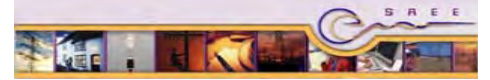


Energy Efficiency with Low Voltage Motors

Mining and Industrial Energy Optimisation
Energy Efficiency Seminars 2010

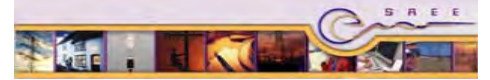


Energy efficiency

The issue

- Without appropriate actions the prognosis is that world energy consumption will **double** from current levels by 2050
- In the medium to long term energy prices are likely to increase
- Unchecked growth in fossil fuel use will hasten climate change





Low Voltage Motors in brief

- Older: 130 Years
- Function: Energy transformer
- Complexity: About 150 parts all inclusive
- Variants: Thousands of base motors, infinity of options
- Costs: 4-40 hours of engineering
- Customers view: “Industrial Standard Product”

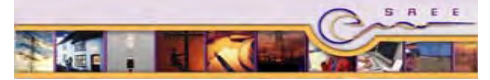
Possibilities to create a motor

Base motor

+

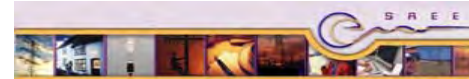
Option(s)





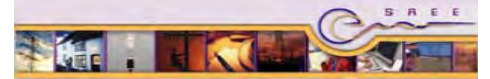
Topics of discussion

1. Introduction
2. Selection of High Efficiency motors
3. Installation considerations
4. Benefits of Energy Efficiency Motors & Case Study
5. Investment considerations
6. Conclusion



Introduction to Energy Efficiency Low Voltage Motors





Introduction

History

- Manufacturers started to produce high efficiency LV motors in the early 90's
- Demand came from large end users due to electricity cost and supply limitations

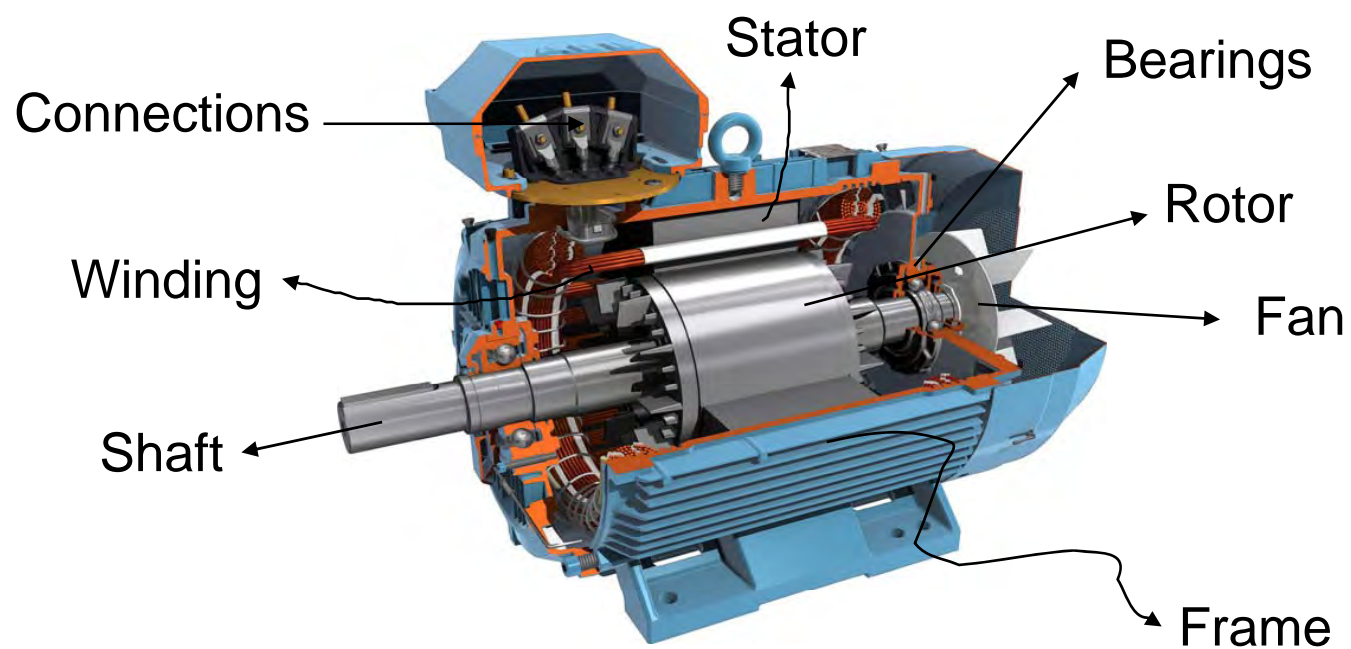
Global Efficiency Standards

- Many different standards globally that manufacturers had to comply with

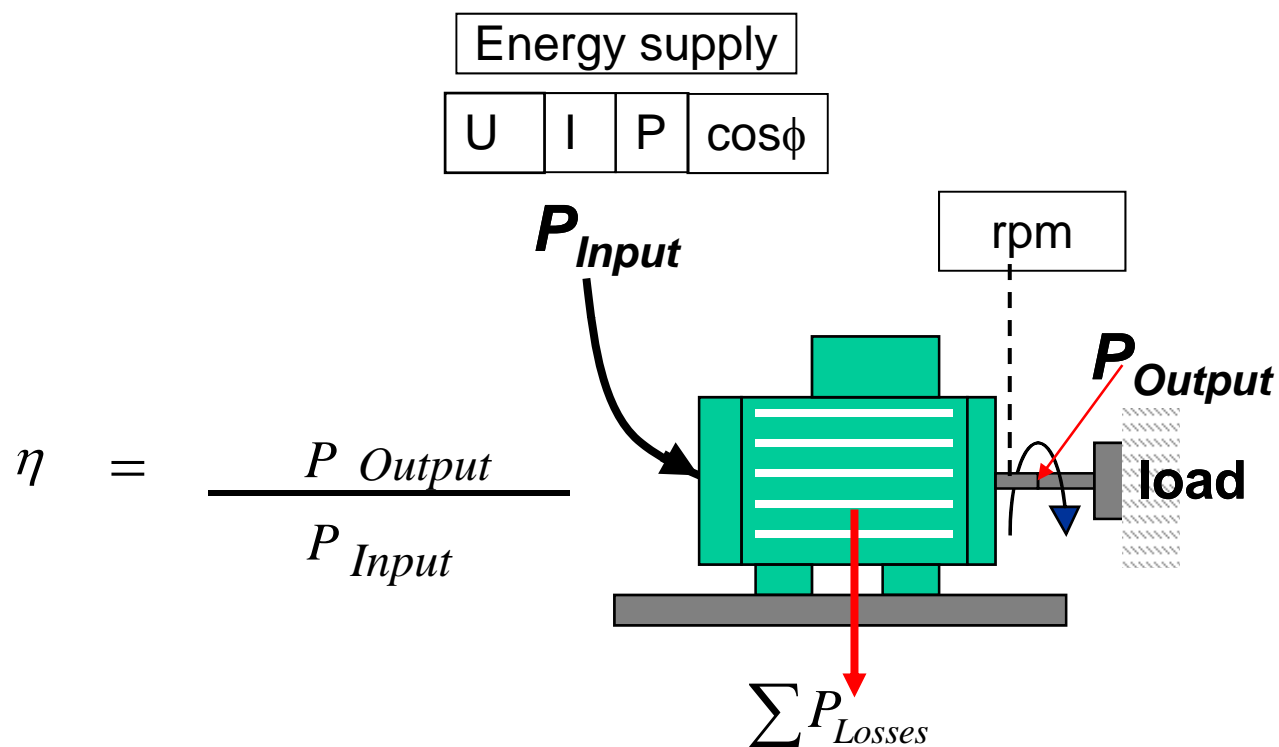
Product development

- New materials used and better CNC machines
- More money allocated to R&D as demand increased
- Higher efficiencies obtained such as IE4

Basic construction of motor

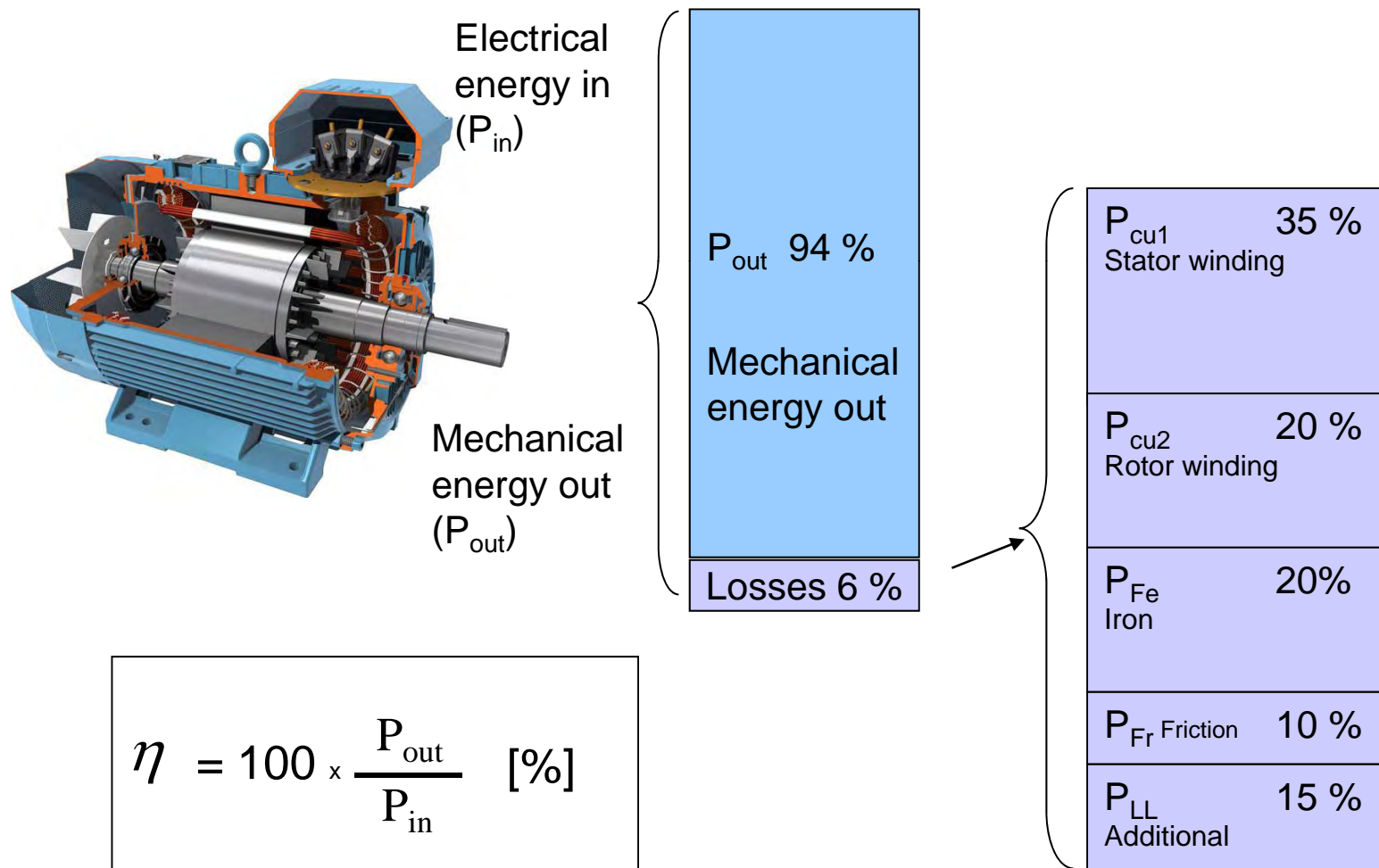


Efficiency definition



- Efficiency is ratio between mechanical output and electrical input
- High efficiency means that the motor is converting electrical power to mechanical power with small losses

Losses & efficiency in electrical motors

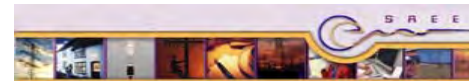


$$\eta = 100 \times \frac{P_{out}}{P_{in}} \quad [\%]$$



Selection of Energy Efficiency Low Voltage Motors



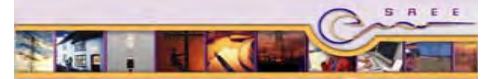


Low Voltage Motors Efficiency Classes



Where do you start?





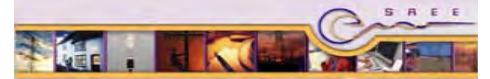
Efficiency classes

Much debate about the different standards

- CEMEP from Europe
- MEPS from Australia and New Zealand
- EPAAct from NEMA form the United States

This caused much confusion to the end user as they unfortunately differ from each other in terms of scope, wording and values.

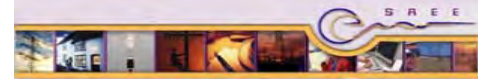
That was the reason for the IEC (International Electrotechnical Commission) to develop and publish an energy efficiency standard which replaces all the different national issues and the harmonisation work of the efficiency standards started.



Efficiency classes

IEC/EN 60034-30 standard published by the IEC in October 2008

- Defines new efficiency classes for motors
- Harmonize the different requirements for induction motor efficiency levels around the world
- Provides a single international scheme for motor energy efficiency rating, measured by a common test method
- Regulating bodies can use these standards to implement MEPS (= Minimum Energy-efficiency Performance Standard) programs and will be able to do so with consistency with respect to other regulators



Efficiency classes

IEC/EN 60034-30 covers almost all motors

For example standard, hazardous area, marine, brake motors:

- Single-speed, three-phase, 50 and 60 Hz
- 2, 4 or 6-pole
- Rated output from 0.75 to 375 kW
- Rated voltage U_N up to 1000 V
- Duty type S1 (continuous duty) or S3 (intermittent periodic duty) with a rated cyclic duration factor of 80% or higher

Excluded are:

- Motors made solely for converter operation
- Motors completely integrated into a machine (for example, pump fan or compressor) that cannot be tested separately from the machine



New efficiency classes

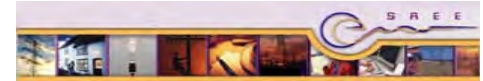
Super premium efficiency *	IE4	Super premium efficiency
Premium efficiency	IE3	Premium
High efficiency	IE2	Comparable to EFF1
Standard efficiency	IE1	Comparable to EFF2

* The standard also introduces IE4 (Super Premium Efficiency), a future level above IE3



IEC/EN 60034-30: 2008 and other efficiency standards

IEC/EN 60034-30	EU MEPS	CEMEP (European voluntary agreement)	US EPAct	Other, similar local regulations
IE3 Premium efficiency	IE3 Premium efficiency		Identical to NEMA Premium efficiency	
IE2 High efficiency	IE2 High efficiency	Comparable to EFF1	Identical to NEMA Energy efficiency /EPACT	Switzerland 2011 Canada Mexico Australia New Zealand Brazil 2009 China 2011
IE1 Standard efficiency		Comparable to EFF2	Below standard efficiency	Switzerland 2010 China Brazil Costa Rica Israel Taiwan



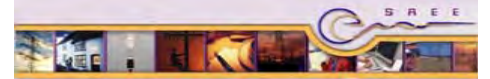
How is the IE class marked ?



- **Rating plate marking**
 - The efficiency value and the associated IE-code
 - Efficiency at the full rated load and voltage (%), 75% and 50%
 - Year of manufacture
- The new rating plate design put into use during 2009 for all the motors valid according to IEC/EN 60034-30



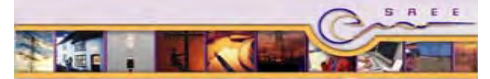
Other factors to consider when selecting Energy Efficiency with Low Voltage Motors



Over Dimensioned Motors

Why are motors over dimensioned?

- In order to secure against breakdowns in critical processes
- In order to prepare for future capacity increases in production
- In order to minimize the need for spare motors
- In order to secure for load variations and unknown process factors



Over dimension vs. Power factor

We can increase the efficiency of the motors but what about the power drawn from the local electricity supplier?

Motor 45kW, 4-Pole, 400 Volt:

Standard Eff

IE1

Eff 92%

Pf 0.87

High Eff

IE2

Eff 94%

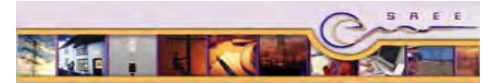
Pf 0.83

Premium Eff

IE3

Eff 95%

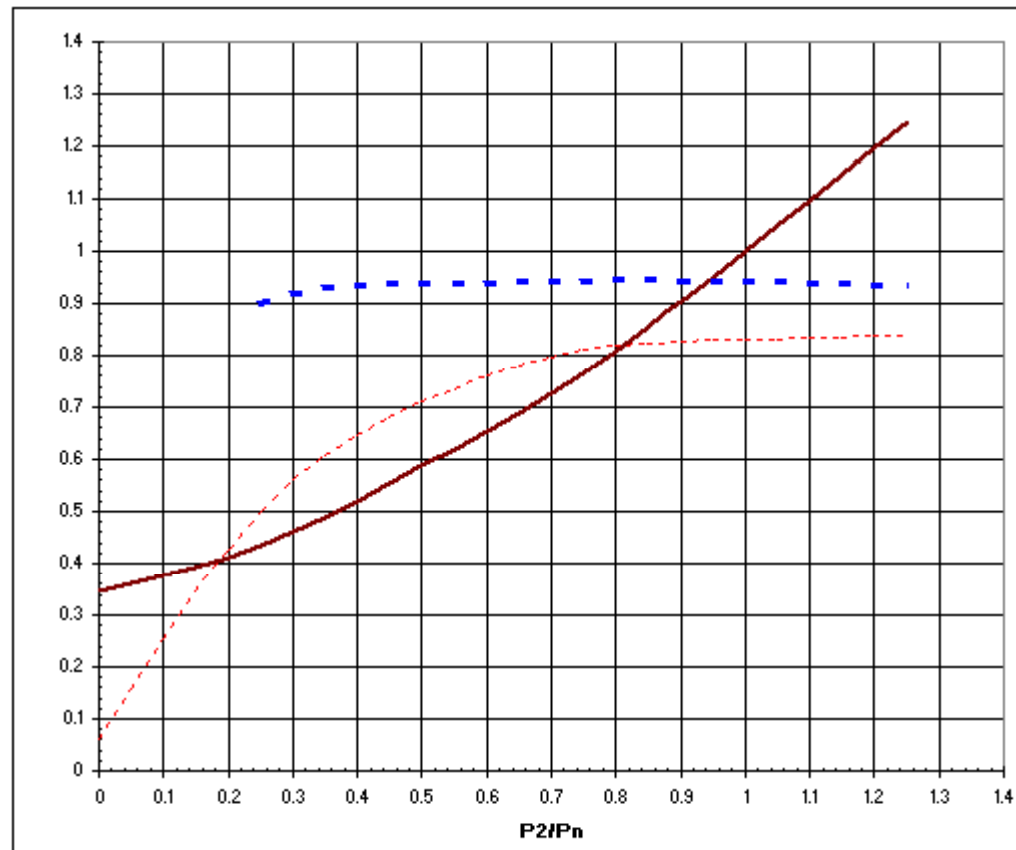
Pf 0.85



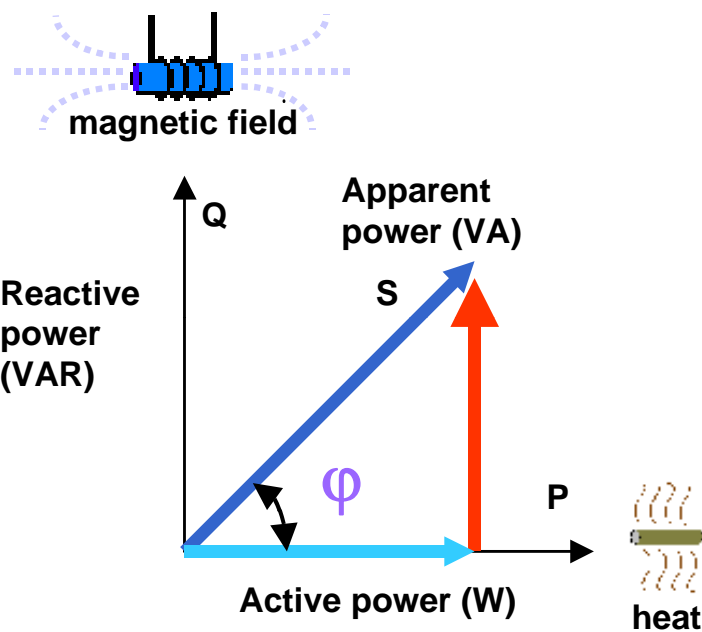
Power factor of High Efficiency motors

Type/Frame **M3BP 225 SMB 4**
Product code **3GBP 222 002-ADA**
Rated output P_H **45** kW
Type of duty **S1(IEC) 100%**

Voltage (V) **400** Current I_H (A) **83** Power factor at P_H **0.83**
Frequency (Hz) **50** Speed (r/min) **1480** Efficiency (%) at P_H **94**



Power factor



The power factor is a relevant characteristic of each motor. This factor depends on the need for a magnetic field to create the flux and is called the reactive power. Active power used for running the motor.

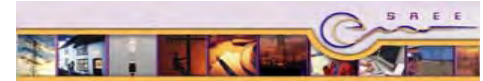
Power factor



The power factor indicates the need of reactive power Q compared with effective power P.

The effective input power (active power) in the motor is given by the formula.

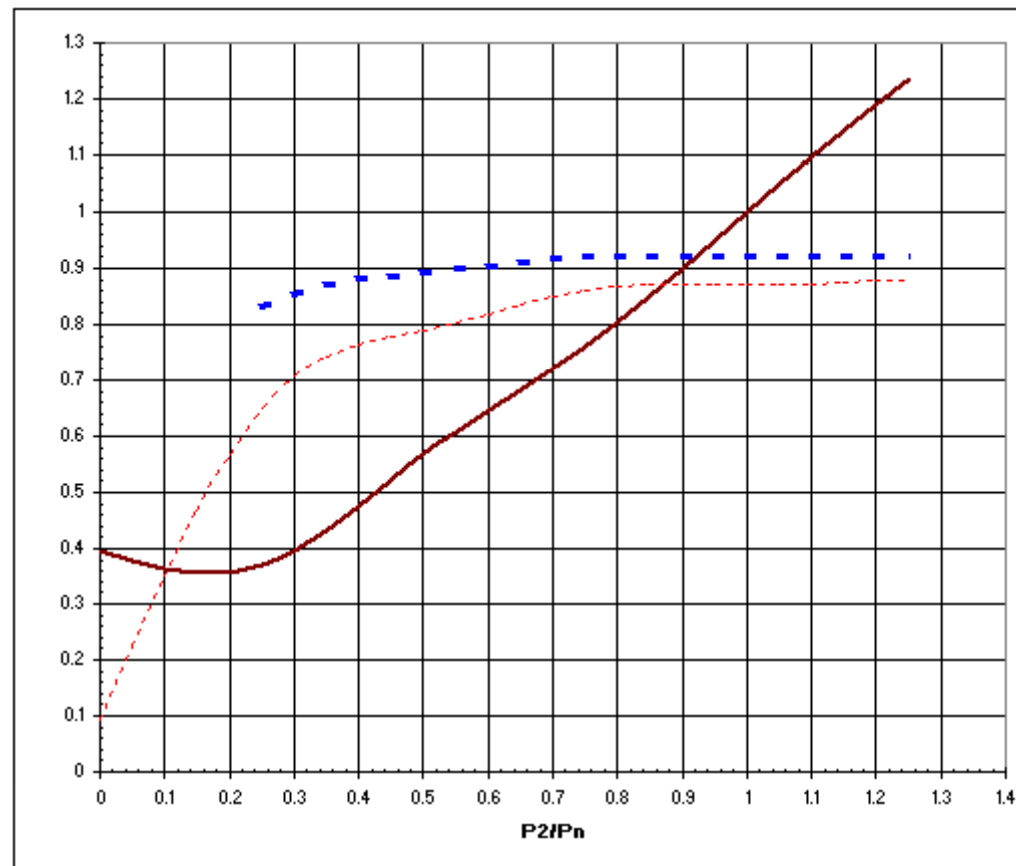
$$P_{\text{INPUT}} = \sqrt{3} * U * I * \cos \varphi$$

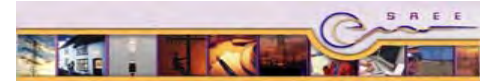


Power factor of High Efficiency motors

Type/Frame **M2QA 225 M4A 4**
Product code **3GQA 222 301-ADA**
Rated output P_N **45** kW
Type of duty **S1(IEC) 100%**

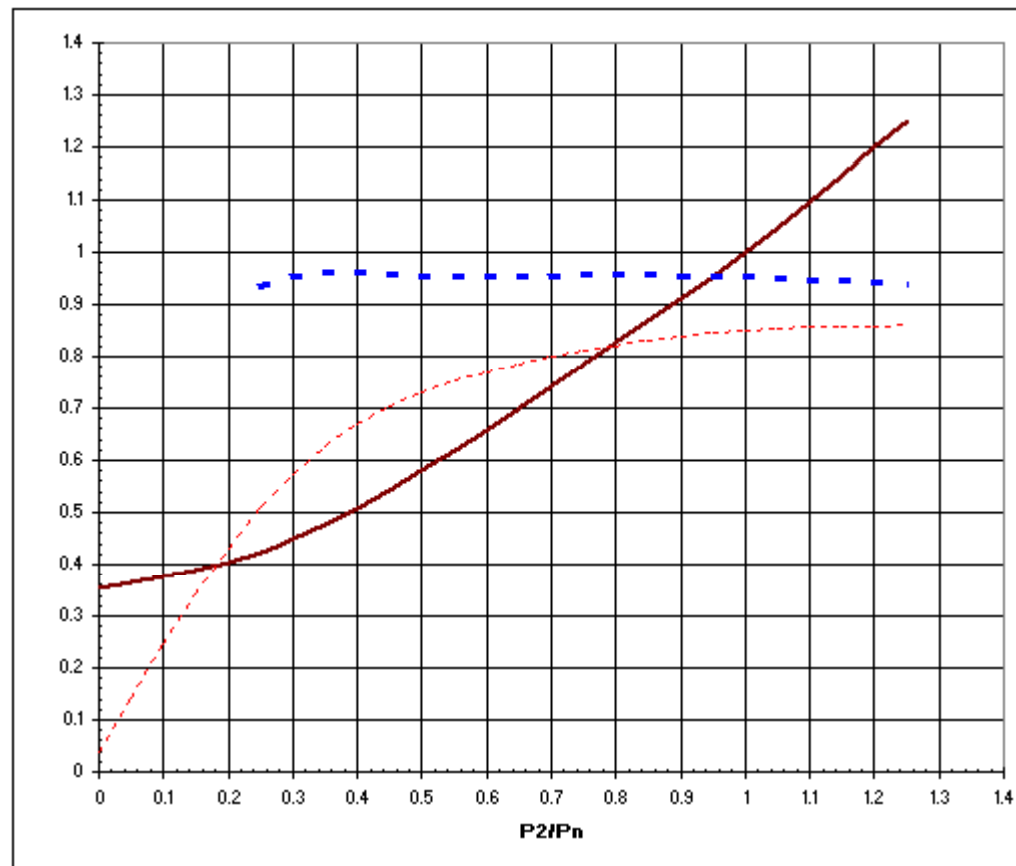
Voltage (V) **400** Current I_N (A) **81** Power factor at P_N **0.87**
Frequency (Hz) **50** Speed (r/min) **1480** Efficiency (%) at P_N **92**

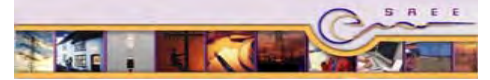




Power factor of High Efficiency motors

Type/Frame	M4BP 225 SMB 4	Premium efficiency	
Product code	3GBP 222 052-ADG		
Rated output P_N	45 kW		
Type of duty	S1(IEC) 100%		
<hr/>			
Voltage (V)	400	Current I_N (A) 80	Power factor at P_N 0.85
Frequency (Hz)	50	Speed (r/min) 1482	Efficiency (%) at P_N 95





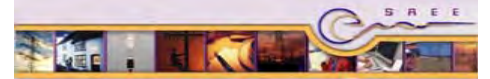
Benefits of a high power factor

- Feasible to transmit only effective power through the electrical network
- Compensation can be made with synchronous machines or capacitors
- Loadability of your motors are very important.



How will Energy Efficiency Motors effect other equipment in your plant?





Starting & Inrush currents

Starting current of the High Efficiency motor will be higher than Standard Efficiency motors.

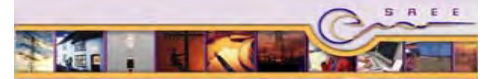
Refer to 45 kW motor:

SE 7 x FLC

HE 7.9 x FLC

13% higher starting current !

This is due to the design of HE motors that contains more Copper in the motor stator.



Starting & Inrush currents

The inrush current of the motor will also be higher.

What is inrush current?

The peak transient current in the first half-cycle, associated with the starting of a motor due to the reactance effect.

Ensure that your current switchgear for starting your motor is suitable for your new HE motor.

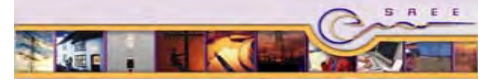
If not it could cause random tripping.

Electronic circuit breakers is also more sensitive and the possibility of not detecting and clearing short circuit faults.



Operating Environment of the new Energy Efficiency Low Voltage Motors





Operating Environment

Factors to consider when replacing old motors

1. Supply voltage rated at 10% above rated value

Starting current increases by 10 to 12% (Locked Rotor Currents)

Power factor decreases by 3 to 5%

Locked Rotor Torque increases by 21%

2. Altitude de-rating

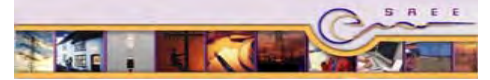
1400 MASL = 3% de-rating, 1600 MASL = 5% de-rating

3. Ambient conditions

40 deg C – No de-rating

45 deg C – 5% de-rating

50 deg C – 9% de-rating



Repair of High Efficiency motors

Purchasing decision is made to go to High Efficiency Motors

Next step is price.

There are local supplier sell you a motor that can not be repaired!

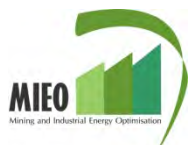
Ensure that your High Efficiency motors above 15kW can be repaired by an approved SABS accredited rewinding shop

80% of major motor failures are due to mechanical failures.

Consider when repairing your high efficiency motors what tests the repairer can offer you to ensure the motors efficiency is maintained



After evaluating your current motors in your plant, lets look at the **benefits** of Energy Efficiency Low Voltage Motors



Present situation in your plant

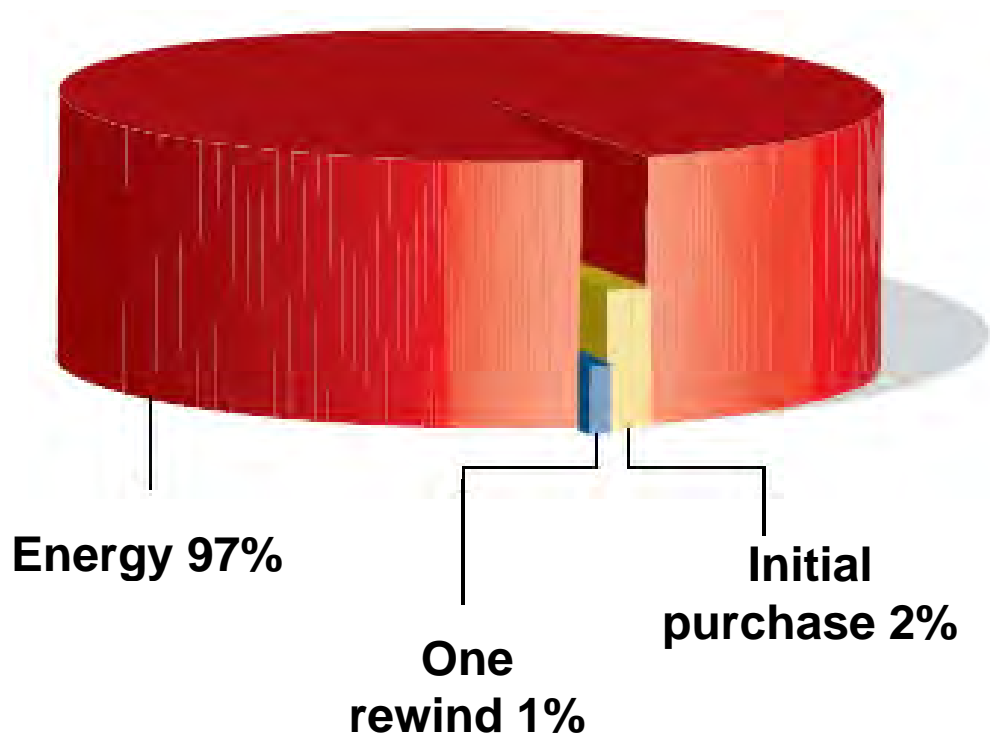
Are you wasting energy and money?



- 65 % of total electricity at industrial sites is consumed by electric motors
- Motor purchasing price corresponds to 12 to 16 weeks of its electricity consumption
- The capital cost represent only **2%** of the total life cycle operational costs of the motor

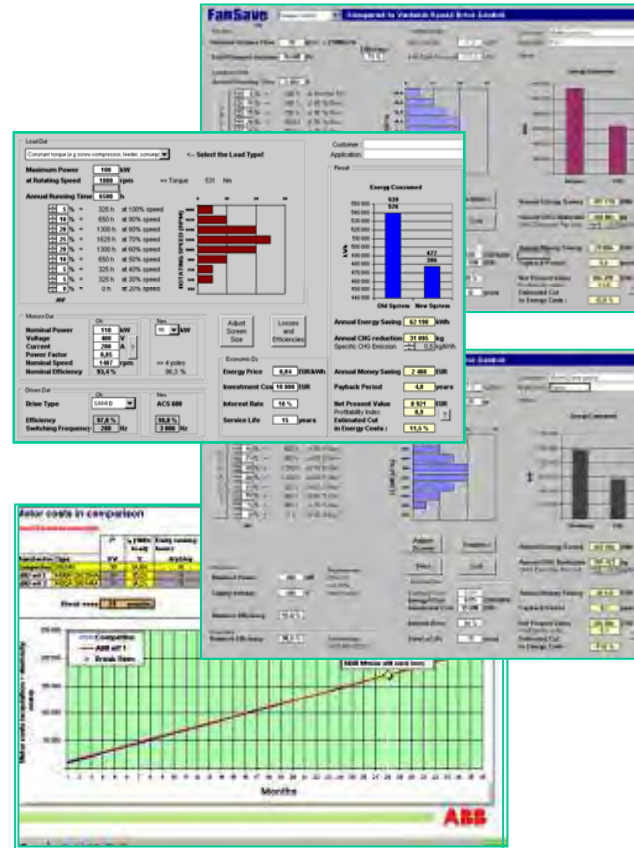
Looking at the big picture

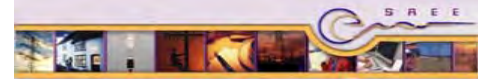
Moving the focus to decades of use



Easy-to-use calculation tools

- **FanSave**
 - To calculate the energy consumption of fan applications
- **PumpSave**
 - To calculate the energy consumption of pump applications
- **Efficiency Tool**
 - For comparing the efficiency level of an old drive+motor combination versus a new drive+high efficiency motor combination
- **Energy Saving Tool**
 - For calculating the payback time of a high efficiency motors





Investment Considerations

- To reduce energy costs, a company should evaluate its energy usage.
- Look at replacing all motors below 55 kW with energy efficiency motors. This makes up the bulk of motors in an industrial plant and is where the most amount of energy can be saved.
- Tag all motors and start keeping a repair history on all your plant motors.
- Motors below 15kW should be replaced when failed due to repair cost vs. replacement cost.
- Ensure your new energy efficiency motors operate in the 85 to 100% load range of motor.
- Use software tools to help you with your motor selection.



Case Study:

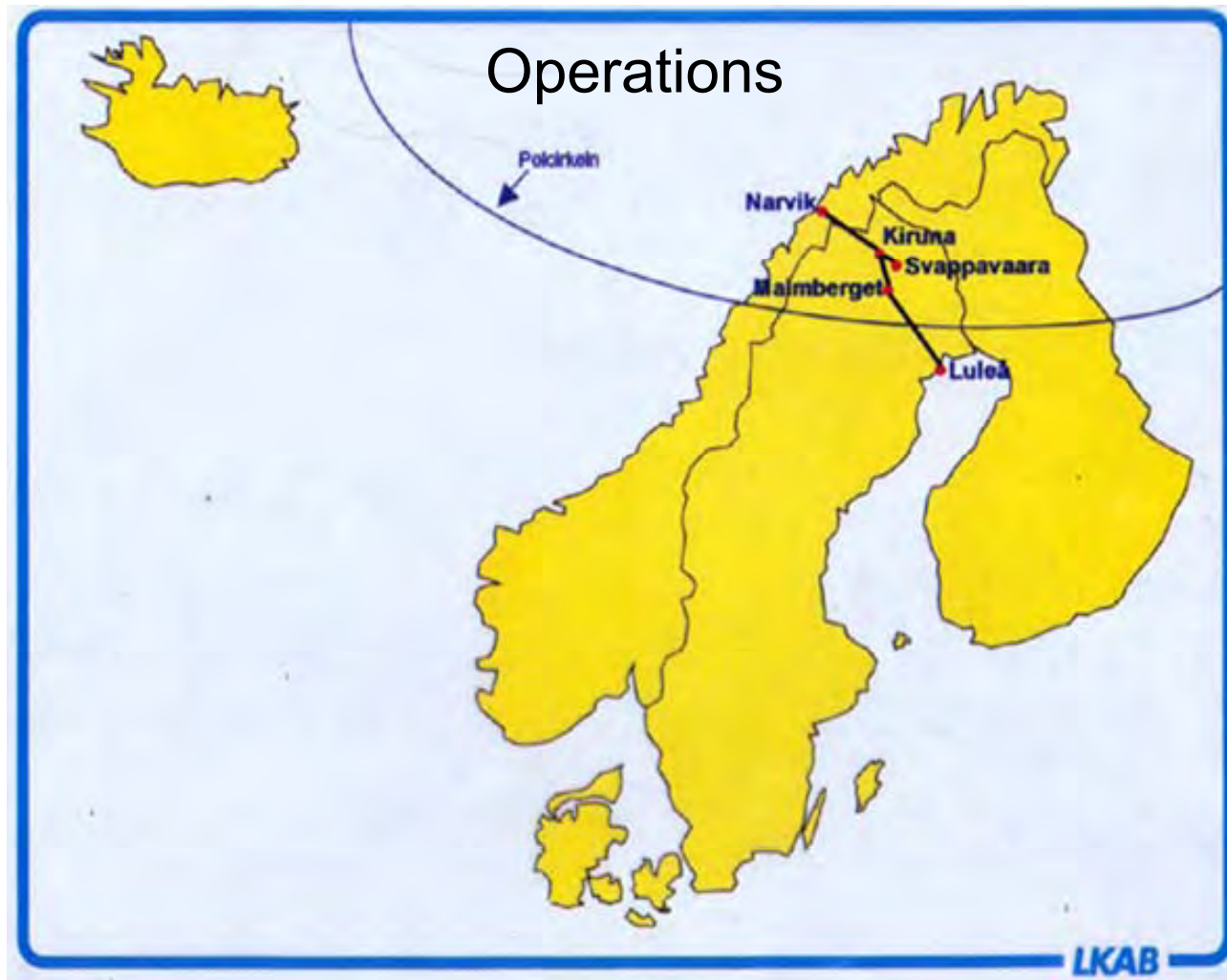
Low Voltage motors at LKAB since the 90s

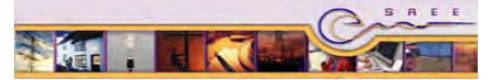


LKAB (Pty) Limited

- LKAB is the largest producer of iron ore products in EU
- Annual production is about 25 million tonnes
- The customers are steelworks in Sweden, Europe, Far East and Middle East

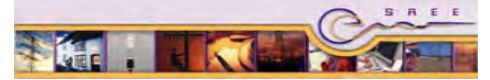






Energy consumption

- In mining, sorting, concentrating, pelletizing and transport of the iron ore products there are several energy intensive operations
- Annual energy consumption is about 3000 GWh of which electrical energy is about 1700 GWh (52% of total) and the rest is coal, oil and waste heat.
- 90% of the electrical energy is used to supply electrical motors.
- The cost for the annual energy consumption is about 60 million Euro (10% of the costs for the operations)

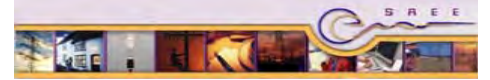


The Electric Motor Study

LKAB started with investigation into high efficiency motors at the KK2 pelletizing plant in the early 90s

Laboratory Motor Tests at the Royal Institute of Technology

- Tests in a test bench to confirm the rated technical data.
- Tests to compare motors from different manufacturers.
- Tests to comparing Standard Eff vs. High Eff motors.

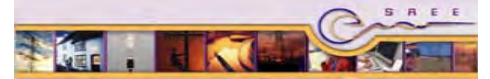


The Electric Motor Study

The report revealed:

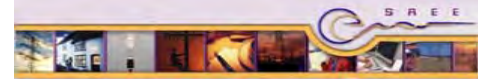
- 84 percent of those motors were over-dimensioned.
- The combination of lower efficiency and over-dimensioning meant that LKAB was wasting costly energy – lots of it.
- The study revealed that some of the company's motors often had a lower efficiency rate than the rates given in the vendors' specification sheets

That's when we made the decision to only buy energy-efficient motors and dimension them for a 80 percent load in normal operations



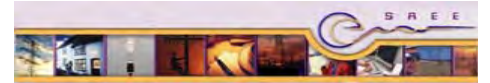
The Results

- It has now been several years that LKAB has been using high efficient process performance motors.
- They have saved substantial amount in energy costs.
- Other benefits are also less service intervals.
- New concentrating and pelletizing plant are under construction to which more than 1000 high efficiency motors.

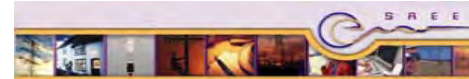


Conclusion

- Energy Efficiency Motors can save you between 3 to 6% on your current power consumption. This based on the condition of the old motors that will be replaced as well as the duty point of the old motor.
- Current price in South Africa is R0.35 per kWh. With a price increasing of 25% per year for the next 2 years the future price in South Africa will be R0.68.
- Premium LV Motor are designed to run for 30 years plus.
- This means that even if the saving is not significant today it will be in some years to come.
- Possible problem is not the price of energy but the lack of energy and energy saving can avoid future load shedding.



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Thank you !

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