.5	84.3	87.5	81.8	87.5	85.9	86.5	86.7	89.5	84.3	89.5
3		81.5	–	81.5	–	79.7	–	84.6	–	85.5	–	83.3	–	87.1	–	87.7	–	85.6	–
3.7	5	–	84.5	–	85.0	–	83.5	–	87.5	–	87.5	–	87.5	–	88.5	–	89.5	–	89.5
4		83.1	–	83.1	–	81.4		85.8	–	86.6	–	84.6	–	88.1	–	88.6	–	86.8	–
5.5	7.5	84.7	86.0	84.7	87.0	83.1	85.0	87.0	88.5	87.7	89.5	86.0	89.5	89.2	89.5	89.6	91.7	88.0	91.0
7.5	10	86.0	87.5	86.0	87.5	84.7	86.0	88.1	89.5	88.7	89.5	87.2	89.5	90.1	90.2	90.4	91.7	89.1	91.0
11	15	87.6	87.5	87.6	88.5	86.4	89.0	89.4	90.2	89.8	91.0	88.7	90.2	91.2	91.0	91.4	92.4	90.3	91.7
15	20	88.7	88.5	88.7	89.5	87.7	89.5	90.3	90.2	90.6	91.0	89.7	90.2	91.9	91.0	92.1	93.0	91.2	91.7
18.5	25	89.3	89.5	89.3	90.5	88.6	90.2	90.9	91.0	91.2	92.4	90.4	91.7	92.4	91.7	92.6	93.6	91.7	93.0
22	30	89.9	89.5	89.9	91.0	89.2	91.0	91.3	91.0	91.6	92.4	90.9	91.7	92.7	91.7	93.0	93.6	92.2	93.0
30	40	90.7	90.2	90.7	91.7	90.2	91.7	92.0	91.7	92.3	93.0	91.7	93.0	93.3	92.4	93.6	94.1	92.9	94.1
37	50	91.2	91.5	91.2	92.4	90.8	91.7	92.5	92.4	92.7	93.0	92.2	93.0	93.7	93.0	93.9	94.5	93.3	94.1
45	60	91.7	91.7	91.7	93.0	91.4	91.7	92.9	93.0	93.1	93.6	92.7	93.6	94.0	93.6	94.2	95.0	93.7	94.5
55	75	92.1	92.4	92.1	93.0	91.9	92.1	93.2	93.0	93.5	94.1	93.1	93.6	94.3	93.6	94.6	95.4	94.1	94.5
75	100	92.7	93.0	92.7	93.2	92.6	93.0	93.8	93.6	94.0	94.5	93.7	94.1	94.7	94.1	95.0	95.4	94.6	95.0
90	125	93.0	93.0	93.0	93.2	92.9	93.0	94.1	94.5	94.2	94.5	94.0	94.1	95.0	95.0	95.2	95.4	94.9	95.0
110	150	93.3	93.0	93.3	93.5	93.3	94.1	94.3	94.5	94.5	95.0	94.3	95.0	95.2	95.0	95.4	95.8	95.1	95.8
132		93.5		93.5	–	93.5	–	94.6	–	94.7	–	94.6	–	95.4		95.6	–	95.4	–
150	200	–	94.1	–	94.5	–	94.1	–	95.0	–	95.0	–	95.0	–	95.4	–	96.2		95.8
160		93.8		93.8	–	93.8	–	94.8	–	94.9	–	94.8	–	95.6	–	95.8	–	95.6	–
185	250	–	94.1	–	94.5	–	94.1	–	95.4	–	95.4	–	95.0	–	95.8	–	96.2	–	95.8
200		94.0	–	94.0	–	94.0	–	95.0	–	95.1	–	95.0	–	95.8	–	96.0	–	95.8	–
220	300	94.0	94.1	94.0	94.5	94.0	94.1	95.0	95.4	95.1	95.4	95.0	95.0	95.8	95.8	96.0	96.2	95.8	95.8
250	350	94.0	94.1	94.0	94.5	94.0	94.1	95.0	95.4	95.1	95.4	95.0	95.0	95.8	95.8	96.0	96.2	95.8	95.8
300	400	94.0	94.1	94.0	94.5	94.0	94.1	95.0	95.4	95.1	95.4	95.0	95.0	95.8	95.8	96.0	96.2	95.8	95.8
330	450	94.0	94.1	94.0	94.5	94.0	94.1	95.0	95.4	95.1	95.4	95.0	95.0	95.8	95.8	96.0	96.2	95.8	95.8
375	500	94.0	94.1	94.0	94.5	94.0	94.1	95.0	95.4	95.1	95.4	95.0	95.0	95.8	95.8	96.0	96.2	95.8	95.8



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Energy Efficiency in Engines

EU CEMEP classification for engines with 4 poles:

kW	EFF3 η_n	EFF2 η_n	EFF1 η_n
1.1	< 76.2	>= 76.2	>=83.8
1.5	< 78.5	>= 78.5	>=85.0
2.2	< 81.0	>= 81.0	>=86.4
3	< 82.6	>= 82.6	>=87.4
4	< 84.2	>= 84.2	>=88.3
5.5	< 85.7	>= 85.7	>=89.2
7.5	< 87.0	>= 87.0	>=90.1
11	< 88.4	>= 88.4	>=91.0
15	< 89.4	>= 89.4	>=91.8
18.5	< 90.0	>= 90.0	>=92.2
22	< 90.5	>= 90.5	>=92.6
30	< 91.4	>= 91.4	>=93.2
37	< 92.0	>= 92.0	>=93.6
45	< 92.5	>= 92.5	>=93.9
55	< 93.0	>= 93.0	>=94.2
75	< 93.6	>= 93.6	>=94.7
90	< 93.9	>= 93.9	>=95.0

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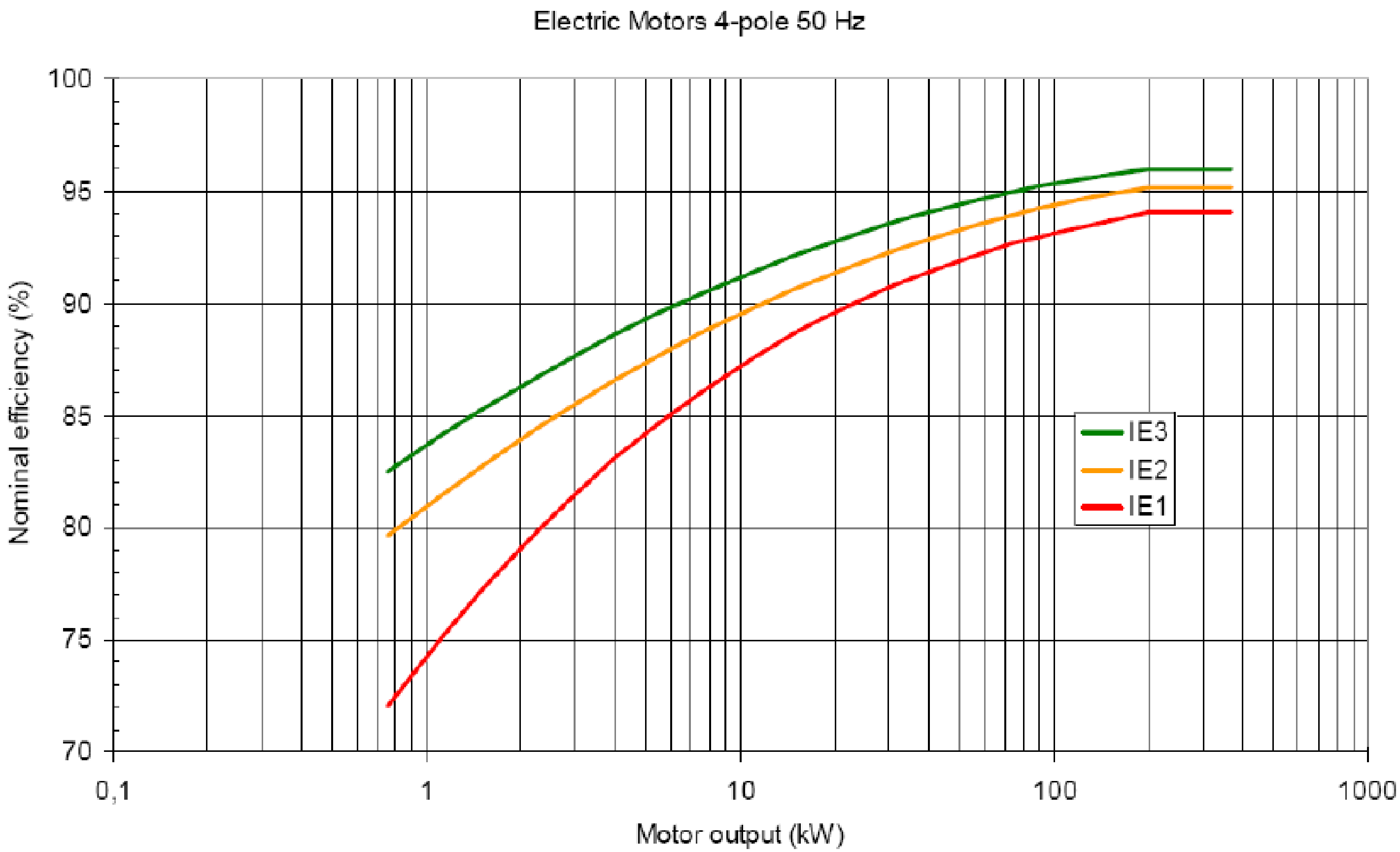
Energy Efficiency in Engines

Classification by means IEC 60034-30:



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Energy Efficiency in Engines

What are the opportunities to save energy in electric engines?

3.- Replace old engines by new ones with high efficiency.

High efficiency engines are recommended in the following cases:

- When older engines have to be repaired or replaced
- In new installations
- If the engines have more than 4.000 hours of annual operation
- In some processes where the engines are working at a constant speed and at maximum power

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What are the opportunities to save energy in electric engines?

4.- Install Variable Frequency Drive

The goal is to modify the engine speed to ensure that it is always operating in optimum conditions.

Assessing the potential savings of installing a variable frequency drive is difficult, so the best way is to use the manufacturer’s software:

- Omron → Esaver
- Schneider electric → Eco 8

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Energy Efficiency in Engines

What are the opportunities to save energy in electric engines?

4.- Install Variable Frequency Drive

There are devices such us pumps, fans, elevators, compressors or conveyor belt, which operate at variable load.

It is interesting that these devices can modify the speed of rotation of the engine so that it always works in optimum conditions and does not require more of the necessary power.

The viability of this device depends on:

- Engine power
- Number of operation hours
- Charge or load

Profits:

- Saving up to 40 % of energy
- Increased lifespan of all components
- Less noise

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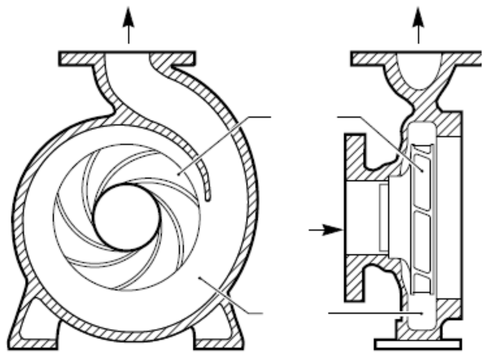
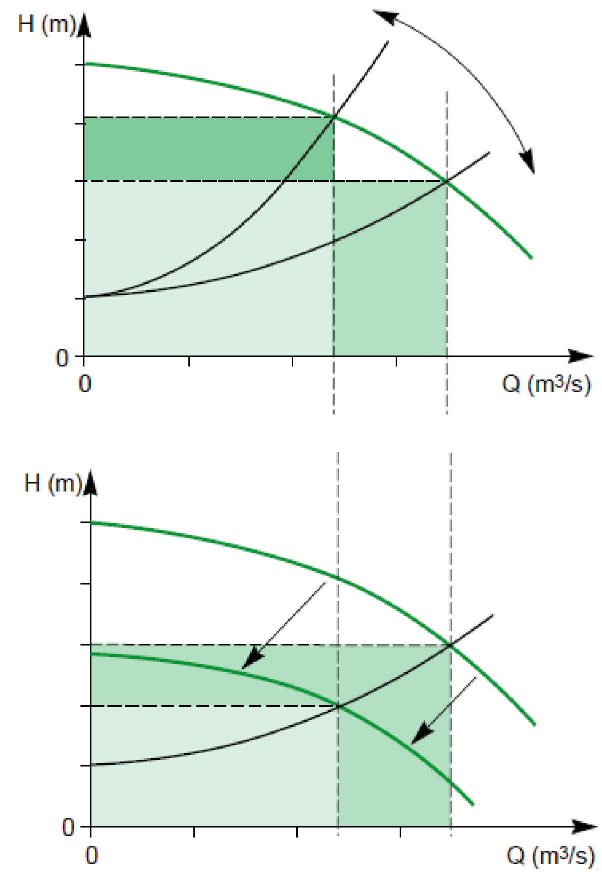
Energy Efficiency in Engines

What are the opportunities to save energy in electric engines?

4.- Install Variable Frequency Drive





This engines are working at constant speed when they are connected to the electric grid, however they are ready to operate at variable speed if they are connected to a frequency inverter.

There is a high potential for energy savings since energy depends on speed exponentially, so when it is reduced, the energy demand is too low.

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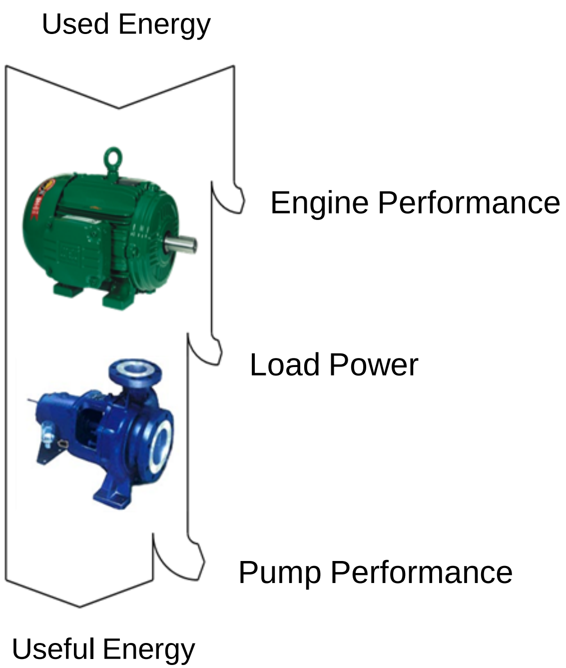
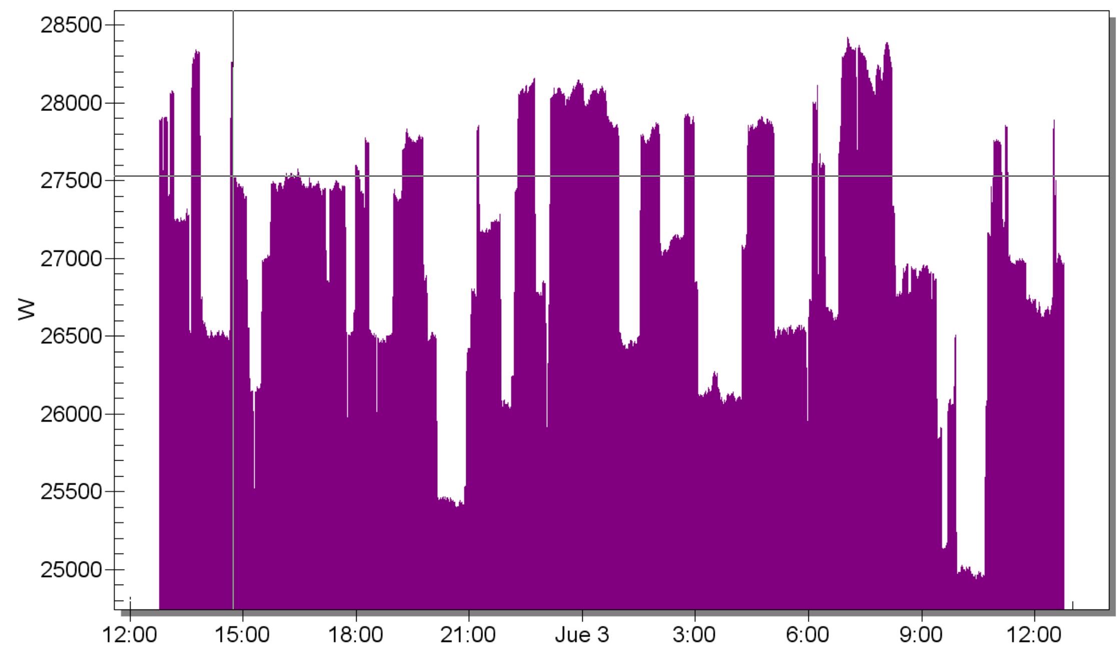
Energy Efficiency in Engines

What are the opportunities to save energy in electric engines?

4.- Install Variable Frequency Drive





It is shown that for 24 hours a day, an engine with 37 kW, the actual power demanded is an average of 26,5 kW. The daily energy consumption is 625 kWh so that this value is 133.750 kWh.

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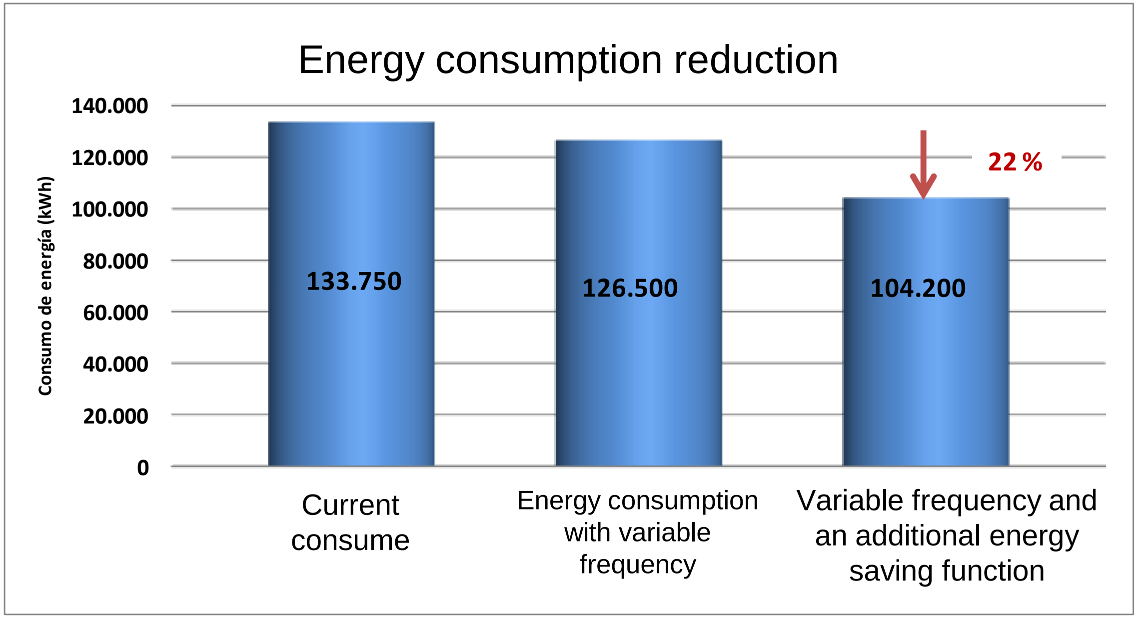

Energy savings of 6 %.
Energy saving implementing an additional saving energy function 22 %.
Payback time 0,9 year

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Energy Efficiency in electric transformers

A transformer can operate at full load or low load

Load level is defined as the speed between the input current being absorbed by the transformer and the value it would absorb at nominal conditions.

$$C = \frac{I_1}{I_{1n}}$$

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Energy Efficiency in electric transformers

If the "C" value is **0,75 < C < 1** the efficiency of the transformer is OK

If the "C" value is **C < 0,75** the transformer is oversized so the performance is lower

If the "C" value is C > 1 the transformer is undersized so that the operating conditions are not correct

The problems is knowing how to evaluate the "C"

- Measurement by means of the grid analyzer

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Thank you for your attention!

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