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COMMISSION STAFF WORKING DOCUMENT

Accompanying document to the

Commission Regulation implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors

FULL IMPACT ASSESSMENT

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Lead DG: DG TREN

Associated DG: DG ENTR

Other involved services: SG, LS, DG ENV, DG COMP, DG ECFIN, DG INFSO, DG MARKT, DG SANCO, DG TRADE, DG RTD.

1. PROCEDURAL ISSUES AND CONSULTATION

1.1 Organisation and Timing

This implementing measure is one of the priorities of the Action Plan on Energy Efficiency[1], and is part of the 2008 Catalogue of actions to be adopted by the Commission for the year 2008.[2]

The proposed implementing measure is based on the Directive 2005/32/EC of the European Parliament and of the Council establishing a framework for the Commission, assisted by a regulatory committee to set ecodesign requirements for energy-using products[3]. An energy-using product (EuP), or a group of EuPs, shall be covered by ecodesign implementing measures, or by self-regulation (cf. criteria in Article 17), if the EuP represents significant sales volumes, while having a significant environmental impact and significant improvement potential (Article 15). The structure and content of an ecodesign implementing measure shall follow the provisions of the Ecodesign Directive (Annex VII).

Article 16 provides the legal basis for the Commission to adopt implementing measures on this product category.

Consultation of stakeholders is based on the Ecodesign Consultation Forum as foreseen in Article 18 of the Directive (see next section for details), including the consultation of stakeholders during a preparatory technical study from March 2006 till February 2008 in order to assist the Commission in analysing the likely impacts of the planned measures.[4]

Article 19 of the Directive 2005/32/EC, amended by Directive 2008/28/EC[5] foresees a regulatory procedure with scrutiny for the adoption of implementing measures. Subject to qualified majority support in the regulatory committee and after scrutiny of the European Parliament, the adoption of the measure by the Commission is planned by the very end of 2008.

1.2 Impact Assessment Board

This impact assessment has been scrutinised by the Commission's Impact Assessment Board (IAB). In its opinion, the IAB concluded that the IA report provides an adequate level of analysis but that market failures should be demonstrated more clearly, general objectives should be linked more thoroughly with problem analysis, some restructuring of policy options was needed, specific methodological aspects should be further improved and compliance regime should be addressed. These aspects have been addressed in the Impact Assessment Report below.

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1 COM(2006)545 final.
2 COM(2008)11 final.
3 Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC, OJ L 191, 22.7.2005, p. 29.
4 A. de Almeida, *Motors*, EuP preparatory study for Lot 11, University of Coimbra, 18.2.2008.
5 Directive 2008/28/EC of the European Parliament and of the Council of 11 March 2008 amending Directive 2005/32/EC establishing a framework for the setting of ecodesign requirements for energy-using products, as well as Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC, as regards the implementing powers conferred on the Commission, OJ L 81, 20.3.2008, p. 48.

1.3 Transparency of the consultation process

External expertise on motors and motor drives was gathered in particular in the framework of a study providing a technical, environmental and economic analysis (in the following called "preparatory study") carried out by external consultants[6] on behalf of the Commission's Directorate General for Energy and Transport (DG TREN). The preparatory studies followed the structure of the "MEEuP" ecodesign methodology[7] developed for the Commission's Directorate General for Enterprise and Industry (DG ENTR). MEEuP has been endorsed by stakeholders and is used by all ecodesign preparatory studies.

The preparatory study was developed in an open process, taking into account input from relevant stakeholders including manufacturers and their associations, environmental NGOs, consumer organisations, and EU Member State experts. The preparatory studies provided a dedicated website[8] where interim results and further relevant materials were published regularly for timely stakeholder consultation and input. The study website was promoted on the ecodesign-specific websites of DG TREN and DG ENTR. Open consultation meetings for directly affected stakeholders were organised at the Commission's premises in Brussels on 29/06/2006, 21/11/2006, 02/11/07 and 24/10/2007 for discussing and validating the preliminary results of the studies.

Further to Article 18 of the 2005/32/EC Directive, formal consultation of stakeholders is to be carried out throughout the Ecodesign Consultation Forum consisting of a "balanced participation of Member States' representatives and all interested parties concerned with the product group in question ".

Meetings of the Ecodesign Consultation Forum took place on 27 May 2008. Building on the results of the preparatory studies, the Commission services presented a Commission Staff Working Document suggesting ecodesign requirements based on scenario developed under the preparatory study.[9] The working documents were sent out one month before the meeting to the members of the Consultation Forum, and to the secretariats of the ENVI (Environment, Public Health and Food Safety) and ITRE (Industry, Research and Energy) Committees of the European Parliament for information. The working documents were published on DG TREN's ecodesign website, and they were included in the Commission's CIRCA system alongside the stakeholder comments received in writing before and after the Consultation Forum meeting.

1.4 Preliminary results of stakeholder consultation

The main stakeholder consultation took place at the Consultation Forum meeting on 27 May 2008 on the basis of the results from the preparatory study and the above-mentioned Commission Staff Working Documents.

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6 EuP preparatory studies "Lot 11: Motors, by A. de Almeida, final report of 28 Feb. 2008; documentation available on the ecodesign website of the Commission's Directorate General Energy and Transport http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm.

7 "Methodology for the Ecodesign of Energy Using Products", Methodology Report, final of 28 November 2005, VHK, available on DG TREN and DG ENTR ecodesign websites:
http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm
http://ec.europa.eu/enterprise/eco_design/index_en.htm.

8 [URL of preparatory study website].

9 Available on DG TREN's ecodesign website:
http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm#consultation_forum.

The **Member States** largely agreed with the suggested levels for the requirements and the staged timing of the proposed requirements. Several Member States, supported by environmental NGOs, required the coverage of the whole power range of considered motors and the coverage of variable speed drives, in line with the Ecodesign 'product approach'.

The general approach to set mandatory minimum requirements in the framework of ecodesign was largely supported by **Industry**[10] associations. However, CEMEP[11] opposed the proposed requirements at IE3 level, as it would terminate the European IE2 motor market, which is economically important for the industry. Due to the large savings potential (171 TWh instead of 31 TWh by 2020) manufacturers supported a broader approach, which would include system elements, such as drives.

Environmental NGOs and **consumer's associations** were also in support of the proposed measure but requested tighter and speedier introduction of requirements, including the inclusion of the low power range motors for the IE3 requirement. This had become easier after the lowering of efficiency levels for these motors in the revised IEC 60034-30 standard. Environmental organisations also supported the inclusion of motor system elements, such as drives, into the planned measure, if possible.

A general request was made to indicate the noise level of the motor, as an information request.

2. PROBLEM DEFINITION

The underlying problem can be summarised in the following way: technical solutions exist on the market leading to low energy consumption of motors but the market penetration of high-efficient motors is lower than it could.

As requested by Article 15 of the Ecodesign Directive, the preparatory study identified the relevant environmental aspects. The analysis shows that the environmental and lifecycle cost impacts resulting from motor operation are almost 100% attributable to the use-phase. The results show very significant reduction of the LCC both with the IE2 and IE3 motors[12] for the low power motors, with savings reaching more moderate levels as the motor power increases.

Examples: AC induction motor improvements involve increasing the cross-section of the stator and rotor windings to lower electric resistance, lengthening the lamination stack to reduce magnetic flux density and further reducing the core losses by using steel with better magnetic properties.

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[10] See e.g. contributions of ORGALIME and CECED to the consultation of Directive 92/75/EEC, available on http://ec.europa.eu/energy/demand/legislation/domestic_en.htm#consultation (CECED vision on Energy Efficiency" of 1st July 2007, available on www.ceced.eu and the CEMEP contribution to the Consultation Forum available on the CIRCA system.

[11] European Committee of Manufacturers of Electrical Machines and Power Electronics represents the European manufacturers of electrical machines and power electronics equipment and systems.

[12] The preparatory study considered IE3 level as BAT, as the IE4 level has not yet been defined in the standard (IE60034-30), which would correspond to permanent magnet technology.

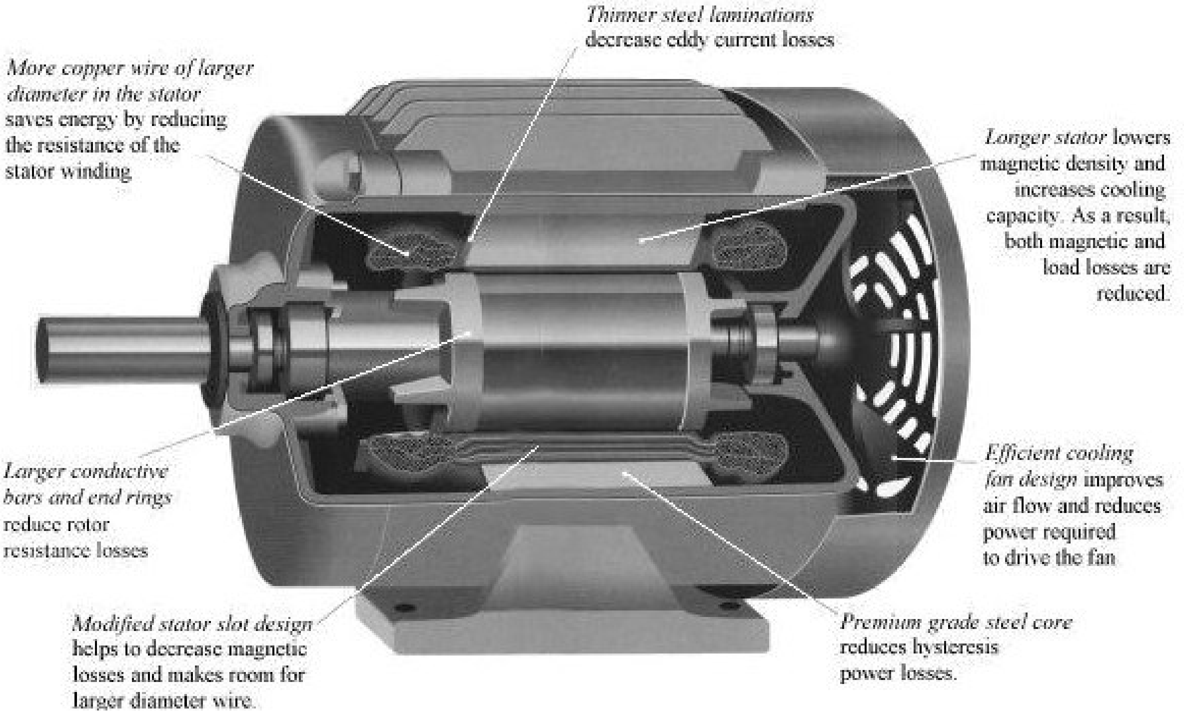

Figure 2: NEMA Premium motor features.

An alternative in the lower power range is the Electronically Commutated (EC) motor, a.k.a. Brushless Permanent Magnet DC motor, where the rotor uses permanent magnets to create the rotor magnetic field without incurring the excitation losses.

In a variable speed drive (VSD), exactly the right amount of energy is delivered through the motor to the pump, fan, blower or compressor to obtain the required flow or pressure. No energy is wasted, unlike traditional systems using mechanical braking, chocking valves, etc. where excess energy is converted into useless heat. The non-linear behaviour of fluid dynamics appliances likes pumps and fans are a further boost to the system efficiency.

As electric motors are mainly built with materials that are recyclable and that have a very high value (e.g. steel, aluminium, copper), the majority of motor materials are recycled at the end-of-life. Thus, the existing improvement potential is best caught in setting ecodesign requirements on the use-efficiency of the product.

2.1 Market failures

The main market barriers hampering a larger market penetration of energy efficient motors were identified in the preparatory study and are as follows:

1. Negative externality

Not all environmental costs are included in electricity prices. Consumer choice is made on the basis of the purchase price, as the lower electricity price is not reflecting environmental costs for the society.

2. Asymmetric information

A part from using high-efficient motors, a main consumer related barrier for energy efficiency is the fact that consumers are not able to consider the cost-efficiency of the use of a high-efficiency motor and drive technology and the full life-cycle cost of the motor and its related drives. The purchase price is well visible and is typically higher for energy efficient motors. On the other hand, information on running costs/cost savings is not explicit and can be obtained only with difficulties**.** CEMEP and the European Commission tried to correct this market failure in establishing a voluntary agreement on 1999. However, the results of the agreement were not satisfactory (see Chapter 2.2.) despite of the very short payback time for high-efficiency motors (see Chapter 4.4.2).

The motor market, particularly the low and medium power ranges, is largely an OEM market, in which OEM purchases represent 80-90% of the sales[13]. In the EU, this large share of the market, combined with the standard efficiency IE2 prices, which typically are 20-30% above IE1 motors price, leads to a low penetration of standard efficiency EI2 motors. The more expensive high efficiency IE3 motors have almost no market share at all in the EU due to an inexistent demand for high efficiency motors by end-users and appliance industry integrating motors in their products. The situation persists despite of the fact that a high efficiency motor would be a cost-efficient solution in basically all industrial full speed operations and in many variable speed applications. Also, appliance manufacturers and installers tend to base their purchases on motor purchase cost instead on life cycle cost, since they will not pay the motor operating costs.

Motors coupled with VSDs are a growing market due to an important industry interest (see Section 5.1.3) but still insignificant to make a difference. There are varying reasons for the market failure of consumers being myopic to the life cycle cost savings linked to the use of a drive. First, in a market, where drives are mainly sold separately from the motor, the incentive for a motor seller to promote the use of a drive is not a primary goal but the sales of the motor, in particular due to the additional high purchase cost of the drive. Second, drives of different technologies and varying quality exist since decades but the recent technological development of electronic drives is not yet widely known. For example, drives used to generate harmonics with negative impacts in the power network and on the efficiency and lifetime of other equipment. They also generated, conducted and radiated electromagnetic interference associated with high frequency harmonics. Drives could also be physically very big, which can be a problem in industrial applications, where space is a critical issue. Today, drives are equipped with filters against negative impacts of harmonics, system designers and installers are capable in addressing the potential problem of radiated electromagnetic interference and the shrinking of the size of the drives have changed the situation drastically.

In addition, besides purchasing price, many users consider other factors than energy efficiency to be at least of the same importance, such as availability, service, and known brand name.

As a result, manufacturers have no incentive to reduce the energy consumption of motors, even though this could be done at reasonable additional cost to the manufacturer and would bring significant savings to the consumer and reduced CO_2 emissions.

[13] Big motors are more often purchased directly for a given factory load.

3. Split incentives

It is common in industry (and in governments) that one budget is responsible for the purchase of the motor but that another budget is responsible for the running cost, whereas the maintenance costs are allotted to a third budget. The budget manager responsible for the purchase cost will not be inclined to have an interest in savings shown in other budgets.

In addition, motors and drives are seen as being responsible for only relatively small efficiency improvements in relation to the whole motor system. For instance, for motors and drives operating in variable speed and load, such as in processing plants, a wider system approach would be considered more important than addressing the motor and/or drive purchase only. Motors exist with drive technology, which could lead to considerable life cycle savings but the impact of these motors is not understood. For example, reducing the speed of a fan from 100% to 50% leads to power consumption drop from 100% to 12.5%, resulting in power consumption savings of 87,5%[14].

Finally, it is often not seen "economic" to replace a motor before it fails (forced replacement) due to the high cost related to the down-time of a plant during the replacement. Even if plant managers would be aware of the expensive running costs of the current low-efficient motor, it is not common practice to change the motor due to the cost related to the down-time of the plant. This also reduces the use of drive technology, as its installation is more labour intensive. Furthermore, for maintenance personnel, often it is quicker to repair the failed motor rather than replace it, which will very likely lead to further decreased efficiency.

2.2 Baseline scenario for the electricity consumption of motors

In order to carry out a technical, environmental and economic analysis the preparatory study has considered typical industrial and tertiary motor usage patterns with a detailed analysis of representative models in three main power categories. In particular the study has, amongst others, provided the following key elements:

– a set of definitions of operating conditions that can be applied for the three main power categories;

– electricity consumption in several annual running hour scenarios in each power category, including the electricity consumption in conjunction with drives;

– the installed base ("stock"), the annual sales, and the typical life time in each power category;

– technologies yielding reduced electricity consumption and the additional costs for applying them compared to the current "market average", including the impact of drives;

– potential trade offs between electricity consumption and material related environmental impacts.

The structure of the methodology of the technical, environmental and economic analysis is contained in Annex 2.

14 Affinity Law.

Electricity consumption of motors in 2005

The preparatory study comes to the conclusion that the large penetration rate of motors leads to very important overall electricity consumption but that the increased motor efficiency alone can only tackle some 10% of the total efficiency potential of the motor system. An additional 30% could be addressed with help of appropriate drives coupled to the motor in variable speed and load applications.

For the year 2010, the preparatory study estimates that an installed base of 110 million motors exists in Europe, leading to electricity consumption of 1119 TWh in EU-27, corresponding to electricity costs of 97,2 billion Euro[15], and 513 Mt of CO_2 emissions[16], as shown in the below table. Detailed information on consumption figures and on estimated scenario outputs to sub-options is presented in Annex 4.

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15 average electricity price in the EU 2005: 0.136 €/kWh.

16 average specific EU emissions in 2003 for EU-25: 400g CO2 per kWh (EURELECTRIC, Environmental Statistics of the European Electricity Industry, Trends in Environmental Performance 2003-2004); this figure is higher if e.g. mining related effects are taken into account (MEEuP: plus 10%).

Table 2.2.1a: Electricity consumption, electricity expenditure and Co2 emissions in 2010 vs. 2020				
	2005	**2010**	**2020**	2025
TWh	1067	1119	1252	1309
€	90,9	97,2	108,3	113,0
Mt of Co2	475	513	574	600

Electricity consumption of motors in 2020

In 2020, without any further action, the electricity consumption of motors is estimated to amount to 1252 TWh, corresponding to 574 Mt of Co2 and €108,3 billion of electricity cost, as shown in the above table. Building on the technical, environmental and economic analysis, the baseline option for estimating the future evolution of the electricity consumption related to standby and off-mode until the year 2020 has been developed under the following conditions:

– The market trend as developed in the preparatory study leads to a continuing growth of standard efficiency motors leading to an increase in installed base of motors from 110 million to approximately 127 million motors in 2020, with annual sales of some 10 million units per year.

On the other hand:

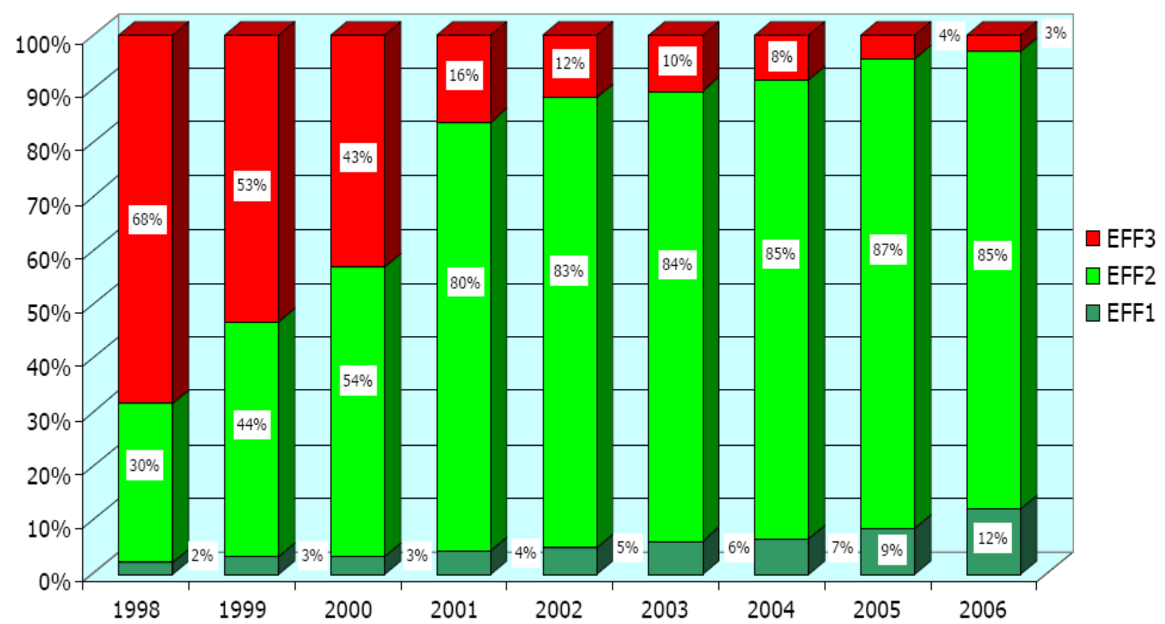
– Awareness raising campaigns aiming at market transformation by increasing the demand for motors with low energy consumption have been carried out in several EU Member States, leading to increased awareness of energy savings potential of appliances in motor systems, but the impact on purchase decisions towards high-efficient and premium efficiency motors have reminded insufficient. Nevertheless the Legislator has identified appliances in motor systems as being a priority ecodesign measure, because the market failures are likely to remain unresolved since it is difficult and time consuming to address the underlying problem laid out above by promotional/awareness rising approaches aimed at various industry sectors (cf. the discussion of the policy option related to labelling in Section 4).

– The European Commission Motor Challenge Programme is a voluntary programme (launched in February 2003) through which industrial companies are aided in improving the energy efficiency of their motor driven systems. Companies can receive aid in defining and carrying out an Action Plan to reduce energy related operating expenses and public recognition for their contribution to achieving the objectives of the European Union’s energy and environmental policies. The programme results in promoting the visibility of motor system efficiency have been good. However, the programme is voluntary and not focused on motor efficiency but on the system efficiency.

– An Implementing Agreement (Efficient Electrical End-Use Equipment 4E) has been launched with all willing world's stakeholders in motor issues by the IEA to propagate energy efficiency in electric motor systems. The project deals with pumps, fans, compressors and traction equipment focusing on implementation support, technical guides for motor systems, testing centres, instruments for motor policies, training and capacity building, energy management in industry, new motor technologies and total motor systems integration, including the use of drives. The results of the activity will be available in about two years.

– voluntary agreement supported by CEMEP and the European Commission was established and signed in 1999 by 36 motor manufacturers, representing 80% of the European production of standard motors. The agreement supported the removal, which might have happened anyway due to the inefficiency of these motors, of most low efficient[17] motors (called 'EFF3' in SEMEP agreement) from the EU induction motor market. As a consequence, today European markets are still dominated by low efficiency IE1 motors (EFF2 in SEMEP agreement) representing 85% of motor sales. The penetration of standard efficiency IE2 motors (EFF1 in CEMEP agreement) is still very small (12% of motors sold) and the high efficiency IE3 motor market is practically inexistent (this level does not exist in CEMEP agreement). Simultaneously, many third countries have achieved better results by the implementation of mandatory standards introducing minimum efficiency levels at IE2 and IE3 levels.

Picture 2.2.1: European motor market — share of motors in different efficiency classes.



17 The IEC6004-30 standard classifies motors in four categories according to the efficiency of the motor from IE1-IE4 as follows: IE1 = low efficiency; IE2 = standard efficiency, IE3 = high efficiency; IE4 = a non-identified efficiency level for future technology such as permanent magnet motor technology. The SEMEP classification corresponds with IEC classification as follows: EFF1 = below IE1; EFF2 = IE1 and EFF3 = IE2. No EFF classes are identified, which would correspond to IE3 or IE4 classes.

– Ecodesign implementing measures on products (e.g. pumps, fans, compressors, air-conditioning appliances) can not address the improvement potential of all motors considered in this impact assessment. On the contrary, a measure on motors and drives will have a link with several of these products, as motors are often part of this equipment (e.g. a pump that includes a motor and a drive). This overlap is discussed below with implications on the scope of the considered measure. It is therefore concluded that, without taking additional specific action on motors and drives in the framework of the ecodesign, the market transformation towards more efficient motors will take place only very slowly.

Under these assumptions, it is expected that electricity consumption of motors will rise to approximately 1252 TWh per year in 2020 (see Annex 3 for further clarification on the BaU option and the base case applied).

Structure of motor market and manufacturer reactions

Three-phase AC induction motors covered by this implementing measure dominate the European motor market representing 83,5% of the total motor markets, with a growing market share. The rest of the motor market is represented by various types of DC motors, single-phase induction motors, universal and synchronous motors. These motors are often used in particular applications; many of them do not have test standards and are sold in small quantities with shrinking market share. The developments in power electronics in the last decades have allowed induction motors to achieve the same or even better torque/speed performance than DC motors in high demand applications, but with much higher reliability, leading to a shift away from DC to AC solutions in industry. However, the emergence of new technologies, such as permanent magnet motor technologies, might change this trend on the medium- or long-term.

During the preparatory study, it was found that high efficiency motors in European frame-sizes are not yet produced in the whole power range and in all poles. However, an inquiry by Commission services to manufacturers showed that major manufacturers are either producing or planning to start the production of high efficiency motors during the coming 2-4 years. Two major European manufacturers, ABB and Grundfos, required earlier introduction of IE3 requirements in order to limit the design and production investments to one efficiency level only. However, this would be a major constraint to manufacturers not yet producing IE1 or IE2 motors[18].

Manufacturers producing only low efficiency motors (IE1) would have to invest in the development of IE2 motors, if requirements were set at this level. This is a relatively easy task, as IE2 simply requires better electrical steel than IE1, which is a cost issue in production (sheets used in production need to be thinner to reduce losses, typically 0,5mm); it is not a technological issue. By CEMEP, there is a strong request of keeping the standard motor (IE2) market alive in order to avoid negative impact on industry and jobs. However, in such a case, the implementing measure should aim at directing the purchase of these motors only or primarily to applications in which they achieve best efficiencies, and only if such a solution would lead to a more cost efficient overall solution than in setting requirements at IE3 level alone.

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[18] However, ABB and Grundfos share the request of other manufacturers to include a requirement for the inclusion of VSDs

Almost all the major economies have some kind of voluntary or mandatory regulatory scheme regarding motor efficiency. Many of these economies have mandatory minimum efficiency levels for motors sold in the respective countries and labelling schemes for the promotion of higher efficiency motors, and industry world-wide is increasingly demanding minimum efficiency requirements. The Figure 2.2 shows the evolution of the motor stock for the industrial and the Figure 2.3 for tertiary sectors in the period 1998-2020.

Figure 2.2.2: Evolution of installed motor base in the industry (baseline)

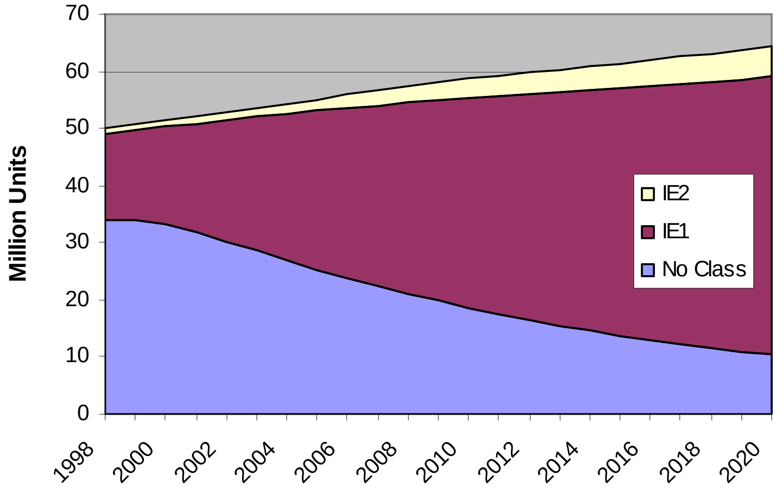
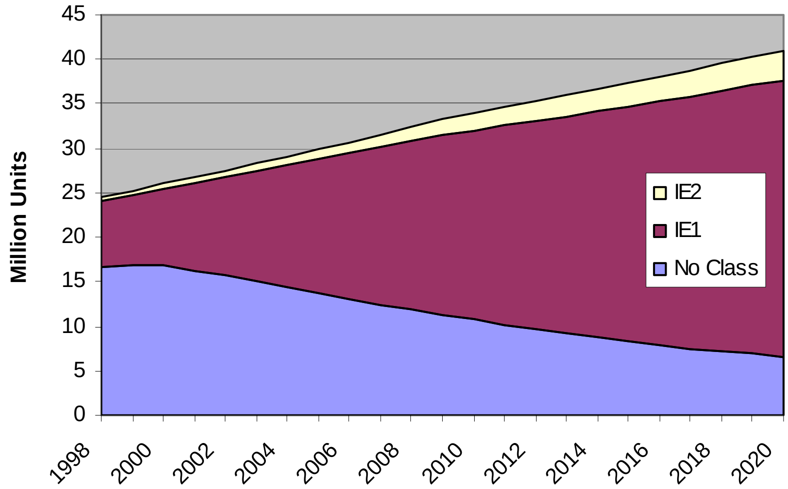


Figure 2.2.3: Evolution of the installed motor base in the tertiary sector (baseline)



The Table 2.1 shows the dominance of the AC induction 3-phase motor with sales of 9 million units per year, representing 84% of the unit sales and, given that DC motors operate mainly in the smaller segments, an even higher share of energy consumption (close to 90%).

Table 2.2.2	Motors in EU27, market segmentation 2005					
	EU27 unit sales			EU27 unit sales		
	%			mln. Units		
AC	**96,2%**			**10,3**		
AC induction 3phase	87%	trend slight up		9		
AC universal	4%	trend equal		0,41		
AC single phase	4%	trend down		0,41		
AC synchronous	5%			0,51		
DC	**3,8%**			**0,4**		
DC shunt wound	57%	trend down		0,23		
DC brushless PM	15%	trend up		0,06		
DC brushed PM	22%	to drop 10-15% per year		0,11		
DC by size						
0,75-7,5	87,30%					
7,5-75	11,50%					
75-750 kW	1,10%					
				EU27 unit sales	**EU15**	
AC by size	unit %	capacity GW	capacity	mln. Units	mln. Units	avg. kW
0,75-7,5	79,10%	22,5	28,20%	8,15	7,2	3,1
7,5-37	16,50%	30	37,60%	1,7	1,5	20,0
37-75	3,30%	15,6	19,60%	0,34	0,3	52,0
75-750 kW	1,10%	11,6	14,80%	0,12	0,1	116,0
Total	**100%**	**79,7**	**100%**	**10,31**	**9,1**	**8,8**
AC by poles						
2 pole	15-35%					
4 pole	50-70%					
6 pole	7-15%					
8 pole	1-7%					

A load factor of 100% (equal to the test method) is used in these calculations. The efficiencies of motors in part load are considerably lower than in full speed/load without appropriate drives. The distance covered over the motor life only includes trips for repair and maintenance. The MEEUP model assumes a distance of 200 Km for the first trip from manufacturer (or retailer) to the installation site.

The VSD sales and market structure is explained in Annexes 2 and 6.

2.3 Legal basis for EU action

The Ecodesign Directive and, more specifically, its Article 16 provides the legal basis for the Commission to adopt an implementing measure reducing energy consumption of motor products in electric motor systems.

3. OBJECTIVES

As laid out in Section 2, the preparatory study has confirmed that a large cost-effective potential for reducing electricity consumption of motors exists. This potential is not captured, as outlined above. The general objective is to develop a policy which corrects the market failures, and which:

- I) Reduce energy consumption and related CO2 and pollutant emissions due to motors and drives following Community environmental priorities, such as those set out in Decision 1600/2002/EC or in the Commissions European Climate Change Programme (ECCP);

- II) Promote energy efficiency hence contribute to security of supply in the framework of the Community objective of saving 20% of the EU's energy consumption by 2020.

The Ecodesign Directive, Article 15 (5), requires that ecodesign implementing measures meet all the following criteria:

- a) there shall be no significant negative impacts on the functionality of the product, from the perspective of the user;

- b) health, safety and the environment shall not be adversely affected;

- c) there shall be no significant negative impact on consumers in particular as regards affordability and life cycle cost of the product;

- d) there shall be no significant negative impacts on industry's competitiveness;

- e) in principle, the setting of an ecodesign requirement shall not have the consequence of imposing proprietary technology on manufacturers;

- f) no excessive administrative burden shall be imposed on manufacturers.

4. POLICY OPTIONS

4.1 Option 1: No EU action

This option would have the following implications:

- The market failures would persist, although the Voluntary Agreement between CEMEP and the European Commission and various initiatives on motor system efficiency such as the Motor Challenge Programme and the international activities within the IEA to some extent contribute to the awareness of the importance of motor efficiency. The impact of this option is described in more detail in Section 2.

- It is to be expected that Member States may want to take individual non-harmonised action on motor efficiency given the requirements from industry to set minimum requirements on motor efficiency. This possibility, in the absence of EU action, is further reinforced due to the rapid introduction of minimum requirements on motors in third countries across the world. This would hamper the functioning of the internal market and lead to high administrative burdens and costs for manufacturers, in contradiction to the goals of the Ecodesign Directive.

– The specific mandate of the Legislator would not be respected.

Therefore this option is discarded from further analysis.

4.2 Option 2: Self-regulation

This option would have the following implications:

– No initiative for self-regulation on motors has been brought forward by any industrial sector.

– CEMEP voluntary initiative have not delivered the expected results in terms of sales of high-efficient motors and industry has called for a clear legal framework ("level playing field") ensuring fair competition, while voluntary agreements could lead to competitive advantages for free-riders and/or non-participants to the "self-commitment".

– The specific mandate of the Legislator would not be respected.

Therefore this option is discarded from further analysis.

4.3 Option 3: Energy labelling targeting motors

This option would include the labelling of motor efficiency either in seven efficiency classes as under the Energy Labelling Directive or in three classes on the basis of the IEC60032-30 standard (IE1-3).

This option would imply the following:

– In general, two main objectives of labelling schemes are to increase the market penetration of, in this case, energy efficient products by providing incentives for innovation and technology development, and to help consumers to make cost effective purchasing decision by addressing running costs. The first aspect is not relevant, because the technologies for reducing the energy consumption of motors readily exist.

– In principle labelling could be suitable to increase the market penetration of motors with low energy consumption, but the scope of the Energy Labelling Framework Directive[19] does not allow labelling other than household appliances. On the other hand, as outlined above, it would be close to impossible to generate seven energy efficiency classes, as the IEC60032 only includes three defined levels. Also, the nature of the motor market (largely OEM) is not ideal for such labelling.

– Various European actions during the last ten years to guide end users towards high efficiency motors and motor systems, notably the Voluntary Agreement between CEMEP and the European Commission, have lead to insignificant sales of high efficiency motors.

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[19] Council Directive 92/75/EEC of 22 September 1992 on the indication by labelling and standard product information of the consumption of energy and other resources by household appliances, OJ L 297, 13.10.1992, p. 16.

– Trying to define energy efficiency classes after having set possible minimum requirements at IE2 and/or IE3 levels would be impossible/useless.

– Consequently there is a high risk that any market transformation towards high-efficient and premium efficiency motors with desirable levels of energy consumption would anyway take place slowly or not at all.

– The administrative burdens for manufacturers would be higher when compared with the burdens associated to minimum requirements on motors.

– The specific mandate of the Legislator would not be respected.

Therefore this option is discarded for further analysis.

4.4 Option 4: Ecodesign implementing regulation on motors and drives

This option aims at improving the environmental impact of motors, i.e., setting maximum levels for their power consumption. This sub-section contains details of the rationale for the elements of the corresponding regulation, as listed in Annex VII of the ecodesign framework directive.

The preparatory study and stakeholder comments lead to following 4 sub-options:

1. **IE2:** IE2 mandatory from 2011;

2. **IE2+IE3:** IE2 mandatory for all motors from 2011 and IE3 from 2015 for motors > 7,5 kW;

3. **IE3:** IE2 mandatory for all motors from 2011 and IE3 from 2015 for all motors;

4. **VSD/IE3:** IE2 mandatory for all motors from 2011 and either IE2+VSD or IE3 for 0,75-7,5kW motors on 2015 and for all motors from 2017.

4.4.1 Definition of the types of energy-using products covered

The scope of the product categories addressed by an ecodesign measure on motors is in line with the scope of the preparatory study and stakeholder discussions in addressing motors and their drives. The motors included in the measure are based on currently approved technical definitions as stipulated in standard IEC60034-30. The power range (0,75-375 kW) and the efficiency levels are in line with the standard.

The definition of drives is based on an agreement with European drives manufacturers recognising that the daily technical terminology often refers to words such as ASD (Adjustable Speed Drive), VSD (Variable Speed Drive) and VFD (Variable Frequency Drive), which basically all means the same in regard to CO2 reduction.

The definition of VSDs is based on agreement with VSD industry meaning a system that is continuously adapting the electric power according to the motor load in controlling the rotational speed of an alternating current electric motor by changing the three-phase 50 Hz grid power supply to an variable frequency and voltage supplied to the motor. The wording VSD (Variable Speed Drive) was chosen as based on stakeholder input.

Excluded are, as stipulated in IEC60034-30:

- Motors specifically design for converter operations, e.g. motors that cannot start directly from 50Hz supply;

- Motors physically integrated into a machine (pump, fan, compressor…), which cannot be separated from the machine;

- Motors specifically built for operation in explosive atmospheres according to IEC 60079-0 and IEC 61241-1;

- All other non-general-purpose motors (like smoke-extraction motors built for operation in high ambient temperature environments according to EN12101-3 etc.);

- Non-AC non-electric drives (e.g. mechanical and hydraulic).

The exclusions from the scope of this legislation will allow considering these products, such as pumps or fans, in separate forthcoming legislation, if appropriate.

4.4.2 Staged implementation of ecodesign requirements

According to the 2005/32/EC the target levels for measures should be set at least life cycle cost (LLCC), which presumes that at some point the price of the product increases so much with extra design options to save energy that the life cycle costs (purchase price plus running costs) will start to rise again.

With motors this is not the case: The product price constitutes only a few percent of the total LCC and each existing set of design measure, even if it doubles the purchase price and saves only a little bit of running costs, is economical, starting from less than 1000 operating hours per motor per year.

This is shown in the following table with LCC calculations for the base case (IE1) and design options IE2, IE3 and IE2+VSD. The calculation is done for 3 motor sizes (1,1 – 11 – 110 kW) and for 4 different operating hours per year (2000-4000-6000-8000). Product prices, excluding VAT because it is a 'business to business' market, and other economic variables were taken from the preparatory study but recalculated with EU27 average electricity rate of € 0,12kWh by 2007. More of the background is explained in the next chapter on the impact analysis and in the Annexes.

The main conclusion is that the most energy efficient design option is the combination of an IE3 (for fixed speed operation) with IE2+VSD (for variable speed applications), which would also be the most economic solution. At the indicated electricity rate the payback period can be measured in a couple of months; even if the electricity price would be twice as low and the product price twice as high, the payback would still be clearly lower than the life time of the motor. Additionally, this option efficiently addresses the main worry of many manufacturers regarding the discontinuation of IE2 production. The reason why the IE4 option was discarded was that energy efficiency measurement standards and test facilities do not yet exist and that there is not yet the necessary production capacity, especially for the higher power range.

Table 4.4.1: LCC calculation for base case and design options for 3 motor sizes (source: recalculated from preparatory study with 2007 electricity rate.

SMALL (share)	**Output (kW)**	**Life L (yrs)**	**Discount**	L**discor(yrs)**	**load factor**	**elec. Rate**
market share(units) 87%	**1,1**	12,00	2,0%	12,00	60%	0 087
						2%
	design-->	**IE1(base)**	**IE2**	**IE3**	**IE2+VSD****	**IE4***
	efficiency-->	75,0%	81,4%	84,1%	77,3%	87,6%
	performance-->	1,00	1,00	1,00	1,20	1,13
Product price		€96	€125	€154	€288	€288
	hrs/ yr.					
Electricity	2000	€1.837	€1.693	€1.639	€1.485	€1.392
	4000	€3.675	€3.386	€3.277	€2.970	€2.784
	6000	€5.512	€5.079	€4.916	€4.455	€4.177
	8000	€7.350	€6.772	€6.554	€5.940	€5.569
Total Life Cycle Costs	2000	€1.837	€1.693	€1.639	€1.485	€1.392
	4000	€3.675	€3.386	€3.277	€2.970	€2.784
	6000	€5.512	€5.079	€4.916	€4.455	€4.177
	8000	€7.350	€6.772	€6.554	€5.940	€5.569
Payback period in **months**	2000		2	4	7	5
	4000		1	2	3	3
	6000		1	1	2	2
	8000		1	1	2	1

MEDIUM	**Output (kW)**	**Life (yrs)**	**Discount**	L**discor(yrs)**	**load factor**	**elec. Rate**
market share(units) 12%	**11**	15,00	2,0%	15,00	60%	0 087
						2%
	design-->	**IE1(base)**	**IE2**	**IE3**	**IE2+VSD****	
	efficiency-->	87,6%	89,8%	91,4%	85,3%	VSD 95% eff
	performance-->	1,00	1,00	1,00	1,20	
Product price		€450	€563	€675	€1.350	
	hrs/ yr.					
Electricity	2000	€19.664	€19.183	€18.847	€16.827	
	4000	€39.329	€38.365	€37.694	€33.654	
	6000	€58.993	€57.548	€56.540	€50.481	
	8000	€78.658	€76.731	€75.387	€67.307	
Repair & Maintenance	2000	€145	€145	€145	€145	
	4000	€289	€289	€289	€289	
	6000	€434	€434	€434	€434	
	8000	€578	€578	€578	€578	
Total Life Cycle Costs	2000	€20.259	€19.891	€19.667	€18.322	
	4000	€40.068	€39.217	€38.658	€35.293	
	6000	€59.877	€58.545	€57.649	€52.265	
	8000	€79.686	€77.872	€76.640	€69.235	
Payback period in **months**	2000		4	5	6	
	4000		2	2	2	
	6000		1	1	1	
	8000		1	1	1	

Power levels

As described in Section 2, maximum power levels are foreseen which are scheduled to come into force in three stages in accordance with the fifth sub-option **VSD/IE3:**

Stage 1: effective one year after entry into force of the regulation (2011) with minimum energy consumption requirement at IE2 level and;

Stage 2: effective five years after entry into force of the regulation (2015) with minimum energy consumption requirement at either IE3 level or at IE2 level when coupled with a VSD for motors of 0,75 to 7,5 kW.

Stage 3: effective seven years after entry into force of the regulation (2017) with minimum energy consumption requirement at either IE3 level or at IE2 level when coupled with a VSD for all motors 0,75 to 375 kW.

The second and third stages correspond to the desirable level of ambition, as discussed in Section 2. Taking into account possible impacts on manufacturers including SMEs as required by the Ecodesign Directive, less demanding requirements are set in the first stage. In the second requirement, a less demanding level of ambition is still kept due to the requests of some industry of not being able to comply with an IE3 requirement alone, and the possible negative employment effects thereof. However, most importantly, a standard motor can be a better choice than a high-efficient motor in variable speed conditions with a VSD, as explained below. The duration of the transition periods is based on the assessment carried out in Section 5.

4.4.3 Ecodesign parameters for which no ecodesign requirements are necessary

The preparatory study shows that no other environmental parameters than energy in use are necessary as the use-phase almost totally dominate the environmental impacts. Consequently, the aim of the regulation is to set ecodesign requirements on energy consumption in the use-phase and no provision on further aspects is included.

No ecodesign requirements are set on noise levels as electric motors are regulated by the IEC 60034-9 standard, which specifies maximum A-weighted sound power levels (*L*WA) for airborne noise emitted by rotating electrical machines. However, manufacturers will be requested to indicate the noise level for the motor in product documentation.

4.4.4 Measurement standard

Standard IEC60032-30 defines a method for measuring motor efficiency and provides a uniform efficiency classification in three classes (IE1-IE3). A further IE4 efficiency level is to be defined and will correspond to the efficiency of permanent magnet motor technology. Further work is been carried out within the ESOs and IEA in order to aim developing an efficiency standard for VSDs Currently, competing approaches prevail either in favour of defining a measurement standard for the VSD alone or for the product as a whole (containing a VSD). These results are expected to be available at the event of the revision of the currently planned motor and drives measure.

Verification procedure for market surveillance purposes

Energy efficiency levels and tolerances shall be determined applying the low uncertainty efficiency testing procedures set out in accordance with IEC 60034-2-1, as specified by IEC 60034-30.

4.4.5 Information to be provided by manufacturers

In order to facilitate compliance checks manufacturers are requested to provide information in the technical documentation referred to in Annexes IV and V of Directive 2005/32/EC on the efficiency class and noise level of the motor

Electric motors must include permanently fixed motor rating plate on the motor as defined in IEC 60034-1 (CDV 2008). As VSDs do not yet have test standards or standardised rating plate requirements, a standardised VSD-STSD requirement will be made in line with 60034-1 with minimum content as follows:

- VSD for motor output (kW);
- Date of manufacturing, year and month;
- Name and place of manufacturer;
- Serial number;
- VSD type (normal/special environmental conditions);
- VSD speed range (range of rpm);
- Electric data (Voltage (V), frequency (Hz), maximum current (A).

4.4.6 Date for evaluation and possible revision

The main issues for a possible revision of the Regulation are

– appropriateness of the product scope;

– appropriateness of the levels for the ecodesign requirements for the efficiency of allowed motors;

– ecodesign requirements for the efficiency of allowed VSDs

The second stage of the ecodesign requirements becomes effective five years after entry into force of the Regulation. With a view to the level of requirements proposed and the still immature market for new technologies (such as those corresponding to IE4), a review can be presented to the Consultation Forum seven years after entry into force of the regulation. For this revision, it is important to develop the IE4 efficiency levels and the necessary measurement standard. On drives, a measurement standard should be developed and a technical study should be carried on the environmental potential of these devises.

4.4.7 Interrelation with other ecodesign implementing measures — implications on scope

The types of induction motors and drives covered by the measure are products/parts applied in a wide range of end-products, some of which are also planned to be regulated under the

Ecodesign-directive. In this sense, although the planned measure is a product specific ecodesign implementing measure, it can be considered as having a 'horizontal' aspect. Product, such as pumps, that include a motor covered by this implementing measure, must comply with the measure for affixing the CE mark. If there would be product specific implementing measures on any of the products containing a motor, those products would have to comply with both measures, with the motor and the product specific measure, in the same way as these products must comply with any other relevant EU legislation, such as the Low Voltage Directive, for example. The already ongoing ecodesign preparatory studies focus on several products that can contain a motor:

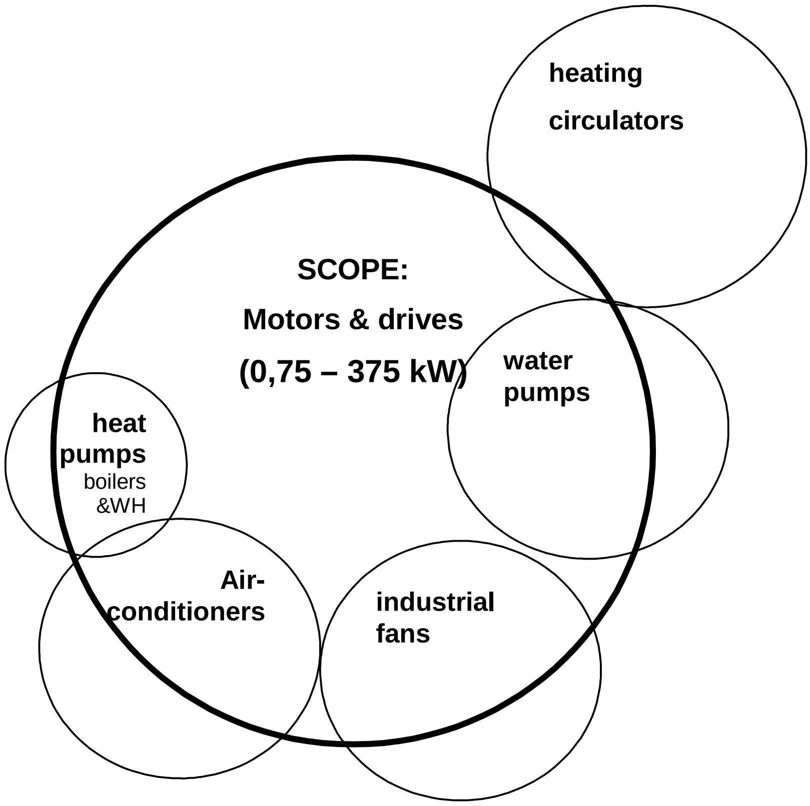
- Lot 11 — industrial fans
- Lot 11 — water pumps (commercial buildings, drinking water and agricultural use)
- Lot 11 — circulator pumps;
- Lot 10 — room air conditioners with input >0,75 kW (output ca. > 2,5 kW). This power range might be extended in a forthcoming study to central air conditioners for mainly the tertiary sector.
- Lot 1 & 2 — boiler integrated circulators (if not regulated in Lot 11) and electric heat pumps.

As mentioned, measures under these lots are not finalised, so it is not possible to make a detailed estimate on the overlap between these products. However, the overlap issue has been considered in several preparatory studies on the basis of which useful estimates can be made. The below figure 4.4.8 provides an overview of products with overlaps. The overlap between these groups is never complete, because:

- each of the other groups also addresses other design features, such as hydraulics (impeller), aerodynamics, system design, drives, etc.;
- some of the product groups predominantly use motors with an output smaller than 0,75 kW, especially circulators but also the lower range of most others.
- some of the products in these product groups use motor types that are not regulated through the proposed implementing measure (e.g. DC motors, single-phase AC-motors, universal motors, such as multistage submersible pumps).

These considerations make part of the scope of the considered measure, including the list of exclusions, which ensure that the environmental performance of motor products not covered by this measure can be considered in the future.

Figure 4.4.7: Estimated overlap in energy consumption and saving potential of motors & drives with other energy-using products



The proposed measures for the other energy-using product groups are — in line with the 2005/32/EC stipulations — not technology-specific, so it is difficult to predict which part of the generic efficiency requirements should be attributed to the motor measure and which to the other measures. Nevertheless, it is possible from the technical analysis in the preparatory studies and the market trends to show the main developments:

- VSDs play a major role in achieving energy efficiency for the product groups considered in variable speed operations (some 2/3 of all applications). In the measures considered, this is implicit from the demand on part-load efficiencies;

- Motor efficiency is measured in full-load efficiency. Stricter requirements in measures on the above product groups are being considered. E.g. for stand-alone circulators, the proposed levels go up to levels comparable to the future IE4 efficiency level corresponding to brushless permanent magnet DC motors.

As mentioned, quantification of the overlap is difficult at this stage. Based on the diagram above, the current motor applications can be taken into account as specified in Table 4.4.8 below based on the preparatory study (except that figures in this impact assessment are upgraded to EU27, 2005).

As a conclusion, an estimated overlap of around 30% between the motor measure and the forthcoming measures on other energy-using product groups is assumed as a preliminary estimate in terms of energy consumption and energy saving potential. The precise impact will be known when the studies on other product groups have been finalised.

Table. 4.4.7: Total motor electricity consumption in EU27, 2005 for industrial and tertiary sector*

End-use applications	Industry		tertiary		total	
	TWh/a	%	TWh/a	%	TWh/a	%
Pumps	163,2	21%	45,9	16%	209,1	24%
Air compressors	139,9	18%			139,9	14%
Fans	124,3	16%	68,9	24%	193,2	22%
Cooling compressors	54,4	7%				
Refrigeration			74,6	26%	177,8	16%
Air conditioning			48,8	17%		
Conveyors	15,5	2%	31,6	11%	47,1	5%
Other motors	279,7	36%	20,1	7%	299,8	35%
TOTAL TWh/a	**777**		**290**		**1067**	

*= based on Almeida et al. prep. study 2008 but corrected for EU27, 2005 (from EU15, 2000)

The overlap between various motor products has an impact on the scope of the foreseen Ecodesign measures, which should aim at maximum efficiency with lowest possible administrative burden of the foreseen regulatory interventions. Following considerations can be made.

No motor system exists without (a) motors(s) but numerous motor systems exist without pumps, fans, compressors or other similar devises that are run by the motor. The motor being the only single appliance that exists in every single motor system gives it a 'horizontal' character in terms of legislation; regulating the efficiency of the motor will have an impact on the efficiency of every single motor system (after the full replacement of the stock). This is likely to lead to a fewer Ecodesign Regulations than when considering every motor driven product individually. Also, the definition and verification of a motor efficiency in full load is common practice and an international standard exists for these purposes.

The savings impact of efficient motors is multiplied, if drives are used in systems with variable speed and load. Drives do not exist in all variable speed/load motor systems but where they exist there is always a motor. However, the efficiency of the drive depends on the rest of the system (type and level of load and speed, type of motor etc). This, together with the fact that no efficiency calculation method yet exists on drives, makes it possible to regulate the efficiency of the drive only at the level of A Class levels, as identified by the IEC WG 28 on Rotating Electric Machines; the high positive impact on motor and system efficiency through the use of appropriate drives is well known.

Consequently, the setting of minimum requirements separately on the efficiency of the motor and drive and on the use of a drive in conjunction with a motor used in variable speed and load applications, guarantees the maximum efficiency far beyond traditional efficiency measures known in the world ensuring the lowest possible administrative burden of the foreseen regulatory intervention.

4.4.8 *Including drives into the measure*

Despite of specific requests from manufacturers, and of generally known important savings associated to the use of drives, as shown by the preparatory study, motor efficiency legislations around the world do not yet included drives.

An Ecodesign Regulation can not be specified on the basis of the type of the usage for which a product is purchased but must be based on generally acceptable measurable technical efficiency criteria. As no such criteria have been identified for the drive for the purposes to consider setting ecodesign requirements on drives as such, the setting of requirements on the basis of the level of the efficiency of the motor and the drive coupled to the motor remains currently the only technically possible option. Drives used in conjunction with other motors will not have to comply with this measure.

An efficient legislation must, on the one hand, offer enough products for various needs, and on the second, limit the access to low efficient products. In the case of motors, the customer must be offered at least two distinctive solutions (motors); one suitable for variable speed and load operations in principle, and one suitable for full load and speed operations in principle[20] Concretely, this implies a motor without and a motor with a drive.

Consequently, in order to be able to realise the important savings from the use of drives, motors must be available on the market at least in two different measurable efficiency levels. This implies a trade off between the choice of limiting the access of e.g. standard efficiency IE2 motors on the market in setting minimum requirements at premium efficiency IE3 level, as done in the US, or allowing high-efficiency motors on the market when coupled with a drive and offering an alternative premium efficiency IE3 motor for customers, to be chosen by the customer depending on the type of application.

Drives are not relevant for full speed full-load applications (estimate ca. 1/3 of total) and they are already being sold with a relevant number of AC motors (see graph below)[21]. For more details, see Annex 2.

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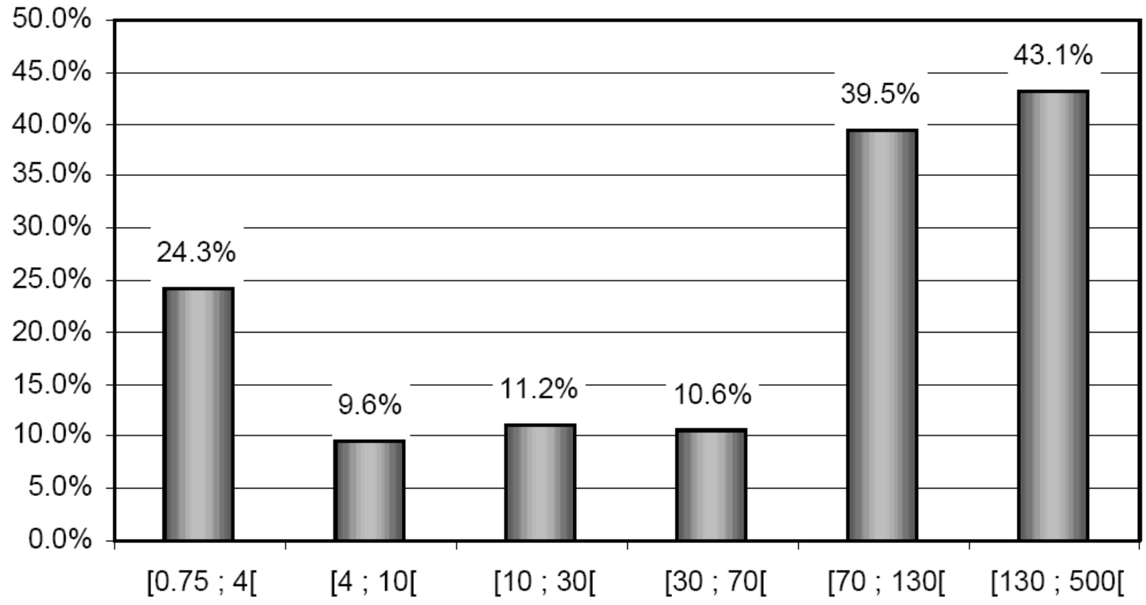
[20] There are always borderline cases in which both solutions may do.

[21] Note that the effect of drives already delivered with new products is not modelled in the stock model. In order to keep it simple, just the incremental effect of the drives throughout the stock was taken into account.



Section 5 analyses the impacts and presents the results of the two alternative approaches in following either the international practice in motor efficiency legislation in setting requirements only on motor efficiency or in including the drives into the measure, without setting requirements on drives other than those coupled to the motors that are in the scope of this measure.

5. IMPACT ANALYSIS

Given that options 1-3 have been discarded in Section 4, this Section looks into the impacts of option 4. To this end an assessment of possible sub-options as regards the "intensity" of the measure — the combination of the levels of requirements and the timing for the levels pursuant to Article 15(4f) of the Ecodesign Directive — is carried out.

The assessment is done with a view to the criteria set out in Article 15(5) of the Ecodesign Directive, and the impacts on manufacturers including SMEs. The aim is to find a balance between the quick realisation for achieving the appropriate level of ambition and the associated benefits for the environment and the user (due to reduction of life-cycle costs) on the one hand, and potential burdens related e.g. to un-planned re-design of equipment for achieving compliance with ecodesign requirements on the other hand, while avoiding negative impacts for the user, in particular as related to affordability and functionality. The methodology of the analysis is explained in Annex 2.

The economic, environmental and social impacts are analysed and presented in a summary table at the end of the chapter followed by a brief discussion of the sensitivity to price changes. Also, a number of sub-options for introductory dates are considered. The starting point for impacts is the electricity (TWh) savings, which are depicted per sub-option in the below figure and table. Due to the long life time of a motor, which goes up to 20 years in the case of big motors, savings figures are provided for 2020 and 2025.

The savings calculated in this chapter do not take into account the fact that premium efficiency (IE4) motors, based on e.g. permanent magnet motor technology, will be highly competitive with the IE2+VSD option due to strongly reduced difference in purchase price between IE2+VSD and premium efficiency motors. Furthermore, it is expected that a mass production of these motors could lead to an important price decrease in this technology and consequently to sales of premium efficiency motors instead of IE2+VSD motors already well before 2020.

Level of ambition

The preparatory study has shown that existing cost effective technical solutions allow for considerably lower electricity consumption levels for induction motors than the current market average. According to the "base cases" of the preparatory study the electricity consumption of average motors corresponds with IE1 efficiency level representing 85% of induction motors sold in Europe, as indicated in the below Table.

Table 5.a: Efficiency values (%) for base case and BAT in electric induction motor technology[22].

	Motor Rated Power		
Type of motor	1,1 kW	11 kW	110 kW
Base case (IE1 Full-load efficiency	75,0	87,6	93,3
IE3 (Full-load efficiency)	84,1	91,4	95,4

The preparatory study and additional input from stakeholders in the Consultation Forum has shown that the lowest achievable power consumption levels ("benchmark") can be achieved by applying the best available induction motor technology. New technologies, such as permanent magnet motor technology, were not included into the study due to its minor share in the power range considered and due to the lack of efficiency measurement standards.

According to the Ecodesign Directive requirements on energy consumption in use the aim should be at the life-cycle cost minimum for the end-user. The preparatory study concludes that a power consumption at IE3 efficiency level reduce the life-cycle cost for the end-user already from the 2000h/a usage. The use of a VSD is cost-efficient in most variable speed and load applications. However, only by knowing the precise system characteristics the efficiency of the drive can be known; the performance of a drive is not only dependent on motors coupled to them and on the part-load conditions but also to a large extent on the type of load, where there are a huge variety of conditions. For example, an efficient drive for motion control can be a bad choice for a fan. In these constraints, it is important to leave the choice of the drive for market based on customer needs. Most importantly, would the customer needs show that the least life cycle cost is not reduced thorough the use of a drive, there is always a second solution below the least life cycle cost, that of IE3.

22 The BAT is calculated here based on IEC60034 standard, which only allows measuring the performance of induction motor technology and not the efficiency of new technologies such as permanent magnet motor technology. A measurement standard is under development for this technology (to correspond with 'IE4' efficiency level in the IEC standard), which already exists mainly in small power range on the market.

Although the technology for achieving these power levels is available and widely sold in third countries such as in the US, the majority of products on the European market do not meet them. In order to take into account the effects on manufacturers, and in particular SMEs, a solution, which optimally satisfies the provisions of the Ecodesign Directive will be searched for in this Chapter.

Figure 5: Electricity consumption scenarios.

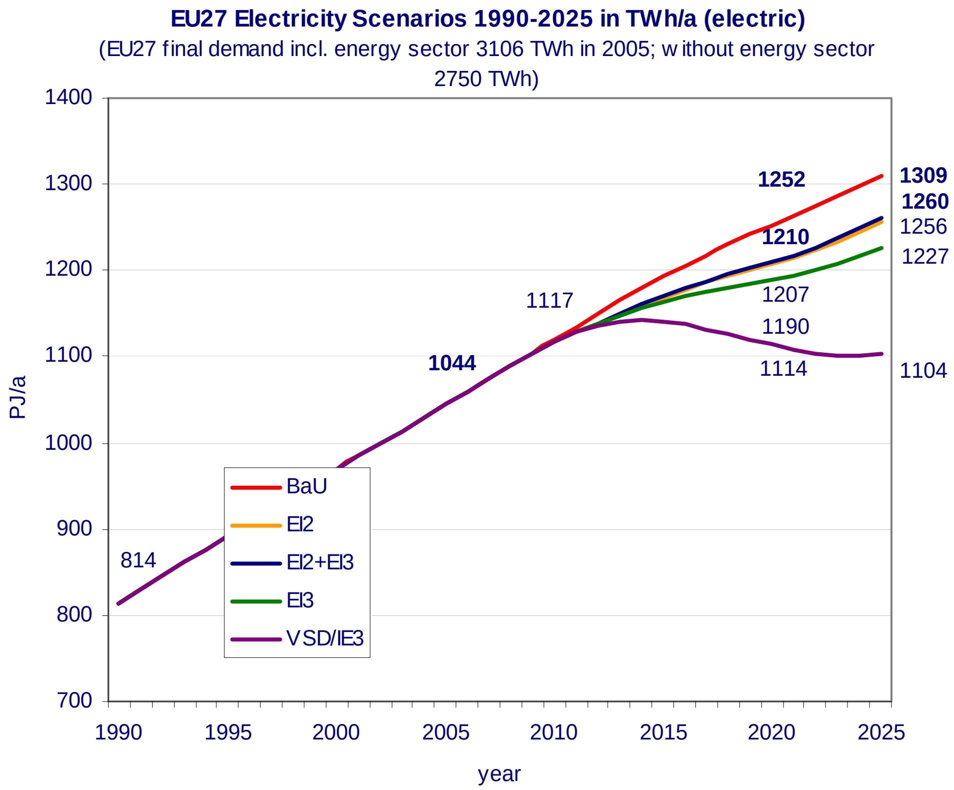


Table 5.b: Electricity Savings 2020 vs. BaU:			
	Use	Savings	
	TWh/a	TWh/a	%
BaU	1252		
IE2	1207	45	3,6%
IE2+IE3	1209	43	3,5%
IE3	1188	65	5,2%
VSD/IE3	1114	139	11,1%

5.1 Economic

5.1.1 Life-cycle cost and additional costs related to the improved technology

As shown by the preparatory study, the power consumption levels of the first and of the second/third stage are provided by readily available technologies which lead to a considerable reduction of the life-cycle cost for motor and drives from the end-user perspective. It is expected that the purchasing cost increases, although the additional cost is paid back in a few months rather than in years. Therefore the requirements for stage 1 and stage 2/3 remain cost-effective also when a lower electricity price is assumed (See table 3a).

5.1.2 Accumulated electricity cost savings

The requirements of the first stage ensure that, during the time span between the first and the second stage, motors placed on the market achieve certain improved efficiency levels. In the opposite case, there is a risk that equipment placed on the market, having life times up to 20 years, would be placed on the market for several years leading to unnecessary electricity consumption.

The accumulated electricity cost savings depend on the timing of the first and second stage. Qualitatively, the sooner the requirements become effective and the shorter the delay between first and second stage, the higher the accumulated electricity cost savings.

The table below shows the accumulated electricity savings from options 1-5 until 2020.

Table 5.1.2a: Accumulative impacts and savings vs. BaU 2010-2020

Base Option: Step1 (2011) Step 2 (2015) Step 3 (2017, for VSD/IE3 option only)

	Electricity	Savings	CO2	Savings	Expenditure (purchase + running cost)	Savings	Running costs	Savings
scenario	TWh	TWh	Mt	Mt	bln. Euro	bln. Euro	bln. Euro	bln. Euro
BaU	13088		5994		1164		1141	
IE2	12827	261	5875	120	1144	20	1118	23
IE2+IE3	12834	253	5878	116	1146	18	1119	22
IE3	12743	345	5836	158	1140	24	1111	30
VSD/IE3	12431	657	5693	301	1137	27	1077	57

Given the long life time, it is useful to compare the change in accumulated savings even after 2020. The below table summarises the accumulated electricity savings from options 1-5 until 2025. As can be seen, the total monetary savings increase from €89 billion to €234 billion in the option VSD/IE3.

Table 5.1.2b: Accumulative impacts and savings 2010-2025								
Base Option: Step1 (2011) Step 2 (2015) or Step 1/2/3 in 2011/2015/2017 for VSD/IE3 option								
	Electricity	**Savings**	**CO2**	**Savings**	**Expenditure**	**Savings**	**Running costs**	**Savings**
Scenario	**TWh**	**TWh**	**Mt**	**Mt**	**bln. Euro**	**bln. Euro**	**bln. Euro**	**bln. Euro**
BaU	19518		8939		1733		1700	
IE2	18999	518	8702	237	1691	41	1655	45
IE2+IE3	19020	498	8711	228	1696	37	1657	43
IE3	18782	736	8602	337	1677	55	1636	64
VSD/IE3	17945	1573	8219	720	1644	89	1553	136

5.1.3 *Business economics and competitiveness*

The diagram[23] below represents the outcome of the stock model as regards business revenues. The options related to motor efficiency alone are expected to lead to a price increase of up to 30% (IE3 sub-option) with respect of BaU. In figures: An increase of ca. €700 million from €2,2 to €2,9 billion for the industry sector.

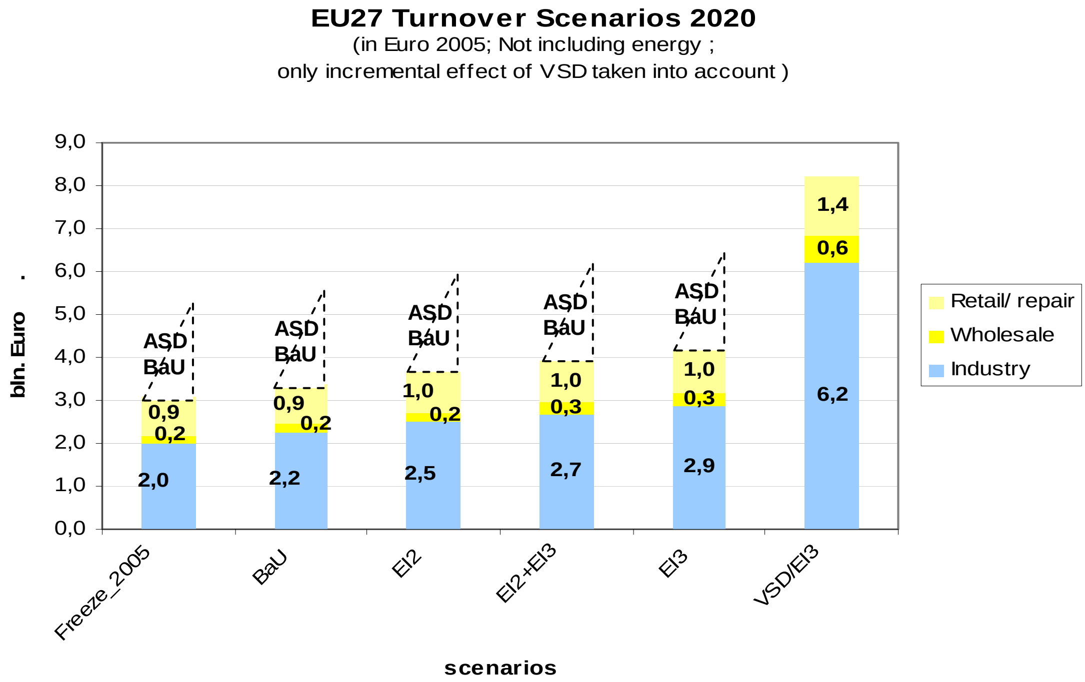


Diagram 5.1.3: Turnover scenarios 2020

[23] Note that 'ASD' in the diagram equals to 'VSD'.

The effect of the VSD/IE3 sub-option is slightly more difficult to evaluate, because it is the only scenario that takes into account VSDs and more specifically the possible increase of revenues from VSD sales due to the measure. It is estimated that the turnover will double but this estimate is lacking reference. In reality, a kind of a BaU sub-option can be assumed for VSDs with the other sub-options. This is symbolised by the dotted triangles in the above graph. The problem with VSD-BaU is that VSDs in today's technology are a relatively young development and it is uncertain how the future growth will look like, in particular as their sales are more sensitive to general economic development than the motor market; a motor is necessary to run a motor system — a VSD is not.

It is not impossible, as most producers seem to think, that the VSD business will continue to grow as in the 2005-2007 period with staggering growth rates. In that case, it may well be that all applications that would profit from a VSD would actually also buy a motor with a VSD. If this is the case, no VSD-related policy measure would be necessary to reach these savings. However, it is highly unlikely that such take-off rates would occur given the increased purchase price. Also, such take off rates has not been experienced in any economy in the world. The table below gives the turnover scenarios in figures.

Figure. 5.1.3: Turnover scenarios for sub-options.

Table 5.1.3: SUMMARY TURNOVER 2020 (BLN. EUR)

	Freeze_2005	BaU	EI2	EI2+EI3	EI3	VSD/EI3
Industry	2,0	2,2	2,5	2,7	2,9	6,2
Wholesale	0,2	0,2	0,2	0,3	0,3	0,6
Retail/ repair	0,9	0,9	1,0	1,0	1,0	1,4
Energy	112,3	108,3	104,4	104,6	102,7	96,3
Total	115,4	111,7	108,1	108,5	106,9	104,5

It can be assumed that the recent VSD sales growth is a 'low-hanging fruit' phenomenon, i.e. generated by progressive customers willing to save energy but that more conservative customers, particularly in the processing industry, are not willing to invest on VSDs On top of that, the current (and future) economic crisis might find a client base that goes back to single speed motors just to save on the purchase product price on the detriment of life cycle savings. In such a case, the recent growth would come to an abrupt halt after which it would only depend on the policy measures to realise the VSD/IE3 sub-option.

The truth may well be in the middle, but the fact is that nobody knows what is going to happen, also with the VSD BaU, but the VSD/IE3 sub-option offers certainty for both the suppliers and the customers to invest in this technology ensuring level playing filed for the industry and guaranteed savings for the society and the customer.

To consider the level of realism of the projections, a check of the economic data from annual reports and financial projections of some of the major motor and drives manufacturers is presented in Annex 6.

5.1.4 Availability of high-efficient motors and investment cost

During the stakeholder consultation, it was claimed that IE3 motor technology does not yet exist in European frame sizes, in particular in small power range, and that the cost to develop the IE3 technology and the production capacity would be unacceptable for the industry.

In order to clarify the situation, a message was sent by the Commission services on 30 July 2008, with a reminder on 30 September 2008, to all 29 European manufacturers and to CEMEP. Eight individual manufacturers replied before 17 December 2008. The results are, per replied manufacturer, as follows:

1. Most power range and poles above 5.5 kW is already produced;
2. Production planned for 2010 on 0,75-200 kW power range (irrespective of EU legislation);
3. Production planned for 2013 on 0,75-30 kW power range (idem);
4. No plans to produce but there are no problems to produce, if sufficient time is given;
5. Will produce only, if minimum requirements are introduced at IE3 level;
6. Not produced and expected a total change from IE2 to IE3;
7. An alternative investment plan is identified to shift to special motors only, if an IE3 level requirement is introduced;
8. Planned to produce IE2 in the future (no IE3).

All but one replied manufacturer were selling motors on a global scale, not only in Europe. One non-European manufacturer out of three main global manufacturers consulted stated that IE3 in European frame sizes is available in almost all poles in the power range considered.

As to the investment cost, three manufacturers stated that it is part of the ordinary investments cost without additional costs, except if requirements were introduced earlier than 18 months. Two manufactures requested an early introduction of minimum requirements at IE3 level in order to ensure return to the investment. Manufacturers that expected additional investment costs to occur stated as follows (for all motors):

- > €10 million;
- €10-20 million;
- €15-20 million;
- €30-40;
- Investment cost expected within the two digit million euro range;
- €50-60 million (this manufacturer considered the cost too expensive and had already identified an alternative strategy to shift production entirely to special motors, if IE3 requirements were introduced);
- 40% increase in production, design and material etc. cost.
- One manufacturer stated €50 million investment cost for the development of IE2 motors.

The information available indicates that:

- for 2/3 of manufactures the situation (ability to produce IE3) is only known based on information from CEMEP stating that many manufactures are not able to produce IE3 motors;

- The expected investment cost in comparison with the turn-over of the sector seems very acceptable;

- IE3 motor availability seems reassured, in particular if minimum requirements are set at IE3 level and sufficient time for the development and investment is given.

Given the moderate level of requirements on drives no investment costs are assumed for the compliance with the A Class requirements.

In summary, cost of complying with the requirements is not a major issue but the time needed for these investments and in particular the request from the industry to keep the IE2 motor market alive. The five year delay of the second requirement responds to this time need in delaying the shrinking of the IE2 market (to be used only in variable speed and load applications). The setting of minimum requirements at IE3 and VSD+IE2 levels will create a clear basis for an investment plan and a guarantee for return to the investment for those manufactures that are not yet producing standard or high-efficient motors.

No additional cost from the assessment of conformity with ecodesign requirements and re-assessment of conformity with further requirements (safety etc.) would occur given that the existing conformity assessment procedures do not change.

5.1.5 Administrative costs for Member States

The form of the legislation is a regulation which is directly applicable in all Member States. This ensures no costs for national administrations for transposition of the implementing legislation into national legislation.

The costs for carrying out the verification procedure for market surveillance purposes depends mainly on the product price (assuming a purchase by public authority), and the possible need for a second test on a sample of three additional products in the case that the power consumption levels established in the first test are excessive. As no minimum efficiency requirements are set on the VSD itself, market surveillance authorities can verify the IE2+VSD motor compliance in simply controlling the speed performance of the product, while controlling the efficiency level of the motor. In any case, it is to be expected that a product is tested not only for its conformity with ecodesign requirements, but also with further applicable requirements, and the part of the costs required for testing the power consumption of a motor is expected to be acceptable because the measurement on motor efficiency (without VSD) is generally used. There are no administrative costs on the verification of the level of requirements of the VSD.

5.1.6 Impacts on trade

The process for establishing ecodesign requirements for motors has been fully transparent, and after endorsement of the regulation by the Regulatory Committee a notification under WTO-TBT will be issued.

Manufacturers, including EU manufacturers, who sell products both inside and outside (where a number of third countries already have minimum requirements on motor efficiency) the EU may either produce all motors for compliance with the ecodesign requirements, independent of the market where the products are sold, or produce to different specifications for different markets. As a consequence a cost disadvantage could arise vis-à-vis manufacturers who do not sell motors in the EU. However, as motor market is global and has been divided to 50Hz vs. 60Hz frame-size markets since the history of electric induction motors, no risk of competitive disadvantages is expected to exist. Furthermore, stakeholders affected by the regulation have not pointed out such a risk. Therefore no competitive disadvantages for EU manufacturers exporting affected products to third countries are expected. There is a kind of a business disadvantage for non-European motor producers, who would not be able anymore to put low efficiency motors on the EU market. However, this is not a competitive disadvantage as such, as all manufacturers must comply with the same requirements.

5.2 Social impacts

As shown above an increase in purchase price due to ecodesign requirements is expected. However, given the low relative price of a motor in comparison with the price to run the motor, in comparison with turnover of a company running a motor, including SMEs, and the type of customer (industry), affordability is considered not to be a problem; investments loans are common practice in industry and tertiary sectors. Most importantly, the pay back period for a high-efficient motor is a few months and in all considered cases less than a year. The short pay back period also provides a business opportunity for ESCOs[24].

At aggregate level, savings in expenditure are reduced most in the option VSD/IE3, as illustrated in the below graph and table.

[24] Energy Service Companies.

Figure 5.2.1: Customer expenditure scenarios.

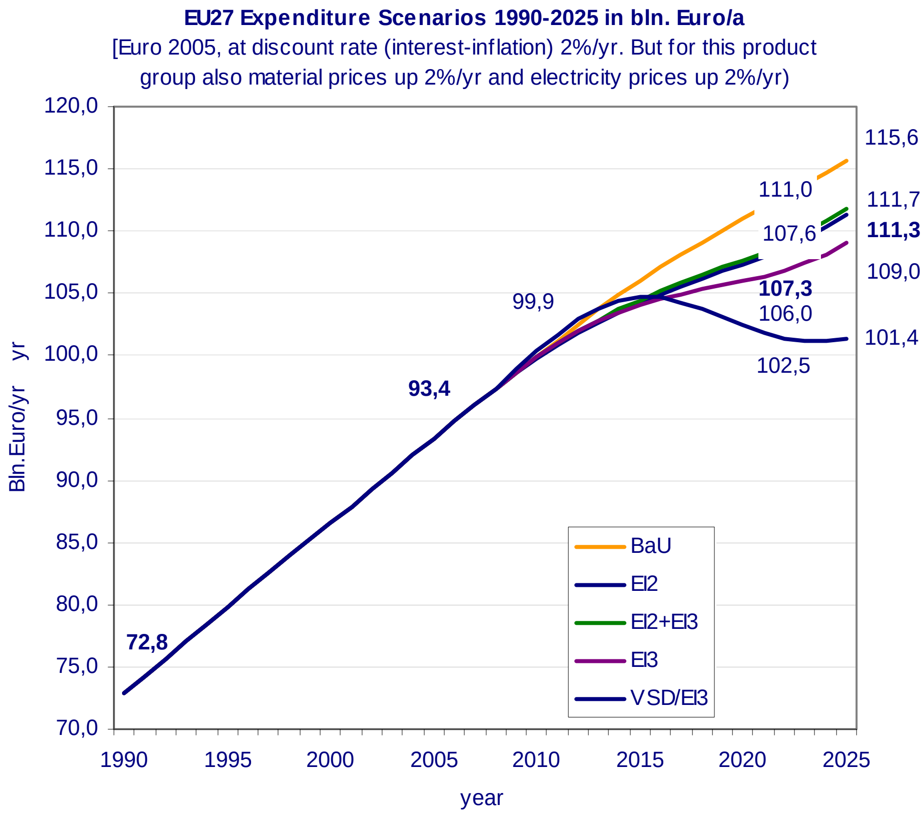


Table 5.4.1: Expenditure 2020 vs. BaU:

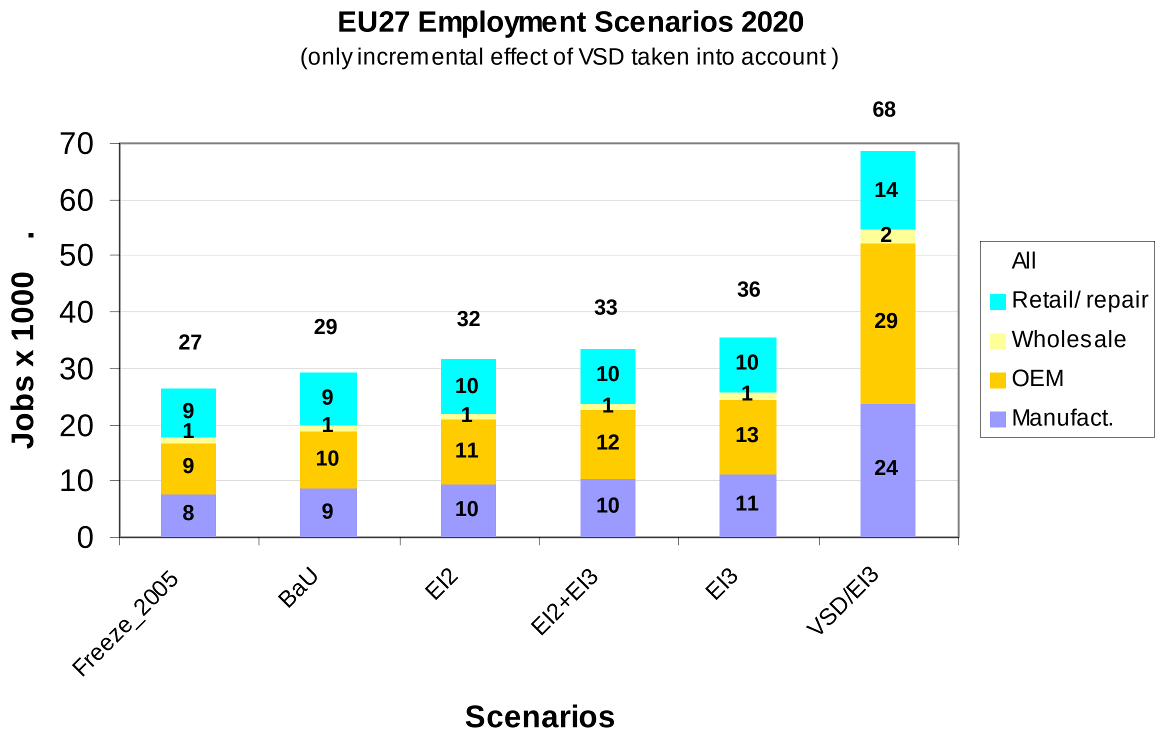
	Expenditure	Savings	
	bln. Euro	bln. Euro	%
BaU	111,0		
IE2	107,3	3,7	3,3%
IE2+IE3	107,6	3,4	3,0%
IE3	106,0	5,0	4,5%
VSD/IE3	102,1	8,5	7,7%

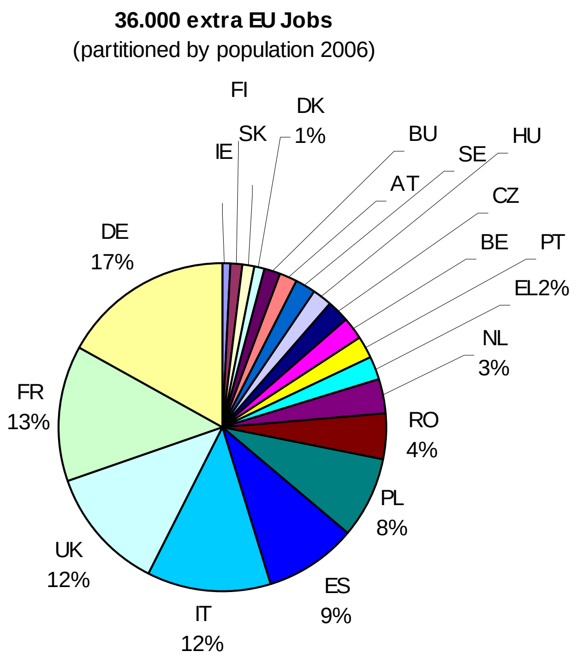
However, as shown in Chapter 4, the overlap between motors and the other relevant motor products used in motors systems is estimated to about 30%. This reduces the total impacts, e.g. of VSD/IE3 option, to about € 6.2 billion by 2020.

Employment

The analysis shows positive employment impacts for all considered sub-options. The increased number of jobs in the fifth sub-option is particularly relevant for SMEs, which are often responsible for installation and maintenance of motor products in motor systems.

Fig. 5.2.2: Employment scenarios for sub-options[25]





25 Note, 'VSD' is interchangeable with 'ASD'.

Fig. 5.2.4: New EU jobs partitioned per Member State on the basis of population

Table 5.4.2: SUMMARY EMPLOYMENT 2020 (JOBS X 1000)

	Freeze_2005	BaU	EI2	EI2+EI3	EI3	VSD/EI3
Manufacturer	8	9	10	10	11	24
OEM	9	10	11	12	13	28
Wholesale	1	1	1	1	1	2
Retail/ repair	9	9	10	10	10	14
Total	27	29	32	33	36	68

5.3 Environmental

5.3.1 Accumulated and annual reductions of CO2 emissions

The accumulated electricity savings and the reduction of CO2 emissions depend on the timing of first and second stage. Qualitatively, the sooner the requirements become effective and the shorter the delay between first and second stage, the higher the accumulated electricity savings and the related CO2 emissions. Therefore the positive impact of the sub-options is becoming lower for longer delays. The accumulated CO2 savings for sub-options 1-5 by 2020 and 2025 are shown in below graph and table.

Graph 5.3.1: Carbon emissions scenarios for sub-options.

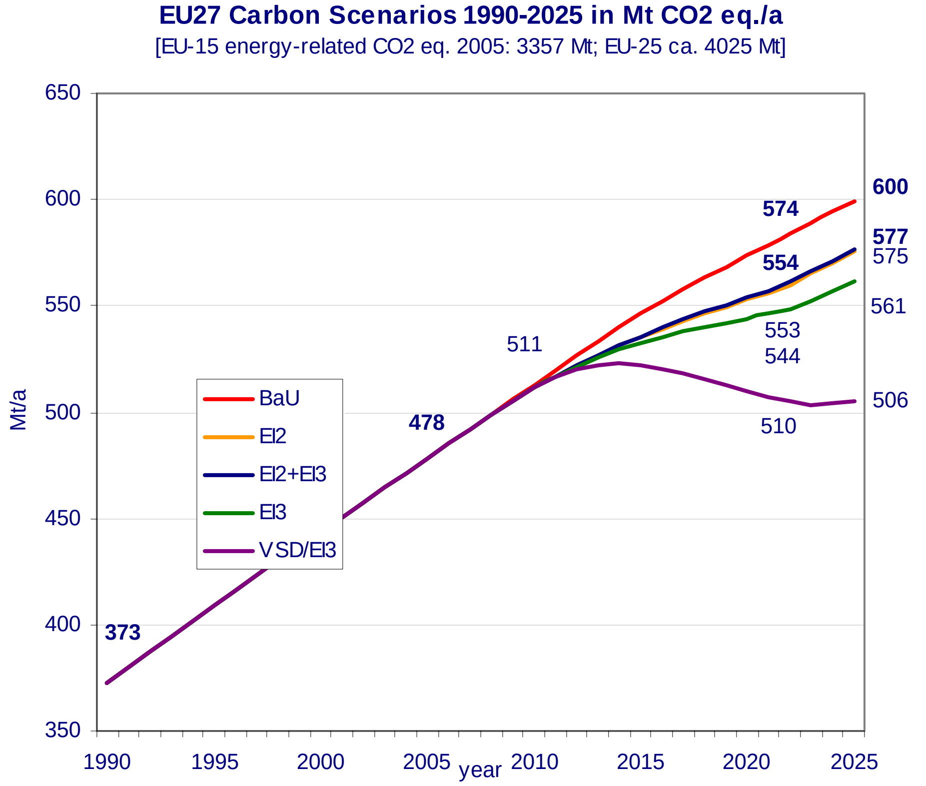


Table 5.3.1: Carbon (CO_2 eq) Savings 2020 vs. BaU			
	Use	Savings	
	CO2 eq/a	CO2 eq/a	%
BaU	574		
IE2	553	21	3,7%
IE2+IE3	554	20	3,6%
IE3	544	30	5,3%
VSD/IE3	510	64	11,5%

5.3.2 Possible trade-offs between low energy consumption and material–related environmental impacts

The preparatory study has qualitatively assessed possible trade-offs between reductions of energy consumption, and material related impacts which possibly, but not necessarily, may be arising due to, e.g., additional copper needed for high-efficient motors. Even in the case that additional components are necessary to comply with ecodesign requirements (e.g. copper rotor) trade-offs are not to be expected, i.e. the reduction of the use phase power consumption environmental impact is larger than possible additional material-related environmental impacts.

5.4 Administrative costs

The Impact Assessment on the recast of the Energy Labeling Directive SEC(2008) 2862 calculates the administrative burden of introducing a new implementing Directive, similar to the proposed to the ecodesign implementing measures for motors, in accordance with the EU Standard Cost Model.

It estimates the administrative cost of implementing measures in the form of a Directive at € 4,7 million of which € 720.000 for administrative work on the amendment/development of the new Directive and €4 million for transposition by Member States. It follows that the administrative cost of an implementing Regulation – as is currently proposed - would save € 4 million in avoiding the transposition cost.

Administrative costs of enforcing the Regulation are difficult to estimate. Enforcement could involve random spot-checks by the authorities, but from experience with other regulations of this type most spot-checks are not random but follow indications of competitors or third parties (e.g. industry or consumer associations). In those cases, the probability of not only recuperating testing costs and legal costs, but also of collecting fines is high. Therefore, no extra enforcement costs for Member States are anticipated from the measure.

Also for business, extra administrative costs, if any, will be modest. In current practice, motors and drives are subject to energy efficiency tests for a number of reasons (CE-marking, client specification, etc.). The proposed Regulation will not change this situation. There is no difference in this respect between various scenarios.

5.5 Conclusion on economic, social and environmental impacts

The below tables give an overview of impacts versus objectives and boundary conditions.

Table 5.5.1: MAIN IMPACTS

			Scenario's 2020				
			1	2	3	4	5
IMPACTS (as Art. 15.4 of 2005/32/EC)			**BAU**	**EI2**	**EI2+EI3**	**EI3**	**VSD/EI3**
ENVIRONMENT							
	ENERGY	PJ/a	**11272**	**10865**	**10882**	**10691**	**10022**
	GHG	Mt CO2 eq./a	**574**	**553**	**554**	**544**	**510**
	environmental	kt Sox eq./a					
CUSTOMER							
EU totals	expenditure	€ bln./a***	**111,0**	**107,3**	**107,6**	**106,0**	**102,5**
	purchase costs	€ bln./a	2,0	2,2	2,4	2,6	5,5
	running costs	€ bln./a	109,0	105,1	105,2	103,4	96,9
per product	product price	€	248	275	297	321	687
	install cost	€	0	0	0	0	0
	energy costs	€ /a	868	833	835	812	729
	payback(4% discount rate)	years	reference	**0,8**	**negative**	**1,1**	**4,4**
BUSINESS							
EU turnover	Manufacturers	€ bln./a	**2,2**	**2,5**	**2,7**	**2,9**	**6,2**
	whole-sale	€ bln./a	**0,2**	**0,2**	**0,3**	**0,3**	**0,6**
	Installers	€ bln./a	**0,9**	**1,0**	**1,0**	**1,0**	**1,4**
EMPLOYMENT							
employ-ment (number of jobs)	industry EU (incl. OEM)	'000	17	19	20	22	47
	industry non-EU	'000	2	2	2	3	6
	whole-sale	'000	1	1	1	1	2
	installers	'000	9	10	10	10	14
	TOTAL	'000	**29**	**32**	**33**	**36**	**68**
	of which EU	'000	27	29	31	33	62
	EXTRA EU jobs	'000	reference	**2**	**4**	**6**	**36**
	of which SME**		reference	1	2	3	13

**= partitioning 30% industry & wholesale, 80% installers

***=all money amounts in Euro 2005 (inflation corrected)

The below table summarises the considerations on the impacts of the five main options and assesses them on a relative scale: 0, +, ++[26].

[26] Based on Article 15 of 2005/32/EC, there should be no 'negative' impacts.

Table 5.5.2: Summary of impacts per sub-option				
	1	2	3	4
IMPACTS	EI2	EI2+EI3	EI3	VSD/EI3
Economic	+	+	+	++
Social	+	+	+	++
Environmental	+	+	+	++

5.6 Comparison of sub-options for introductory dates

The following table summarises the considerations on the impacts of various introductory dates for the sub-option 4 (**VSD/IE3**). Sub-option with introductory dates 2014 is an improvement in terms of life-cycle costs compared to 2015. However, the non-existence of premium efficiency IE3 motors in the whole power range and in all poles is a constraint that could lead to shortage of products in the market, if the requirement was introduced earlier. A few companies that have already planned production in 2-4 years from now would easily comply but the majority of companies would face major difficulties.

Table 5.6: Savings 2020 vs. BaU: BASE and SUBOPTIONS

Base Option Step1 (2011) Step 2 (2015) plus for VSD/IE3 only Step 3 (2017)

	Use	Savings		Expenditure	Savings	
	TWh/a	TWh/a	%	bln. Euro/a	bln. Euro/a	%
BaU	1252			111,0		
IE2	1207	45	3,6%	107,3	3,7	3,3%
IE2+IE3	1209	43	3,5%	107,6	3,4	3,0%
IE3	1188	65	5,2%	106,0	5,0	4,5%
VSD/IE3	1114	139	11,1%	102,5	8,5	7,7%

Sub Option 1: Step 2 (2014)/ Step 3 (2016); one year sooner

	Use	Savings		Expenditure	Savings	
	TWh/a	TWh/a	%	bln. Euro/a	bln. Euro/a	%
BaU	1252			111,0		
IE2	1207	45	3,6%	107,3	3,7	3,3%
IE2+IE3	1208	44	3,5%	107,6	3,4	3,1%
IE3	1186	67	5,3%	105,8	5,2	4,7%
VSD/IE3	1109	144	11,5%	101,9	9,1	7,9%

Sub Option 2: Step 2 (2016)/ 3 (2018); one year later

	Use	Savings		Expenditure	Savings	
	TWh/a	TWh/a	%	bln. Euro	bln. Euro	%
BaU	1252			111,0		
IE2	1207	45	3,6%	107,3	3,7	3,3%
IE2+IE3	1210	43	3,4%	107,7	3,3	3,0%
IE3	1190	62	5,0%	106,2	4,8	4,3%
VSD/IE3	1122	130	10,9%	103,0	7,9	7,1%

Sub Option 3: Step 1 (2012) one year later

	Use	Savings		Expenditure	Savings	
	TWh/a	TWh/a	%	bln. Euro/a	bln. Euro/a	%
BaU	1252			111,0		
IE2	1211	41	3,3%	107,6	3,3	3,0%
IE2+IE3	1212	40	3,2%	107,9	3,1	2,8%
IE3	1192	60	4,8%	106,4	4,6	4,2%
VSD/IE3	1125	127	10,1%	103,3	7,6	6,8%

It is concluded that, from the point of view of savings, the initial VSD/IE3 sub-option is less preferred option than an option to introduce the requirement one year earlier. However, the non-availability of premium efficiency IE3 motors in the full power range and in all poles poses a risk for earlier introduction for most manufacturers despite of a few front-runners whose investments plans include the production of IE3 motors already by 2013. The negative side is that this introductory date delays the correction of the lack of consumer take-up of VSDs by a few years. However, it ensures that there are IE3 motors on the market from a sufficient number of manufacturers/production base on the date of the introduction of the requirement.

In principle, as a fifth sub-option, it would have been possible to set minimum requirements on VSD/IE3 (minimum requirement at IE3 level on the motor coupled with a drive). However, a motor with a drive in full speed operation is more expensive to purchase than a motor alone and would lead to a lower efficiency in use (due to drive losses and additional electricity consumption that does not serve any purpose). This defect would have an impact on about 1/3 of motor on the markets run on full speed/load. Also, if maximum efficiency with a minimum administrative burden is searched for, a sub-option must include, while not being able to regulate the customer choice on the basis of the purpose for which the product is purchased, the choice must be left for the consumer between two alternatives; an efficient motor alone for full speed and load applications and a motor with a drive for variable speed part load applications corresponding with the least life cycle cost level.

5.7 Sensitivities considered

Doubling electricity price in the 4 sub-options reduces the payback period by 50% leading to a payback period of 2,2 years in the case of the most ‘expensive’ option.

Table 5.7.1: Impacts on consumers when doubling electricity price (0,17 euro/kWh)

Consumer			BaU	IE2	IE2+3	IE3	VSD/IE3
EU totals	expenditure	€ bln./a***	**214,3**	**206,9**	**207,4**	**204,0**	**194,4**
	purchase costs	€ bln./a	2,0	2,2	2,4	2,6	5,5
	running costs	€ bln./a	212,3	204,7	205,0	201,4	188,9
per product	product price	€	248	275	297	321	689
	install cost	€	0	0	0	0	0
	energy costs	€ /a	1696	1628	1632	1587	1428
	Payback period(SPP)	years	reference	**0,4**	**negative**	**0,5**	**2,2**

Increasing product price[27] in the 4 sub-options doubles the payback period, but the most expensive option (€1157, which is 4 to 5 times the base case) still has a payback period lower than discounted product life (8,7 years).

Table 5.7.2: Impacts on consumers when doubling the product price

Consumer			BaU	IE2	IE2+3	IE3	VSD/IE3
EU totals	expenditure	€ bln./a***	**111,2**	**107,7**	**108,2**	**106,8**	**105,4**
	purchase costs	€ bln./a	2,2	2,6	3,0	3,4	9,3
	running costs	€ bln./a	109,0	105,1	105,2	103,4	96,9
per product	product price	€	276	330	373	422	1157
	install cost	€	0	0	0	0	0
	energy costs	€ /a	868	833	835	812	730
	payback(SPP)	years	reference	**1,6**	**negative**	**2,1**	**8,7**

Fractional introduction dates: For various reasons it may be decided to choose the introduction date not on the 1st of Jan but e.g. at a more convenient month when business is

[27] Price increase per %-point saving in €/ kWh.

slow, e.g. in summer, and inventory and catalogues changes can be realised more easily . The effect of e.g. a 6 month delay (introduction mid June) is in the order of 3-4 TWh/a of savings missed in 2020. This represents 2-3% of the total savings calculated and is well within the tolerance of the stock model used for the forecasts. For that reason variations of sub-options with a time-span of less than a whole year have not been taken into account.

Further to the price impacts on motors, in the Consultation Forum, it was argued that an ecodesign requirement at IE3 level with increased copper demand would lead to increased copper price and deprivation of scarce resources. The total world copper demand is about 22 million tonnes with Europe demanding 4.7 million tonnes (21% of world's total demand)[28]. The copper used in all worlds' motors is around 5000-6000 tonnes[29] of which non-European countries use the biggest part. Under these conditions, the minuscule share of copper used for electric motors could not affect the copper price even if its demand for all worlds' motors would be many-folded.

6. CONCLUSIONS

Following the principle of proportionality in the analysis, policy options 1 to 3 were discarded at an earlier phase of the analysis. The analysis of 4 sub-options for the intensity of an ecodesign regulation on motors shows that sub-option 4 optimally fulfils the objectives as set out in Section 3. The regulation/sub-option 4 implies in particular:

– cost-effective reduction of motor electricity losses;

– correction of market failures and proper functioning of the internal market;

– no significant administrative burdens for manufacturers or retailers;

– increased purchase cost, including economies of scale for effective technologies, which would be largely overcompensated by savings during the use-phase of the product;

– that the specific mandate of the Legislator is respected;

– reduction of the electricity consumption of about 140 TWh, corresponding to savings of €9 billion vs. 65 Mt of CO_2 by 2020 compared to the "no action" option. The electricity consumption saved corresponds approximately to the annual electricity consumption of the four biggest EU economies combined (DE, FR, UK, IT);

– a reduction in accumulated electricity savings by 2025[30] amount to 1600 TWh, 523 Mt of CO_2 and € 164 billion;

– a clear legal framework for product design which leaves flexibility for manufacturers to achieve the energy efficiency levels of the 2nd stage either in two steps, or earlier (before the 2nd stage comes into effect);

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28 In 2006: European Copper Institute.

29 Industry sources.

30 Amounts by 2025 are given as motor life time is 20 years for big motors. For accumulated savings per sub-option by 2020, see Annex 5.

- costs for re-design and re-assessment upon introduction of the regulation, which are limited in absolute terms, and not significant in relative terms (per product);
- fair competition by creation of a level playing field;
- no significant impacts on the competitiveness of industry, and in particular SMEs due to the possibility of continuing the IE2 motor production and due to the possibility of connecting the VSD to a motor either as a physically inseparable part of the motor or as a separate devise, which could be necessary in some applications involving small motors;
- positive impact on employment, in particular for SMEs.

7. MONITORING AND EVALUATION

The appropriateness of scope, definitions and limits will be reviewed after maximum 6 years from the adoption of the measure (as required by Annex VII.9 of the Ecodesign Directive and laid down in the implementing measure). Account will be taken also of speed of technological development and input from stakeholders and Member States. Compliance with the legal provisions will follow the usual process of "New Approach" regulations as expressed by the CE marking.

Compliance checks are mainly done by market surveillance carried out by Member State authorities ensuring that the requirements are met. Further information from the field as e.g. complaints by consumer organisation or competitors could alert on possible deviations from the provisions and/or of the need to take action.

Input is also expected from work carried out in the context of upcoming ecodesign activities on further product categories and related activities, e.g. the IEA Implementing Agreement for Energy Efficiency End-Use Equipment.

ANNEX 1: **MINUTES OF CONSULTATION FORUM MEETING**

EUROPEAN COMMISSION
DIRECTORATE-GENERAL FOR ENERGY AND TRANSPORT

DIRECTORATE D - New and Renewable Energy Sources, Energy Efficiency & Innovation
Energy efficiency of products & Intelligent Energy – Europe

Brussels, 22.09.2008

SUMMARY MINUTES

Possible Eco-design Implementing Measures on Motors under the Directive on the Eco-design of Energy-Using Products (2005/32/EC)

Seventh meeting of the Eco-design Consultation Forum (27th May 2008)

Charlemagne (CHAR), Alcide de Gasperi (S3) Room, Rue de la Loi 170, 1049 Brussels

EC Participants: André BRISAER (Chairman), Ismo GRÖNROOS-SAIKKALA (TREN/D3), Villo LELKES (TREN/D3), Kerstin LICHTENVORT (ENTR/B1), Ludmila MAJLATHOVA (ENV/C5).

Introduction

The Chairman welcomed the group and introduced Mr Anibal de Almeida who was responsible for the motors study and Mr Rob Boteler, Chairman of National Electrical Manufacturers Association (NEMA) in the US.

The Commission Staff Working Document (CSWD) on possible ecodesign requirements for motors was presented (see presentation circulated together with these draft minutes). The CSWD was made available four weeks prior to the meeting on http://ec.europa.eu/energy/demand/legislation/eco_design_en.htm#consultation_forum.

The proposal focuses on single speed AC 3-phase motors, which are generally standardised worldwide and the only type of motors for which minimum efficiency requirements are being introduced in many countries. Smaller single phase motors and universal motors, mostly used in appliances, will be looked at under other measures tackling specific product groups. AC synchronous motors have a very small market share, and are not standardised. Conventional DC motors with small market share is a further shrinking market, not as standardised as 3-phase motors and therefore no minimum requirements are being developed anywhere. Electronically commutated permanent magnet (EC-PM) motors are an energy-efficient technology being already incorporated in equipment, such as in fans and appliances, with power levels mostly in the power range below 0.75 kW. These motors are not yet standardised, and require an electronic controller to operate.

All single speed AC 3-phase motors put on the market in the power range under consideration, with well defined exceptions due to critical operational constraints, are included, also when they make part of other equipment. Also, motor products that include variable speed drives (VSDs) must comply.

Mr Rob Boteler, representing NEMA, made a **presentation on the situation in US** (see presentation circulated together with these draft minutes).

US manufacturers requested the legislator to regulate the market at the level of IE3 level rather than trying to comply with various pieces of legislation emerging in US states or basing the market on voluntary industry action. The minimum efficiency standards are based on harmonised efficiency levels as in IEC 60034-30 and will come into force in 2011 for power range of 1 – 200 hp (ca 0.75 – 160 kW) at the IE3 level. Also, extension of the scope to motors in the power range of 200 – 500 hp (150 – 375 kW) at minimum efficiency level of IE2 is included. This new US Energy Bill was formally decided in December 2007 to put the IE3 requirements into law. The motor market is developing fast and already now two Chinese manufacturers are known to produce IE3 level motors with accreditation by NEMA Premium.

CEMEP presentation focused on a system based approach called 'extended product approach', which entails optimised installations with variable speed drives (see presentation circulated together with these draft minutes). CEMEP estimates that the presented extended product approach focusing on the motor system saves 200 TWh by 2020 at a cost of 29 billion Euro. CEMEP also notes that even a 100% efficient motor will waste energy if the throttle is not replaced. CEMEP proposes to look at the entire motor system instead of the motor alone.

ECEEE raised a question on the transparency and reliability of the presented CEMEP calculations, whether cumulative or annual data were mentioned, and how comparable the data would be with the technical study. The technical study indicated 15 billion Euro.

Key issues summarised:

CEMEP queried the **expected savings** and the fact that CO2 emissions do not seem to be mentioned at all in the Commission working document. The Chairman clarified that the preparatory study on motors concluded that the only significant environmental impact is energy consumption in the use-phase and reducing electricity consumption reduces CO2 emissions. However, the related CO2 savings depend on the energy mix in a country, therefore in an internal market framework measures should be based on the energy consumption.

CEMEP commented that the 15 TWh annual electricity savings predicted for 2020 is only negligible. The Chairman explained that it is quite a large saving in end-user's electricity consumption. Also, motors have a long life cycle. 15 TWh is expected by 2020 but as the life cycle of a motor is 12 – 20 years annual savings will continue and even increase after 2020.

ECEEE considered that the savings are impressive; 15 TWh is equivalent to the output of two average nuclear power plants in Finland.

The Netherlands commented on the difference in attitude between the US and European Industry Associations and was impressed by the US industry desire to improve and innovate. Also, the Netherlands would like to see the EU harmonising more with the US on timing and ambition. CEMEP would not agree and would favour a system approach to save more energy at less cost.

CEMEP commented that industry have always held the position on **system potential** and presented it two years ago. CEMEP commented that it is important to bear in mind that IE3 motors are not always more cost-effective replacements for IE2 motors — it depends on the application and the system.

ECOS agree that motor systems integrating VSDs (variable speed drives) can be very efficient but consider that, as a starting point, motors as products should be regulated under the Eco-design Directive. The feasibility to achieve further savings through legislation based on VSD and a motor system approach should be further assessed in the future. ECOS sees a contradiction in the CEMEP argument in being unwilling to introduce minimum efficiency requirements at the level of IE3 because of an additional cost of 24% whilst the CEMEP system proposal leads to 120% additional cost for VSDs Mandatory Ecodesign requirements can be complemented with voluntary action on systems.

The Chairman explained that an implementing measure needs to respond to the criteria in Article 15 of the Eco-design Directive. Voluntary Agreements are the preferred option as long as they respond to a number of criteria (Annex 8 of the Directive). Could a voluntary agreement on motors cover a vast majority of market share, particularly in the light of the US experience? And are the signatories willing to commit to deliverables? To date there has not been any proposal from industry for a voluntary agreement that could be considered as a valid alternative to legislation. In addition, it is important to avoid Europe becoming a dumping ground for inefficient imported products. The Chairman invited CEMEP to make additional voluntary proposals on the system savings potential.

Germany commented that they saw the value in a controlled extended product approach but explained that high quality motor components are needed for this to work well. Also, the Lisbon Strategy needs to be taken into account. The EU will lose ground by sticking to low quality products. We need to do both — use good quality products and promote efficient systems.

On **scope and minimum requirements**, Germany asked if motors of less that 7.5 kW would not have to reach IE3 after 2015. In the medium term, this category should have the same or better energy efficiency. Commission services explained that the impact of such a measure should be assessed Commission services invited participants to provide further information on this.

ECOS explained that the IE3 criteria were lowered for the low power range (0.75 – 11 kW) in the revised IEC 60034-30 standard. This now allows also small induction motors to reach the IE3 standard. ECOS insisted that with new motor technology this is easily possible. ECOS commented that there is nothing to prevent fast adoption of minimum efficiency requirements in two tiers, first at IE2 and then at IE3 levels. What is important is to decide and announce the requirements quickly to give industry the necessary time to adapt.

Mr de Almeida explained that, in terms of LLCC, even for low industrial electricity prices (3c Euro), the crossover for IE3 to be feasible is 2000 operating hours per year and for large services (charged at 7.5c Euro), the crossover is 1000 hours. The majority of motor applications fall above these thresholds. If a VSD is used, the cost of the VSD and its losses must also be considered. VSDs have a large application potential but there is no contradiction in promoting both high efficient motors and also VSDs in most variable load applications.

DEFRA support the target of IE3 for motors below 7.5 kW by 2015. CEMEP reiterated that although IE3 motors were the best solution in some applications, from an environmental point of view, it is not the most cost effective solution for every application.

Germany proposed broadening the scope of the proposed measure e.g. to permanent magnet motors after the review of the measure. Once technology shifts have taken place, this could be done. Germany wondered if there was an intention to cover permanent magnet motors already in this measure. Commission services explained that they are not currently in the scope. ECOS explained that IEC test standards would first need to be modified to include permanent magnet motors and maybe this issue could be added in the review of the implementing measure.

Denmark supported ambitious targets for motors stating that it is not acceptable that minimum efficiency requirements in Europe would be lower than in the rest of the world. Denmark support looking at the potential role of VSDs in the future.

Mr Boteler commented that he thinks variable load motor applications are too complex to regulate the use of VSDs In the US, there is a programme called "Save Energy Now" in which CEOs commit to reduce energy intensity. Pressure from the CEO is a better way to target VSDs in areas that can not be regulated easily.

Mr de Almeida clarified that, in the Working Document, IE4 is a technical **benchmark** with performance levels still to be defined**.** Mr Boteler commented that he does not support IE4 as benchmark as it is a level above NEMA Premium.

ECOS supports the IE4 benchmark. CEMEP disagreed because IE4 level has not yet been defined in the standard. ECOS commented that IE4 may represent 15% saving compared to IE3 and is a good benchmark because it can be met by any future motor technology, not induction motors only. The levels would come into force as soon as they would be defined in the IEC standard in all necessary details.

Regarding the wording on the **measurement method**, CEMEP would like to see it changed from "IEC 60034-2-1, Low Uncertainty Method, as specified by IEC 60034-30" to just "IEC 60034-2-1". Mr de Almeida agreed: stating 'as specified by IEC 60034-2-1' preserves the meaning, as the Low Uncertainty Method is stipulated in the standard for IE2 and IE3 anyway.

Orgalime commented that the **cost of materials** such as copper is rising because it's being depleted very quickly and this issue seems to be overlooked. The Chairman explained that this will be looked at in the impact assessment. It's a global issue and is probably best left to the market. As copper becomes more expensive, industry will begin moving to find alternatives. Commission services added that this will have the knock on effect of high recycling rates for items of less availability. Mr de Almeida explained that Bills of Materials were considered in the study and that the price of the materials is embedded in the motor cost, which was used in the LCC assessment. The vast majority (95%) of motors are recycled.

The Chairman agreed to consider adding an information requirement on **noise levels** for motors, as requested.

CEMEP commented that, in the US, compliance needs to be tested and was concerned about imports into the European market. The Chairman replied that **market surveillance** is important. It falls under the remit of Member States and it is important that the EU sets enforceable requirements. This is a general issue and applies across the board. Mr Boteler explained that NEMA went to China to accredit laboratories for testing IE3 products there. The Netherlands commented that Article 12 of the Directive states that the Commission must help and coordinate market surveillance with the Member States.

End of summary minutes

ANNEX 2: IMPACT ASSESSMENT METHODOLOGY

The impact analysis uses the variable **inputs** as defined in the following paragraphs and used in Chapter 5.

The **calculation method** for the analysis is a so-called **Stock Model,** which means that it is derived from accumulated annual sales of motors over the period 1990-2020 (with a start-up period 1960-1990).

The stock-model sets the pace for the sub-options. The direction is determined by trends in terms of increase/decrease in:

- number and size of the customers in industry and tertiary sector (e.g. overall electricity growth rate in industry is 0,9% and in the tertiary sector 2,7% per year) ,
- operating conditions (e.g. average load factor 60%, number of operating hours) and
- energy efficiency.

The first two are derived from sector statistics and trends as described in the preparatory study. The main variable in the various sub-options is energy and its derived parameters.

Outputs for each sub-option are:

- Electricity consumption in TWh/a;
- Primary energy consumption in PJ/a (conversion 1 TWh electric = 2,5 *3,6 PJ primary);
- Carbon emission in Mt CO2 equivalent/a, using a multiplier based on electricity and gas shares (see below) and the values from the EcoReport in the preparatory study;
- Acidifying agents emissions in kt SO2 equivalent/a;
- Customer-related economical parameters: purchase price, energy expenditure, repair cost and total expenditure in € billion/a (2005 Euro, inflation-corrected at 2%/a);
- Business-related economical parameters: turnover per sector (industry, wholesale, retail, etc.);
- Employment: calculating job creation/loss using the sector-specific turnover per employee.

Final outcomes are presented at a high aggregation level (totals), but in the intermediate stages a distinction is made by the typology and by size.

For the economic calculations, an average energy price in €/ kWh primary energy is built from:

- Electricity rates per kWh primary energy. For electricity, the assumption is to use industrial (SME) electricity rates excluding taxes in 2007, i.e. € 0 087/kWh;
- Annual (long-term 2000-2006 average) electricity price rate increase of 2%.

The figures and tables in the Annex 3 show some of the base case key inputs in terms of electricity consumption, operating hours and load. Also economical variables in the stock model are given in the last paragraph of this chapter.

Data from Chapter 4 and Annexes 2 and 3 are used for the definition of the base case and calculated on the basis of the relative market shares of the three motor sizes considered. Then, the three motor sizes are aggregated into one average motor, which gives a base case (IE1) motor with:

- a rated power output Pn of 3,35 kW;
- a product life L a little over 12 years (12,4 years);
- a load factor F of 60%;
- 4000 operating hours ('hours');
- efficiency η of the motor of 76,7%, according to IEC60032-30.

The annual electricity demand Q_{elec} (in kWh/yr) can be calculated as:

$$Q_{elec} = Pn * F * hours / \eta_{motor}$$

The annual electricity consumption of the base case motor is thus around 10.500 kWh/year (10.482). The total lifetime electricity consumption is $Q_{electot} = Q_{elec} * L$ = 130.000 kWh. Note that in the paragraph on sub-options these equations will be adapted to include the effect of VSDs

The economical base case parameters are:

- average product price PP of €182,50;
- repair and maintenance costs €68/a over product life. Per year this amounts to R_{maint} of €5,50;
- electricity rate R_{el} of € 0 087[31];
- discount rate r of 2% (interest — inflation), 4% in 2009[32];

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31 Eurostat 2008 average EU27 industry (SME) electricity price excl. taxes, 2nd semester 2007.

32 Note that Tables above in the report are presented in Euro (2005), except if otherwise indicated. The figures use results from the preparatory study based on the indicators of the 2005 Methodology study ('MEEUP'). This study uses a discount rate (interest minus inflation) of 2 %, an inflation rate of 2% and long-term electricity price increase based on the 2000-2006 Eurostat data, amounting also to 2%. As a net result, the increase in running costs compensates the effect of the discount rate for electricity using products.
When updating the discount rate to 4% also the electricity price development over the past years has to be taken into account. According to Eurostat, the industrial (VAT-free) electricity prices rose by around 11,3% in 2005-2006 and 9,3% in 2006-2007. Preliminary data for 2008 show a continuation of this trend. Therefore it is reasonable to assume a long-term electricity price increase of at least 4% (actually closer to 5%) and again the increased running costs will compensate an update discount rate of 4%. Hence, updated results are practically identical to what is presented in the tables.

- discounted product life L_{dis} of 10,5 years[33];

- an annual electricity rate increase R_{el} of 2% (4-5% in 2009), which brings the corrected discounted product life L_{discor} back to 12,44 years[34];

- Unit sales in the year 2005 amount to 9 million units per year (see Chapter 4: three-phase AC induction motors only);

- Unit installed base (stock) amounts to 100 million units per year (see Chapter 4 and Annex 2 and 3 on BaU).

Installation costs are not taken into account, because only new products (not retrofit) are considered in which the installation is part of the added value of the customer. Product price and electricity rate exclude VAT assuming that the users are in the industrial and tertiary sector (VAT tax deductible).

The life cycle cost of an average new motor bought in 2005 is defined as:

$$LCC = PP + L_{discor} * (R_{el} * Q_{electot} + R_{maint}) = 182{,}5 + 12{,}44 * (0{,}087 * 10.500 + 5{,}5) = € 11.578$$

This shows that on average the purchase price is slightly over 1,5% of the total LCC. Repair and maintenance costs are 0,5% of total LCC and all the rest is energy (ca. 98%).

From the above, it is concluded that the sales of the motors within the scope represent a value of around €1,65 billion (sales * PP). Repairs and maintenance account for € 0,61 billion (current prices) and electricity cost of all motors in stock amounts to €91,35 billion for 1067 TWh of electricity consumed.

For **energy considerations** following figures are used: EU27 electricity demand 2005 was 3106 TWh/a, including the energy sector (including distribution losses). Net final demand, excluding energy sector, was ca. 2755 TWh/a, of which the industry accounts 40,9% (1127 TWh/a) and the tertiary sector 27,4% (755 TWh/a)[35]. With a total of 1067 TWh/a consumption by motors considered (0,75-375 kW) thus constitute 39% of the total EU27 net electricity consumption: 69% in industry and 38% in the tertiary sector.

For this impact assessment, the **environmental analysis** according to the EuP EcoReport from the preparatory study was revised to EU27 as a basis for calculations. This is why, due to differences in power generation efficiencies between the EuP Ecoreport and current policy references, there may be a few percent difference between the values presented here and in the 2005 impacts in Chapter 5.

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33 Using PWF Present Worth Factor calculation as shown in MEEUP Report, VHK, 2005: $PWF = \{1 – 1/(1+r)^L\}/r$. To correct for electricity price increase replace r by (r-Rel).

34 Assuming that also maintenance and repair costs will increase by 2% annually, i.e. with 2% above inflation increase of wages especially in the new Member States.

35 For a complete picture: households sector accounts to 29% (799 TWh/a) and transport to 2,7% (74 TWh/a).

The table below gives EcoReport unitary values (impact per unit), showing the dominance of the use phase.

Table A2.1: Unitary environmental impacts Base case (IE1) motor

Rated power		**1,1 kW**		**11 kW**		**110 kW**	
Lifetime	years	12		15		20	
Efficiency	%	75,1		87,6		93,3	
Operating hours (reference)	h/yr	2250		3000		6000	
Distance covered over motor life (km)	km			250		250	
Packaged volume	m3	0,02		0,15		1,1	
Bulk Plastics	g	0		0		0	
TecPlastics	g	385		1320		6600	
Ferro	g	10340		64350		744700	
Non-ferro	g	3234		34540		227700	
Coating	g	110		550		1100	
Electronics	g	0		0		0	
Misc.	g	0		0		0	
Total weight	g	**14069**		**100760**		980100	
of which recyclable	g	13038		94600		925485	
of which disposal	g	1031		6160		54615	
Energy, Water & Waste		**total**	**use phase**	**total**	**use phase**	**total**	**use phase**
Total Energy (GER)	MJ	80.416	99%	505.064	98%	8.914.548	99%
of which, electricity (in primary MJ)	MJ	79.530	100%	497.013	100%	8.852.188	100%
Water (process)	ltr	5.443	97%	33.980	97%	596.180	99%
Water (cooling)	ltr	211.976	100%	1.324.274	100%	23.594.940	100%
Waste, non-haz./ landfill	g	135.998	68%	1.178.487	49%	15.426.373	67%
Waste, hazardous/ incinerated	g	2.188	84%	12.682	90%	210.106	97%
Emissions to the Air							
Greenhouse Gases in GWP100	kg CO2 eq.	3.536	98%	22.233	98%	390.512	99%
Ozone Depletion, emissions	mg R-11 eq.	negl.		negl.		negl.	
Acidification, emissions	g SO2 eq.	21.132	97%	136.932	93%	2.354.101	97%
Volatile Organic Compounds (VOC)	g	32	94%	213	92%	3.493	96%
Persistent Organic Pollutants (POP)	ng i-Teq	802	65%	5.077	64%	72.061	81%
Heavy Metals	mg Ni eq.	1.788	76%	12.252	71%	180.690	84%
PAHs	mg Ni eq.	201	78%	1.435	77%	20.730	85%
Particulate Matter (PM, dust)	g	698	63%	6.626	75%	67.376	76%
Emissions to the Water							
Heavy Metals	mg Hg/20	720	71%	4.571	70%	67.712	84%
Eutrophication	g PO4	12	25%	68	24%	610	45%
Persistent Organic Pollutants (POP)	ng i-Teq	negl.		negl.		negl.	

The table below gives an overview of EcoReport values based on the stock. Note that the 4000 operating hours are assumed for each motor size and therefore the values cannot be compared with the above.

Table A2.2: Total environmental Impacts EU27-Stock 2005 on basis of 4000 operating hours, weighted by installed units*					
		Small	Medium	Large	**Total**
		87%	12%	1%	**100%**
Energy, Water & Waste					
Total Energy, GER	PJ	2.950	5.264	3.008	11.223
Of which, electricity	TWh	280	500	286	1.067
Water, process	M m3	197	352	200	749
Waste, non-hazardous/landfill	kt	3.717	6.925	3.706	14.348
Waste, hazardous/incinerated	kt	71	123	69	263
Emissions to the Air					
Greenhouse Gases in GWP100	Mt CO2 eq.	128	230	132	491
Acidifying Agents, AP	kt SO2 eq.	762	1.365	778	2.905
Volatile Organic Compounds, VOC	kt	1	2	1	5
Persistent Organic Pollutants, POP	G i-Teq	21	37	21	79
Heavy Metals, HM	ton Ni eq.	53	95	53	201
PAHs	ton Ni eq.	6	10	6	22
Particulate Matter, PM, dust	kt	19	34	17	69
Emissions to the Water					
Heavy Metals, HM	ton Hg/20	21	36	20	76
Eutrophication, EP	kt PO4	0	0	0	0
***=recalc from prep. Study with factor 1 157 for EU27; deviations of a few % with 2005 impacts may occur as a consequence of slight differences in power generation efficiencies between EcoReport and current policy references.*					

Comparing **environmental impacts:** The total of 491 Mt CO2 eq. (574 Mt in the impact analysis) is around 12,2% of the EU27 total in 2005 (source EEA). The emissions of acidifying agents from power generation partitioned to motors amounts to 2905 kt SO2 equivalent. This is close to 30% of the EU-15 total in 2005 with 10.945 kt SOx equivalent, 9015 kt Nox (*0,7) and 4635 kt SO2.

The **business impact** of motors relates to OEMs, manufacturers and, for an estimated one third of sales, also to wholesalers and retailers/repair shops. An average manufacturing selling price of €182,50 and sales of 9 million units results in a 2005 turnover of around €1,65 for the motors within the scope. Wholesalers and retail activities (each at 10%) add an extra €337 million. The repair activities, at on average €5,50 per motor per year, add another € 0,55 billion approximately to the business. All in all, the total economic impact in 2005 exceeds €2,5 billion, not counting the over €100 billion that utilities make in supplying the electricity.

For analysis of **employment** the ratio of turnover per employee for the manufacturer is used and an OEM factor typical of the sector. The latter is set at 1,2, whereby 20% of employment is estimated to be outside the EU. From a study of the annual report of the main motor manufacturers (e.g. ABB, Danfoss, Siemens) shows that the turnover/employee ratio is around €250.000, indicating a mature production process with a high degree of atomisation.

Based on this, an industrial employment of 14.500 jobs (6600 in manufacturing and 7900 in OEMs) is estimated. Motor repair, at a turnover of 610 million annually and an estimated turnover/employee ratio of €100.000 per employee, add an extra 6100 jobs. Taking into account the uncertainties of this estimate the total job dependency of this product is estimated at around 20.000 – 25.000 jobs of which over 90% in the EU.

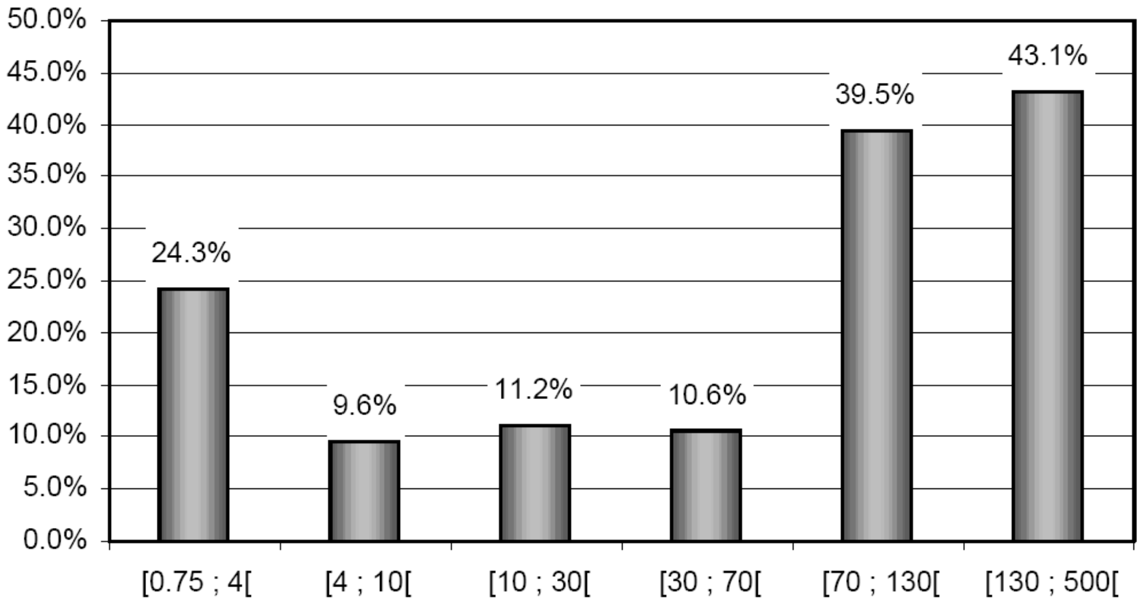
Sub-options

For sub-options, limit values for IE1, IE2 and IE3 motors are given in IEC 60034-30 as explained above. For the sub-option ***IE2+IE3***, the requirement at IE3 level is introduced for small motors on 2015 and for medium and large motors on 2017. These represent 13% of unit sales and average efficiency increase is therefore limited.

Table A2.3: MEPS levels used in stock model for base case (IE1) and for the first 3 sub-options.

Motors	market	IE1 (base)	IE2	IE2+IE3	IE3
Small (0,75-7,5 kW, ref. 1,1 kW)	87,0%	75,0%	81,4%	81,4%	84,1%
Medium (7,5-75 kW, ref. 11 kW)	12,0%	87,6%	89,8%	91,4%	91,4%
Large (75=200 kW, ref. 110 kW)	1,0%	93,3%	94,3%	95,4%	95,4%
Average		**76,7%**	**82,5%**	**82,7%**	**85,1%**

For the **IE3/VSD** sub-option[36] it has to be taken into account that, although in individual cases VSD application may lead to an efficiency improvement of up to 40% in variable speed and load applications. VSDs are not relevant for full speed full-load applications (estimate ca. 1/3 of total) and VSDs are already being sold with a relevant number of AC motors (see graph below)[37].



36 On VSD market data, see Annex 6.

37 Note that the effect of VSDs already delivered with new products is not modelled in the stock model. In order to keep it simple, just the incremental effect of the VSD throughout the stock was taken into account.

Figure A2.1: Percentage of motors sold with VSD (SAVE II study, VSDs for Electric Motor systems, 2000)

On this basis the preparatory study assumes that on average the VSD option will lead to only an additional 18-20% efficiency improvement in the stock. This is defined as the performance factor 1,2 (PF). Furthermore, it has to be considered that also the VSD itself adds losses. The preparatory study assumes a loss of 5%[38] (VSD efficiency η_{VSD} 95%), which means that the efficiency improvement of IE2+VSD option is only around 13-14% (0,95 * 1,19) over the whole stock. To this it has to be added that for 1/3 of total, i.e. the full-load single speed applications market will (have to) move from IE2 to IE3 efficiency level in 2015. This will add an extra 1% improvement ($IE3_{extra}$=1%). Thus, an extended equation for annual electricity consumption is defined as follows:

$$\mathbf{Q_{elec} = Pn * F * hours / (\eta_{motor} * \eta_{ASD} * PF + IE3_{extra}).}$$

In the equation, it has to be considered that η_{motor} (rated motor efficiency) is at IE2 level.

In all sub-options, the requirement at the IE2 level is implemented per 1.1.2011. For step 2, several options exist (including doing nothing, i.e. keep at IE2 level). The table below summarises the efficiency improvements used in the stock model calculations.

Table A.2.4: Efficiencies of base case and sub-options as used in stock model

Year	Base case		2011	2015		
	market	**IE1**	**IE2**	**IE2+IE3**	**IE3**	**VSD/IE3**
Small (1,1 kW)	87,0%	75,0%	81,4%	81,4%	84,1%	81,4%
Medium (11 kW)	12,0%	87,6%	89,8%	91,4%	91,4%	89,8%
Large (110 kW)	1,0%	93,3%	94,3%	95,4%	95,4%	94,3%
VSD efficiency						95%
VSD performance						1,2
IE3 extra						1%
Average		**76,7%**	**82,5%**	**82,7%**	**85,1%**	**95,1%**

The price increase of individual options is already given in Chapter 4.[39] For VSDs it should be noted that the extra price increase is considered. Furthermore, the table below partitions the IE2+IE3 sub-option as above. The price of the VSD/IE3 sub-option is given as mentioned in Chapter 4 with 33% higher price for IE3 than for IE2.

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38 Before the 1990's, the efficiency, functionalities and reliability of VSDs was significantly worse than today. From the beginning of 1990's to 2006, the efficiency of VSD's has been steadily around this level (at 100% load) but, according to industry sources, the VSD efficiency has increased to about 98% in recent years; the early VSD technology was replaced after 1990 with the introduction of modern power transistors (so called IGBT), which are the key for improving the efficiency of a VSD. Further developments of IGBTs are ongoing with primary focus on the improvement of the switching speed through improved materials and technology. In the future, this development is expected to lead to efficiencies approaching 99%.

39 When comparing prices in the sub-options with list prices, consider that through e.g. discounts in this competitive market the real (street) prices [=basis scenario] are around 40% lower than list prices, as shown in the preparatory study.

Table A.2.5: Prices of base case and sub-options as used in stock model

Year	Base case		2011	2015		
	market	**IE1**	**IE2**	**IE2+IE3**	**IE3**	**VSD/IE3**
Small (1,1 kW)	87,0%	€96	€125	€125	€154	€339
Medium (11 kW)	12,0%	€450	€563	€675	€675	€1.573
Large (110 kW)	1,0%	€4.500	€5.400	€6.300	€6.300	€15.579
Average		**€183**	**€230**	**€253**	**€278**	**€639**

The repair and maintenance prices remain unaltered in respect to the base case.

Taking into account both the efficiencies and the prices in the sub-options, the product price increase per % efficiency increase can be calculated for each sub-option as follows:

- IE1 to IE2 → 5,8% efficiency increase, €47 product price increase → €8,10 per %-point;
- IE1 to IE2+IE3 → 6% efficiency increase, €70 product price increase → €11,60 per % point;
- IE1 to IE3 → 8,4% efficiency increase, €95 product price increase → €11,30 per % point;
- IE1 to VSD/IE3 → 18,4% efficiency increase, €456 product price increase → €24,78 per % point.

These are the price factors used in the stock model sub-options.

With respect of VSDs it has to be noted that prices are decreasing rapidly, especially in the low power range. The table below shows the VSD prices 1998 from a SAVE II study on VSDs From the given values, the 1998 prices for 1,1, 11 and 110 kW VSDs were derived (extra/interpolated) and in the last rows of the table compared with the VSD prices 2005, as presented in the preparatory study. For small power range, the VSD price has decreased by 55% over 7 years (7% annually). For medium size VSDs, the price has decreased by 42% (ca. 5% annually) and for the largest VSDs the price has decreased by 10% (ca. 1,2% annually). On average, the price decrease is around 6,6% annually. Given that VSDs are about half of the total product price, this results in a price decrease of 3,3% annually for this combination. For the other sub-options, it is assumed that there is no annual price decrease, as explained with the base case.

Table A.2.6: VSDs prices per unit in each country. (source: VDSs for Electric Motor Systems; SAVE II, 2000)

		Power range (kW)					
EU Country	range	**0,75-4 kW**	**4-10 kW**	**10-30 kW**	**30-70 kW**	**70-130 kW**	**130-500 kW**
	class mid	**2,37 kW**	**7kW**	**20 kW**	**50 kW**	**100 kW**	**315 kW**
Denmark		€490	€1.040	€3.330	€2.850	€10.580	€ 0
U.K. and Ireland		€340	€1.110	€2.350	€4.570	€8.330	€17.500
France		€520	€1.060	€2.630	€5.170	€9.760	€24.450
Germany		€380	€880	€1.630	€3.000	€5.000	€18.000
Portugal and Spain		€570	€1.180	€2.330	€4.400	€7.000	€18.570
The Netherlands		€460	€970	€2.300	€3.680	€8.040	€ 0
Average		**€460**	**€1.040**	**€2.430**	**€3.950**	**€8.150**	**€19.620**
Own calculations		**1,1 kW**		**11 kW**		**110 kW**	
SAVE II, prices **1998**		€362		€1.361		€8.990	
Prep study, prices **2005**		€163		€787		€8.100	

Regarding the environmental impact, it was shown that these depend, for most indicators, for 99% on the electricity consumption in the use phase. Therefore, although e.g. the higher efficiency motors and drives may lead to an increase in copper use of 20%, the influence of the production and recycling phase will be much smaller than 1% of the total impact and therefore negligible.

In other words, only the environmental impacts relating to the use phase will be taken into account in this report, symbolised by carbon impact. All other effects, with the exception of eutrophication, are assumed to move proportionally with the energy efficiency improvements as in the base case.

For impacts on employment the ratio of turnover per employee for the manufacturer and an OEM factor typical for the sector, as well as a ratio of €100.000/employee in the repair sector are used. Employment effects of customer-based installation and dedicated technical staff is not taken into account, although the more efficient motors and especially the VSDs will add to labour and added value with a significant part of the end-product manufacturers.

Summary of the Input Stock Model

The table below gives the economic variables that are used as inputs in the Stock Model.

Table A.2.7: Model Variables

Base price	220,8	Consumer product price incl. VAT in year 2005 [€]
Price Inc Eur	8,1	Price increase per%-point saving BaU [€/ kWh]
Rel	0 087	Electricity rate 2008 [€/ kWh electric]
Rgas	0 047	Gas rate 2005 [€/ kWh primary GCV]
Roil	0 061	Oil rate 2005 [€/ kWh primary GCV]
Rmaint	5,5	Annual maintenance costs [€/ a]
Relinc	2%	Annual price increase electricity [%/ a]
Rgasinc	5,60%	Annual price increase gas [%/ a]
Roilinc	8,20%	Annual price increase oil [%/ a]
Rmaintinc	2%	Annual cost increase maintenance [%/ a]
PriceDec	0,00%	Annual product price decrease [%/ a]
InstallDec	0,00%	Annual installation cost decrease [%/ a]
ManuFrac	83,0%	Manufacturer Selling Price as fraction of Product Price [%]
WholeMargin	10%	Margin Wholesaler [% on msp]
Retail Margin	10%	Margin Retailer on product [% on wholesale price]
VAT	0%	Value Added Tax [in % on retail price]
Manu Wages	0,26	Manufacturer turnover per employee [mln €/ a]
OEMfactor	1,2	OEM personnel as fraction of WH manufacturer personnel [-]
Whole Wages	0,25	Manufacturer turnover per employee [mln €/ a]
Retail Wages	0,1	Manufacturer turnover per employee [mln €/ a]
ExtraEUfrac	0,2	Fraction of OEM personnel outside EU [% of OEM jobs]
Inflation	2%	Inflation rate [%/ a]
Product Life	12	Product Life [years]

Note that:

- wholesale and retail margins apply only to a part of sales; it is assumed that two-thirds of volume is sold through OEM;
- the base price includes the wholesale and retail margins. Without these margins the price is €182,50, as mentioned before.

The table below gives the targets that are used as inputs in the Stock Model.

Table A.2.8: Model scenario input sto sub-options

Scenario		Eff		PriceInc		Year
EI1+1%	src	**77,7%**		**Eur/%**	srcyear	2008
EI2	tgt1	**82,5%**	priceinc1	**8,1**	tgtyear1	2011
EI2+EI3	tgt2	**82,7%**	priceinc2	**11,6**	tgtyear2	2015
EI3	tgt3	**85,1%**	priceinc3	**11,3**	tgtyear3	2017
VSD/IE3	tgt4	**95,1%**	priceinc4	**24,78**		
	posttgt	0,10%	is annual decrease after target (after 2009 for BaU)			

ANNEX 3: BaU OPTION AND BASE CASE KEY INPUTS

BaU option: base case 2005

Stock data 1992-2030 for business-as-usual are based on the market analysis made in the preparatory study. On the basis of this data, corrected for known sales data (see Chapter 4 and Annex 2), sales data were derived for 1990-2030 as shown in below table.

Table A3.1: AC 3-phase induction motors' installed base for EU-27 (Million units)

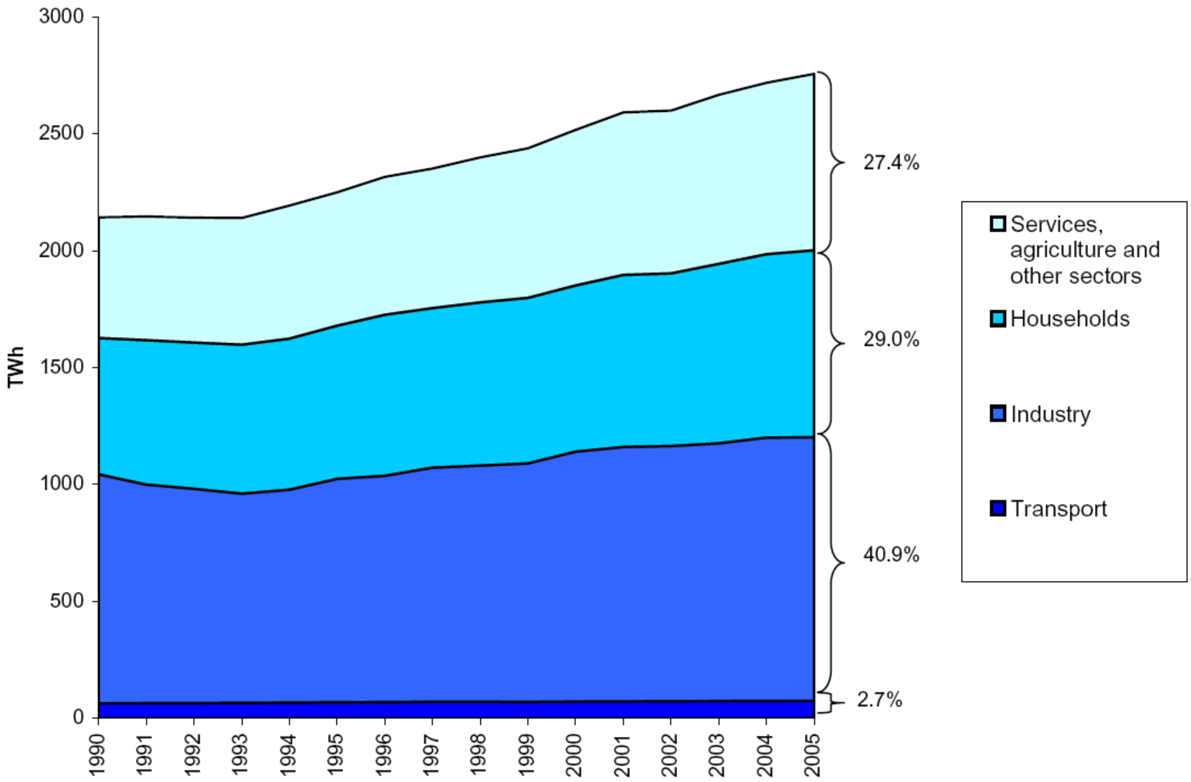
INDUSTRY	**1992**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
0,75 -7,5	45,95	52,58	56,01	60,24	63,32	65,49	67,67	68,69
7,5 -37	5,38	6,16	6,56	7,05	7,41	7,67	7,92	8,05
37 -75	1,21	1,39	1,49	1,59	1,67	1,73	1,78	1,82
>75	0,75	0,87	0,93	0,99	1,04	1,09	1,12	1,13
Total	53,26	61,04	65,04	69,84	73,45	76,01	78,41	79,67
TERTARY	**1992**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
0,75 -7,5	23,89	27,20	31,66	36,80	41,83	45,95	49,38	51,89
7,5 -37	2,37	2,70	3,14	3,65	4,14	4,55	4,89	5,14
37 -75	0,24	0,26	0,31	0,37	0,41	0,46	0,49	0,51
>75	0,03	0,05	0,05	0,06	0,07	0,07	0,08	0,08
Total	26,52	30,18	35,20	40,81	46,41	50,98	54,86	57,72
TOTAL	**1992**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
0,75 -7,5	69,84	79,78	87,67	97,04	105,16	111,44	117,04	120,59
7,5 -37	7,75	8,86	9,70	10,70	11,54	12,22	12,81	13,19
37 -75	1,45	1,66	1,79	1,95	2,08	2,18	2,27	2,33
>75	0,79	0,91	0,97	1,05	1,11	1,15	1,20	1,21
Total	79,78	91,21	100,24	110,64	119,85	126,99	133,27	137,39

Table A3.2: EU27 Motor Unit Sales (mln/a) 1990-2030 (from stock data)

	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Small 1,1 kW (87%)	5,17	5,66	6,15	6,92	7,62	8,00	8,35	8,88	9,09
Medium 11 kW (12%)	1,48	1,62	1,76	1,98	2,18	2,29	2,39	2,54	2,60
Large 110 kW (1%)	0,07	0,07	0,08	0,09	0,10	0,10	0,11	0,12	0,12
Total	**6,72**	**7,35**	**7,98**	**8,99**	**9,90**	**10,39**	**10,85**	**11,54**	**11,81**

Normally, it could be considered that the manufacturing industry, through rationalisation of the production process and labour shifts to low-wage countries, would realise a price decrease of around 2% annually. However, in this particular case with a product price very much influenced by the volatile copper and steel prices, it is expected that the cost reduction through rationalisation will be barely enough to compensate for higher material prices.

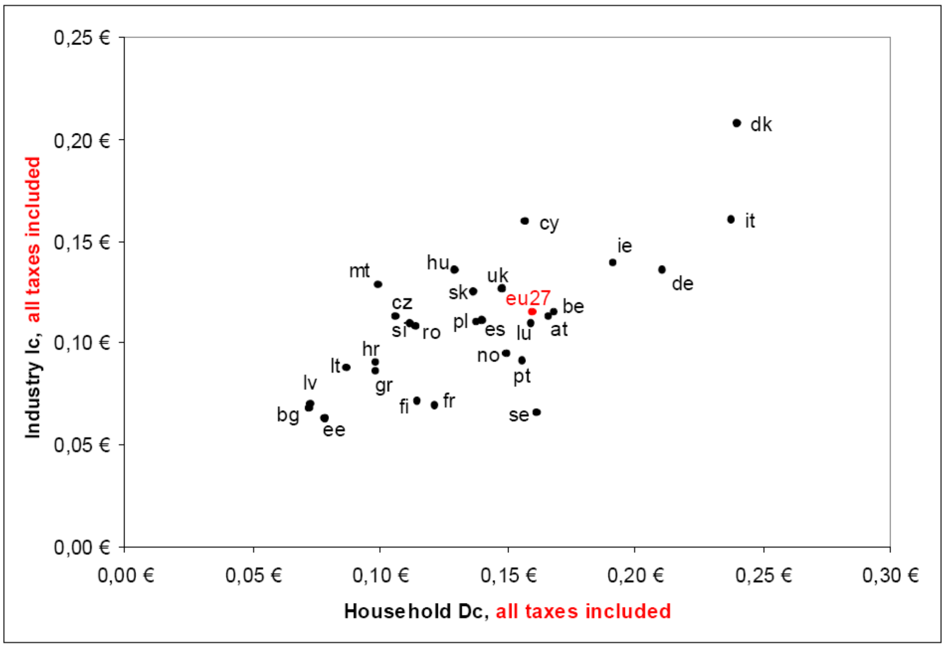
Figure A3.1. Sectoral electricity use (excluding losses in electricity generation and distribution). Source: EEA, 2008.



EU27 Electricity rates

Fig. A3.2 and A3.3: EU27 Electricity rates 2007[40].

The Figure below shows that most customers are in industry and tertiary sector hence the electricity rate is excluding taxes with base case price of € 0 087. Note that data are somewhat older (2000) and relates to EU25 (EU27 is ca. 3% more) but it gives valuable information on the relative shares[41].



40 Source: Eurostat Oct. 2008 relating to retail prices on 2nd semester 2007. Range for annual consumption of household band Dc (2 500 kWh — 5 000 kWh) and industry band Ic (500 MWh — 2 000 MWh).

41 Correction factor EU27=EU25 * 1,03 based on the difference in electricity consumption between EU25 and EU27 (source: Eurelectric).

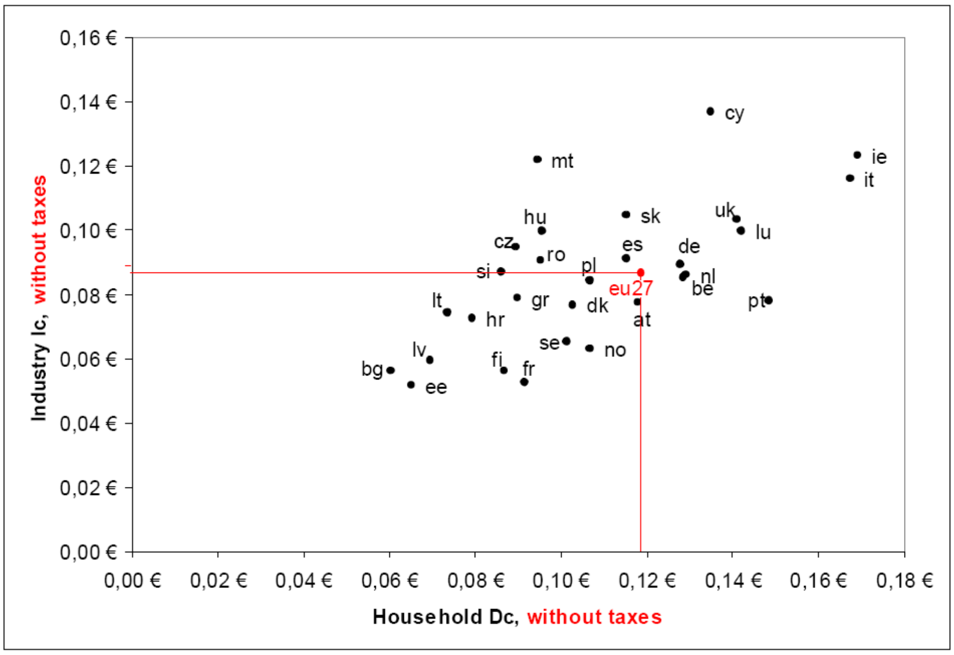
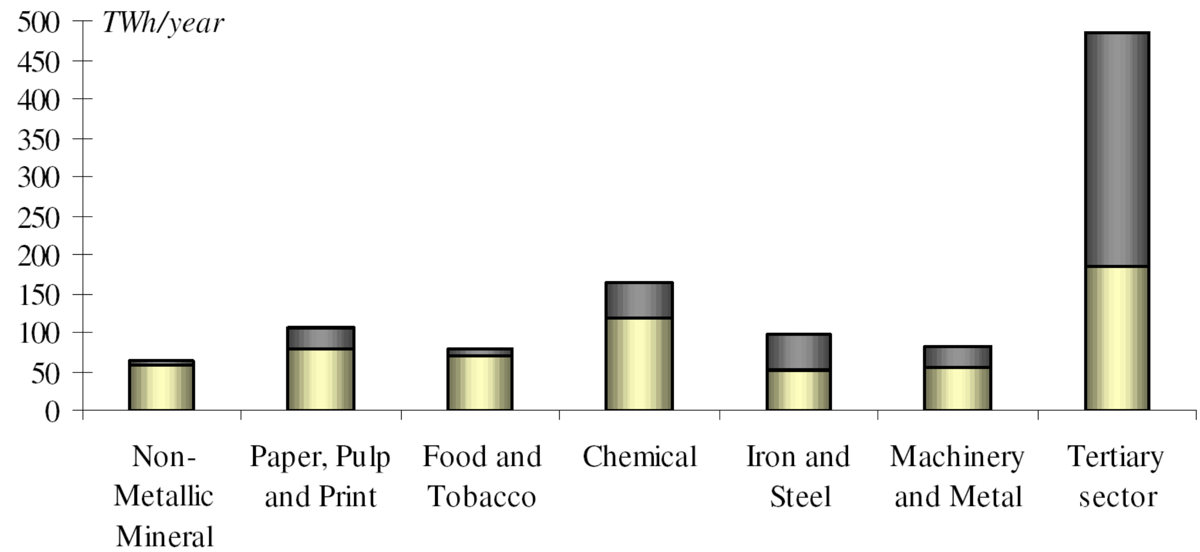


Figure A3.4: Electricity motor consumption in different industrial sectors and in the tertiary sector EU15, 1996[42].

From the below figure, it can be concluded that motors are the biggest electricity users in industry (69% of total). In tertiary sector motors represent ca. 38% of total electricity consumption.



Efficiency

The table below shows motor efficiency in the EU markets according to the CEMEP Voluntary Agreement, demonstrating the average base case efficiency in 2006 of IE1 (indicated EFF2 in CEMEP Agreement) and a progress of 0,5%-points efficiency improvement per annum over the period. As can be seen, although sales of the very low

42 Yellow refers to motors and grey to other electrical equipment.

efficiency motors decrease and the sales of low efficiency IE1 motors increase importantly, sales of standard efficiency (IE2) motors increase only modestly and the sales of high efficiency IE3 motors is non-existent. Contrarily, due to minimum efficiency requirements in the US, the sales of standard efficiency IE2 motors is up to 54% and high efficiency IE3 motors at 15%. The IE3 minimum requirement on 2011 will further improve the situation in the US. Table A3.2 clarifies the relation between different efficiency notions.

Figure A3.5: Total motor sales in the scope of the CEMEP/ EU Voluntary Agreement in the period 1996-2006

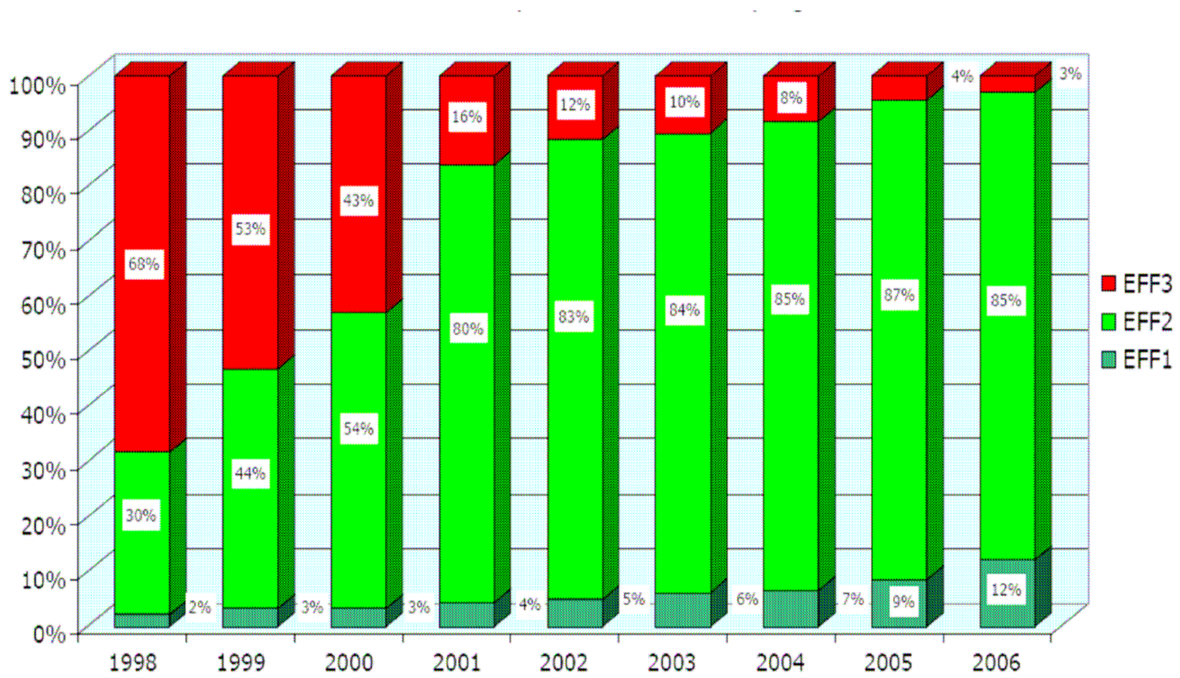


Table A3.2 Efficiency levels compared		
Motor efficiency	**IEC60034-30**	**CEMEP**
Premium efficiency	IE4[43]	-
High efficiency	IE3	-
Standard efficiency	IE2	EFF3
Low efficiency	IE1	EFF2
	-	EFF1

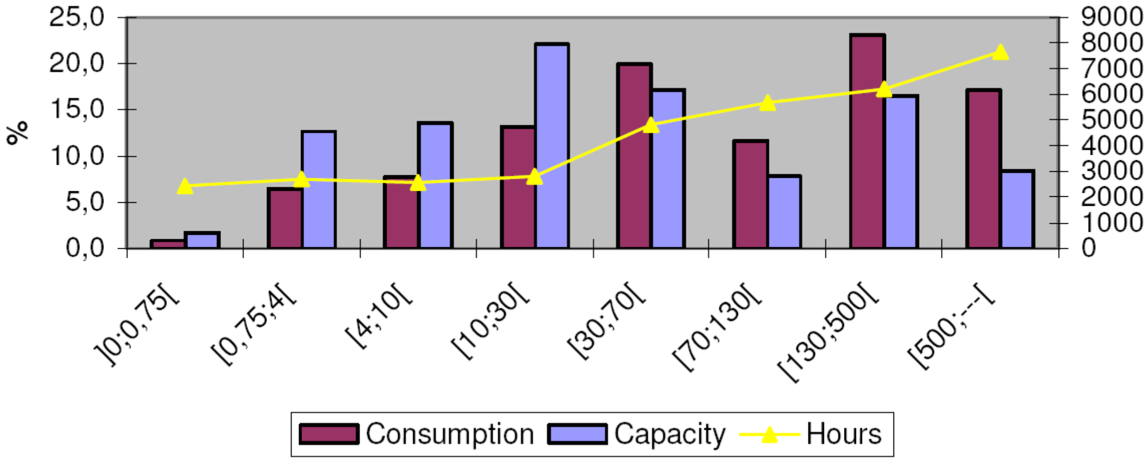
As to the motors produced and sold in Europe per efficiency level, see chapter 2.

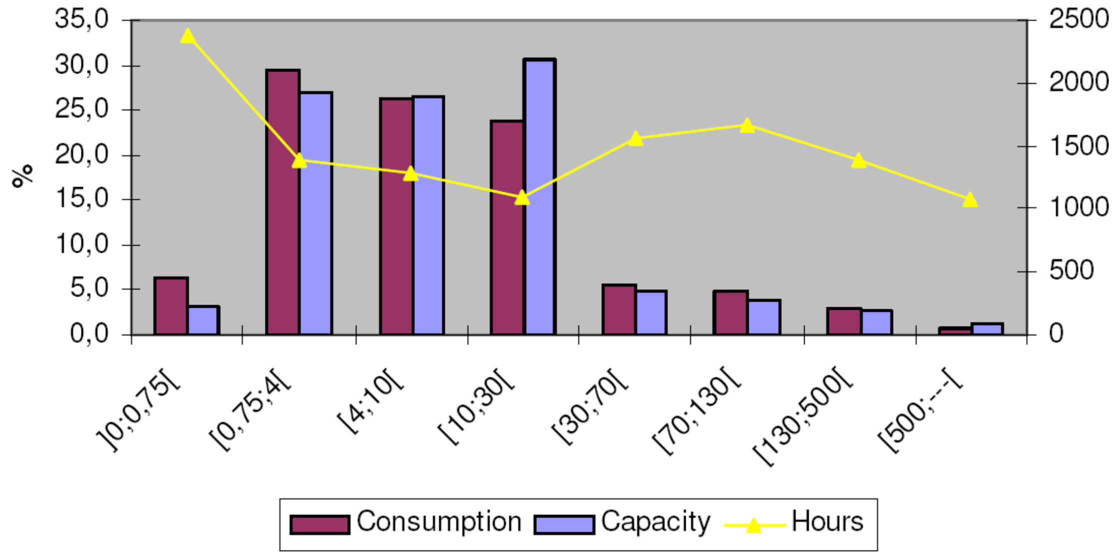
Load Factor and operating hours

The load factor (ratio between load and rated output) and number of operating hours varies with motor size and application. From the analysis in the preparatory study an average load factor of 60% and around 4000 operating hours is estimated.

43 Efficiency level is to be defined. It will correspond to permanent magnet motor technology.

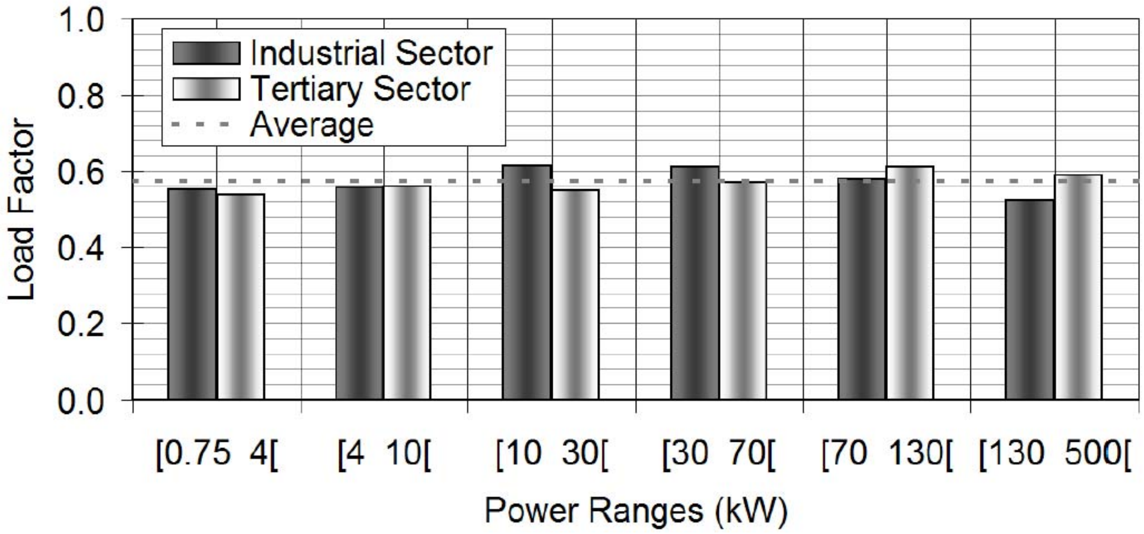
Figure A3.6: Installed motor capacity, electricity consumption and average operating hours by power range in the industrial sector





Above, Figure A3.7: Installed motor capacity, electricity consumption and average operating hours by power range in the tertiary sector

Below, Figure A3.8: Load Factor (ratio of the average load to the rated output power) in the industrial and tertiary sectors by power range. Average ca. 60%



Other

For purchase price, product life, discount rate (interest minus inflation) the data were taken from the preparatory study, as shown in Chapter 4 and in Annexes 2 and 3, for various motor sizes.

ANNEX 4: SCENARIO OUTPUTS (TABLES) TO SUB-OPTIONS

Table B1. STOCK Environmental	1990	1995	2000	2005	2010	2013	2015	2020	2025
net load (kWh/a)	8039	8039	8039	8039	8039	8039	8039	8039	8039
sales (000)	6719	7351	7983	8993	9899	10196	10394	10850	11540
park (000)	72282	79868	87455	96173	106468	112733	116446	123933	130344
Efficiency									
Freeze_2005	72%	72%	74%	77%	77%	77%	77%	77%	77%
BaU	72%	72%	74%	77%	79%	79%	80%	80%	81%
EI2	72%	72%	74%	77%	81%	83%	83%	83%	84%
EI2+EI3	72%	72%	74%	77%	81%	83%	83%	83%	84%
EI3	72%	72%	74%	77%	81%	84%	85%	86%	86%
VSD/EI3	72%	72%	74%	77%	81%	88%	93%	96%	96%
kWh/a.unit									
Freeze_2005	11176	11102	10887	10481	10481	10481	10481	10481	10481
BaU	11176	11102	10887	10481	10165	10127	10101	10038	9976
EI2	11176	11102	10887	10481	9934	9716	9693	9635	9577
EI2+EI3	11176	11102	10887	10481	9934	9728	9716	9658	9600
EI3	11176	11102	10887	10481	9934	9592	9448	9393	9338
VSD/EI3	11176	11102	10887	10481	9934	9159	8644	8417	8373
TWh primary/a new sales (without corr.)									
Freeze_2005	75	82	87	94	104	107	109	114	121
BaU	75	82	87	94	101	103	105	109	115
EI2	75	82	87	94	98	99	101	105	111
EI2+EI3	75	82	87	94	98	99	101	105	111
EI3	75	82	87	94	98	98	98	102	108
VSD/EI3	75	82	87	94	98	93	90	91	97
Stock electricity in TWh/a									
Freeze_2005	814	893	970	1044	1130	1186	1221	1299	1366
BaU	814	893	970	1044	1119	1165	1193	1252	1309
EI2	814	893	970	1044	1117	1150	1169	1207	1256
EI2+EI3	814	893	970	1044	1117	1150	1170	1209	1259
EI3	814	893	970	1044	1117	1148	1163	1188	1225
VSD/EI3	814	893	970	1044	1117	1141	1141	1114	1104
Stock energy in PJ/a									
Freeze_2005	7323	8037	8727	9400	10167	10671	10991	11691	12295
BaU	7323	8037	8727	9400	10073	10484	10734	11272	11781
EI2	7323	8037	8727	9400	10049	10347	10522	10865	11308
EI2+EI3	7323	8037	8727	9400	10049	10349	10527	10882	11334
EI3	7323	8037	8727	9400	10049	10330	10464	10691	11029
VSD/EI3	7323	8037	8727	9400	10049	10265	10266	10022	9934
CO2 in Mt (1 PJ= 0,0577 Mt)									
Freeze_2005	373	409	444	478	517	543	559	595	626
BaU	373	409	444	478	513	534	546	574	600
EI2	373	409	444	478	511	527	535	553	575
EI2+EI3	373	409	444	478	511	527	536	554	577
EI3	373	409	444	478	511	526	533	544	561
VSD/EI3	373	409	444	478	511	522	522	510	506

Table B2. STOCK Customer Economics (not corrected for inflation unless indicated otherwise)

	1990	1995	2000	2005	2010	2013	2015	2020	2025
Oil share	0%	0%	0%	0%	0%	0%	0%	0%	0%
Oil price	0,019	0,028	0,041	0,061	0,090	0,115	0,134	0,199	0,295
Gas price	0,021	0,027	0,036	0,047	0,062	0,073	0,081	0,106	0,140
El price	0,065	0,071	0,079	0,087	0,096	0,102	0,106	0,117	0,129
Maintenance	4	4	5	6	6	6	7	7	8
Share electricity									
Freeze_2005	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
BaU	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
EI2	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
EI2+EI3	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
EI3	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
VSD/EI3	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%
Avg. Fuel price									
Freeze_2005	0,06	0,07	0,08	0,087	0,10	0,10	0,11	0,12	0,13
BaU	0,06	0,07	0,08	0,09	0,10	0,10	0,11	0,12	0,13
EI2	0,06	0,07	0,08	0,09	0,10	0,10	0,11	0,12	0,13
EI2+EI3	0,06	0,07	0,08	0,09	0,10	0,10	0,11	0,12	0,13
EI3	0,06	0,07	0,08	0,09	0,10	0,10	0,11	0,12	0,13
VSD/EI3	0,06	0,07	0,08	0,09	0,10	0,10	0,11	0,12	0,13
Avg. Purchase Product (incl. install)									
Freeze_2005	182	186	198	221	221	221	221	221	221
BaU	182	186	198	221	240	243	244	248	252
EI2	182	186	198	221	255	270	271	275	279
EI2+EI3	182	186	198	221	270	290	291	297	302
EI3	182	186	198	221	269	301	316	321	327
VSD/EI3	182	186	198	221	325	495	625	687	699
Avg. Energy costs Eur/a.unit									
Freeze_2005	722	792	858	912	1007	1068	1112	1227	1355
BaU	722	792	858	912	976	1032	1071	1175	1290
EI2	722	792	858	912	954	990	1028	1128	1238
EI2+EI3	722	792	858	912	954	992	1030	1131	1241
EI3	722	792	858	912	954	978	1002	1100	1207
VSD/EI3	722	792	858	912	954	934	917	986	1082
Total purchase costs EU per annum (inflation corrected, in Euro 2005)									
Freeze_2005	1,6	1,7	1,7	2,0	2,0	1,9	1,9	1,8	1,7
BaU	1,6	1,7	1,7	2,0	2,1	2,1	2,1	2,0	1,9
EI2	1,6	1,7	1,7	2,0	2,3	2,3	2,3	2,2	2,2
EI2+EI3	1,6	1,7	1,7	2,0	2,4	2,5	2,5	2,4	2,3
EI3	1,6	1,7	1,7	2,0	2,4	2,6	2,7	2,6	2,5
VSD/EI3	1,6	1,7	1,7	2,0	2,9	4,3	5,3	5,5	5,4
Total running costs (energy+maint) (inflation corrected, in Euro 2005)									
Freeze_2005	71,2	78,1	84,8	91,4	98,7	103,4	106,5	113,0	118,6
BaU	71,2	78,1	84,8	91,4	97,8	101,6	104,0	109,0	113,7
EI2	71,2	78,1	84,8	91,4	97,5	100,3	101,9	105,1	109,1
EI2+EI3	71,2	78,1	84,8	91,4	97,5	100,3	102,0	105,2	109,4
EI3	71,2	78,1	84,8	91,4	97,5	100,2	101,4	103,4	106,5
VSD/EI3	71,2	78,1	84,8	91,4	97,5	99,5	99,5	97,0	96,0
Customer expenditure (inflation corrected, in Euro 2005)									
Freeze_2005	72,8	79,8	86,6	93,4	100,6	105,4	108,3	114,8	120,3
BaU	72,8	79,8	86,6	93,4	99,9	103,7	106,1	111,0	115,6
EI2	72,8	79,8	86,6	93,4	99,8	102,7	104,2	107,3	111,3
EI2+EI3	72,8	79,8	86,6	93,4	99,9	102,9	104,5	107,6	111,7
EI3	72,8	79,8	86,6	93,4	99,9	102,8	104,1	106,0	109,0
VSD/EI3	72,8	79,8	86,6	93,4	100,4	103,8	104,8	102,5	101,4

Table B3. STOCK Business Economics (inflation corrected, in Euro 2005)

	1990	1995	2000	2005	2010	2013	2015	2020	2025
Avg. Product Price [Euro 2005]									
Freeze_2005	182	186	198	221	221	221	221	221	221
BaU	182	186	198	221	240	243	244	248	252
EI2	182	186	198	221	255	270	271	275	279
EI2+EI3	182	186	198	221	270	290	291	297	302
EI3	182	186	198	221	269	301	316	321	327
VSD/EI3	182	186	198	221	325	495	625	687	699
Avg. Install [Euro 2005]									
Freeze_2005	0	0	0	0	0	0	0	0	0
BaU	0	0	0	0	0	0	0	0	0
EI2	0	0	0	0	0	0	0	0	0
EI2+EI3	0	0	0	0	0	0	0	0	0
EI3	0	0	0	0	0	0	0	0	0
VSD/EI3	0	0	0	0	0	0	0	0	0
Avg. Energy/unit new sales [Euro 2005]									
Freeze_2005	972	966	947	912	910	909	908	906	905
BaU	972	966	947	912	883	878	875	868	861
EI2	972	966	947	912	863	843	840	833	827
EI2+EI3	972	966	947	912	863	844	842	835	829
EI3	972	966	947	912	863	832	819	812	806
VSD/EI3	972	966	947	912	863	794	749	728	723
INDUSTRY Turnover [€ bln 2005]									
Freeze_2005				1,6	1,8	1,9	1,9	2,0	2,1
BaU				1,6	2,0	2,1	2,1	2,2	2,4
EI2				1,6	2,1	2,3	2,3	2,5	2,7
EI2+EI3				1,6	2,2	2,5	2,5	2,7	2,9
EI3				1,6	2,2	2,5	2,7	2,9	3,1
VSD/EI3				1,6	2,7	4,2	5,4	6,2	6,7
WHOLESALER Turnover [€ bln 2005]									
Freeze_2005				0,2	0,2	0,2	0,2	0,2	0,2
BaU				0,2	0,2	0,2	0,2	0,2	0,2
EI2				0,2	0,2	0,2	0,2	0,2	0,3
EI2+EI3				0,2	0,2	0,2	0,3	0,3	0,3
EI3				0,2	0,2	0,3	0,3	0,3	0,3
VSD/EI3				0,2	0,3	0,4	0,5	0,6	0,7
INSTALLER Turnover [€ bln 2005]									
Freeze_2005				0,7	0,8	0,8	0,8	0,9	0,9
BaU				0,7	0,8	0,8	0,9	0,9	1,0
EI2				0,7	0,8	0,9	0,9	1,0	1,0
EI2+EI3				0,7	0,8	0,9	0,9	1,0	1,0
EI3				0,7	0,8	0,9	0,9	1,0	1,1
VSD/EI3				0,7	0,9	1,1	1,2	1,4	1,5
VAT on product (excl. Energy) Turnover [€ bln 2005]									
Freeze_2005				0,0	0,0	0,0	0,0	0,0	0,0
BaU				0,0	0,0	0,0	0,0	0,0	0,0
EI2				0,0	0,0	0,0	0,0	0,0	0,0
EI2+EI3				0,0	0,0	0,0	0,0	0,0	0,0
EI3				0,0	0,0	0,0	0,0	0,0	0,0
VSD/EI3				0,0	0,0	0,0	0,0	0,0	0,0
ENERGY SECTOR Turnover [€ bln 2005], incl. VAT and other taxes									
Freeze_2005				90,9	98,1	102,8	105,8	112,3	117,9
BaU				90,9	97,2	101,0	103,3	108,3	113,0
EI2				90,9	96,9	99,7	101,3	104,4	108,4
EI2+EI3				90,9	96,9	99,7	101,4	104,6	108,7
EI3				90,9	96,9	99,5	100,8	102,7	105,8
VSD/EI3				90,9	96,9	98,9	98,8	96,3	95,3
ALL SECTORS Turnover [€ bln 2005] (=consumer expenditure inflation corrected)									
Freeze_2005				93,4	100,9	105,7	108,8	115,4	121,2
BaU				93,4	100,2	104,1	106,5	111,7	116,6
EI2				93,4	100,1	103,1	104,8	108,1	112,4
EI2+EI3				93,4	100,2	103,3	105,0	108,5	112,9
EI3				93,4	100,2	103,2	104,7	106,9	110,3
VSD/EI3				93,4	100,8	104,6	106,0	104,5	104,1

Table B4. STOCK Social-Economics									
	1990	**1995**	**2000**	**2005**	**2010**	2013	**2015**	**2020**	**2025**
INDUSTRY									
MANUFACTURER Personel [000]									
Freeze_2005				**6,3**	**7,0**	7,2	**7,3**	**7,6**	**8,1**
BaU				**6,3**	**7,6**	7,9	**8,1**	**8,6**	**9,3**
EI2				**6,3**	**8,1**	8,8	**9,0**	**9,5**	**10,3**
EI2+EI3				**6,3**	**8,5**	9,4	**9,7**	**10,3**	**11,1**
EI3				**6,3**	**8,5**	9,8	**10,5**	**11,1**	**12,0**
VSD/EI3				**6,3**	**10,3**	16,1	**20,7**	**23,8**	**25,8**
OEM Total Personell [000]									
Freeze_2005				**8**	**8**	9	**9**	**9**	**10**
BaU				**8**	**9**	9	**10**	**10**	**11**
EI2				**8**	**10**	11	**11**	**11**	**12**
EI2+EI3				**8**	**10**	11	**12**	**12**	**13**
EI3				**8**	**10**	12	**13**	**13**	**14**
VSD/EI3				**8**	**12**	19	**25**	**29**	**31**
of which OEM Personell in EU [000]									
Freeze_2005				**6**	**7**	7	**7**	**7**	**8**
BaU				**6**	**7**	8	**8**	**8**	**9**
EI2				**6**	**8**	8	**9**	**9**	**10**
EI2+EI3				**6**	**8**	9	**9**	**10**	**11**
EI3				**6**	**8**	9	**10**	**11**	**12**
VSD/EI3				**6**	**10**	15	**20**	**23**	**25**
WHOLESALER									
Personell Wholesaler [000]									
Freeze_2005				**1**	**1**	1	**1**	**1**	**1**
BaU				**1**	**1**	1	**1**	**1**	**1**
EI2				**1**	**1**	1	**1**	**1**	**1**
EI2+EI3				**1**	**1**	1	**1**	**1**	**1**
EI3				**1**	**1**	1	**1**	**1**	**1**
VSD/EI3				**1**	**1**	2	**2**	**2**	**3**
INSTALLER									
Personell [000]									
Freeze_2005				**7**	**8**	8	**8**	**9**	**9**
BaU				**7**	**8**	8	**9**	**9**	**10**
EI2				**7**	**8**	9	**9**	**10**	**10**
EI2+EI3				**7**	**8**	9	**9**	**10**	**10**
EI3				**7**	**8**	9	**9**	**10**	**11**
VSD/EI3				**7**	**9**	11	**12**	**14**	**15**
ALL SECTORS									
Personell x 1000									
Freeze_2005				**22**	**24**	25	**25**	**27**	**28**
BaU				**22**	**26**	27	**27**	**29**	**31**
EI2				**22**	**27**	29	**30**	**32**	**34**
EI2+EI3				**22**	**28**	31	**31**	**33**	**36**
EI3				**22**	**28**	32	**34**	**36**	**38**
VSD/EI3				**22**	**32**	48	**60**	**68**	**74**

ANNEX 5: ACCUMULATIVE SAVINGS

Given that motor life can be up to 20 years (big motors) accumulative savings are also shown up to 2025 in table A5.2.

Table A5.1: Accumulative Impacts and savings 2010-2020

Base Option: Step1 (2011) Step 2 (2015)/ 3 (2017)

	Electricity	Savings	CO_2	Savings	Expenditure	Savings	Electricity costs	Savings
	TWh	TWh	Mt	Mt	bln. Euro	bln. Euro	bln. Euro	bln. Euro
BaU	13088		5994		1164		1134	
IE2	12827	261	5875	120	1144	20	1111	23
IE2+IE3	12834	253	5878	116	1146	18	1112	22
IE3	12743	345	5836	158	1140	24	1104	30
VSD/IE3	12431	657	5693	301	1137	27	1077	57

Sub Option: Step 2 (2014)/3 (2016); one year sooner

	Electricity	Savings	CO_2	Savings	Expenditure	Savings	Electricity costs	Savings
	TWh	TWh	Mt	Mt	bln. Euro	bln. Euro	bln. Euro	bln. Euro
BaU	13088		5994		1164		1134	
IE2	12827	261	5875	120	1144	20	1111	23
IE2+IE3	12831	257	5877	118	1146	18	1112	22
IE3	12729	358	5830	164	1139	25	1103	31
VSD/IE3	12381	706	5671	323	1134	30	1073	61

Sub Option: Step 2 (2016)/3 (2018); one year later

	Electricity	Savings	CO_2	Savings	Expenditure	Savings	Electricity costs	Savings
	TWh	TWh	Mt	Mt	bln. Euro	bln. Euro	bln. Euro	bln. Euro
BaU	13088		5994		1164		1134	
IE2	12827	261	5875	120	1144	20	1111	23
IE2+IE3	12837	251	5879	115	1146	17	1112	22
IE3	12755	332	5842	152	1141	23	1105	29
VSD/IE3	12475	613	5713	281	1139	25	1081	53

Sub Option: Step 1 (2012) one year later

	Electricity	Savings	CO_2	Savings	Expenditure	Savings	Electricity costs	Savings
	TWh	TWh	Mt	Mt	bln. Euro	bln. Euro	bln. Euro	bln. Euro
BaU	13088		5994		1164		1134	
IE2	12863	225	5891	103	1147	17	1115	19
IE2+IE3	12866	221	5893	101	1149	15	1115	19
IE3	12787	301	5856	138	1143	21	1108	26
VSD/IE3	12523	564	5736	259	1143	21	1085	49

Table A5.2: Accumulative Impacts and savings 2010-2025

Base Option: Step1 (2011) Step 2 (2015)/ 3 (2017)

	Electricity	Savings	CO2	Savings	Expenditure	Savings	Electricity costs	Savings
	TWh	TWh	Mt	Mt	bln. Euro	bln. Euro	bln. Euro	bln. Euro
BaU	19518		8939		1733		1689	
IE2	18999	518	8702	237	1691	41	1645	45
IE2+IE3	19020	498	8711	228	1696	37	1646	43
IE3	18782	736	8602	337	1677	55	1626	64
VSD/IE3	17945	1573	8219	720	1644	89	1553	136

Sub Option: Step 2 (2014)/ 3 (2016) ; one year sooner

	Electricity	Savings	CO2	Savings	Expenditure	Savings	Electricity costs	Savings
	TWh	TWh	Mt	Mt	bln. Euro	bln. Euro	bln. Euro	bln. Euro
BaU	19518		8939		1733		1689	
IE2	18999	518	8702	237	1691	41	1645	45
IE2+IE3	19010	508	8707	232	1695	38	1646	44
IE3	18756	762	8590	349	1676	57	1624	66
VSD/IE3	17862	1655	8181	758	1638	95	1546	143

Sub Option: Step 2 (2016)/3 (2018); one year later

	Electricity	Savings	CO2	Savings	Expenditure	Savings	Electricity costs	Savings
	TWh	TWh	Mt	Mt	bln. Euro	bln. Euro	bln. Euro	bln. Euro
BaU	19518		8939		1733		1689	
IE2	18999	518	8702	237	1691	41	1645	45
IE2+IE3	19028	490	8715	224	1696	36	1647	42
IE3	18805	712	8613	326	1679	53	1628	62
VSD/IE3	18022	1495	8254	685	1649	84	1560	129

Sub Option: Step 1 (2012) one year later

	Electricity	Savings	CO2	Savings	Expenditure	Savings	Electricity costs	Savings
	TWh	TWh	Mt	Mt	bln. Euro	bln. Euro	bln. Euro	bln. Euro
BaU	19518		8939		1733		1689	
IE2	19047	471	8723	216	1695	37	1649	41
IE2+IE3	19056	462	8728	211	1699	34	1650	40
IE3	18834	683	8626	313	1682	51	1630	59
VSD/IE3	18070	1448	8276	663	1652	80	1564	125

ANNEX 6: VSD ISSUES CONSIDERED AND MARKET DATA

Currently no harmonised efficiency test standards or efficiency classification methods for drives (VSD) exists. For this reason, the impact assessment did not consider the impact of setting ecodesign requirements on drives as such. The Working Group (WG) 28 on IEC 60034-2-3 (on Rotating Electrical Machines: specific test methods for determining losses of converter-fed AC machines) is in the process of developing harmonised test standards and efficiency classification methods on drives, including a guide for using motors with a VSD[44]. The WG has identified preferable efficiency levels for drives in order to guide customers towards more efficient appliances (not the top-efficiency drives but drives with adequate efficiency levels). The drives reaching these levels are called 'Class A' drives. The Class A efficiency levels for various VSD sizes are shown in the below table.

Table A.6.1: Class A efficiency levels for drives

Class A	**Size**	**Load / Speed (%)**			
	kW	**25%**	**50%**	**75%**	**100%**
VSD Size (kW)	**>0,1**	74,0%	80,0%	85,0%	88,0%
	>1	83,0%	87,0%	90,5%	92,5%
	>10	92,0%	94,0%	96,0%	97,0%
	>100	95,0%	96,0%	97,0%	98,0%
	>1000	96,0%	96,5%	97,0%	98,0%

The Class A includes efficiency levels for different drive sizes at four different load/speed patterns, which is necessary to have a full picture on the drive performance in variable speed/load conditions. The Class A efficiency values help customers to distinguish between high-efficient (not necessary the best of the best) and the lower efficient drives.

The drive technology continues developing very quickly reaching today generally efficiencies above 98% (in full load/speed). That is, it is possible, although not necessarily probable, that today's technological development of drives will lead to 'A Class' efficiencies by 2015 in any case. However, it is also possible, in the light of this innovative and fast evolving technology, that cheap and low-efficient drives be developed and put on the market in order to considerably lower the motor+drive price after 2015.

The date used in the below considerations is based on a SAVE II study from the year 2000: VSDs for Electric Motor Systems (ADEME et al.). This data relate to EU15 1998 but it is still the most recent and comprehensive study on the subject. To complement the picture, a 'reality check' of the projections is made at the end of this annex based on the economic data from annual reports and financial projections of the three major motor and drives manufacturers.

44 Two guides already exist, one under the IEC 60034-17 standard on cage induction motors when fed from converters; Application Guide, May 2006, and under the IEC 60034-25, a guide for the design of motors with VSD; Guidance for the design and performance of A.C. motors specifically designed for converter supply, March 2007.

Table A6.1: VSD prices per unit in each country. (source: VDS[45]s for Electric Motor Systems; SAVE II, 2000)						
Price in 1000 Euro per unit	**Power range (kW)**					
EU Country	**0,75-4 kW**	**4-10 kW**	**10-30 kW**	**30-70 kW**	**70-130 kW**	**130-500 kW**
Denmark	€490	€1.040	€3.330	€2.850	€10.580	€ 0
U.K. and Ireland	€340	€1.110	€2.350	€4.570	€8.330	€17.500
France	€520	€1.060	€2.630	€5.170	€9.760	€24.450
Germany	€380	€880	€1.630	€3.000	€5.000	€18.000
Portugal and Spain	€570	€1.180	€2.330	€4.400	€7.000	€18.570
The Netherlands	€460	€970	€2.300	€3.680	€8.040	€ 0
Average	**€460**	**€1.040**	**€2.430**	**€3.950**	**€8.150**	**€19.620**
	1,1 kW		**11 kW**		**110 kW**	
Prep study	€163		€787		€8.100	

Table A6.2: Considered average power and estimated EU average VSD prices per kW in each power range.						
Power range (kW)	**[0,75 4[**	**[4 10[**	**[10 30[**	**[30 70[**	**[70 130[**	**[130 500[**
Average Power (kW)	1,93	5,37	16,44	38,75	85,49	213,82
Price per kW (1000 Euro)	0 237	0 194	0 148	0 102	0 095	0 092

Table A6.3: Estimated EU VSD installation costs per kW and total prices per unit and per kW, by power range.						
Power range (kW)	**[0,75 4[**	**[4 10[**	**[10 30[**	**[30 70[**	**[70 130[**	**[130 500[**
Installation Costs (% of VSD price)	60%	50%	40%	35%	30%	25%
Total cost per kW (1000 Euro)	0 379	0 291	0 207	0 137	0 124	0 115
Total cost per unit (1000 Euro)	0 732	1.560	3.400	5.326	10.596	24.523

45 VSD = ASD.

Table A6.4: Estimated total number of units and sales of AC induction motor discrete drives in 1998 in the EU.

			Application (%)						
Power range (kW)	**Number of units**	**Total sales in 1000 Euro**	Air compressor	Fan	Materials handling	Materials processing	Pump	Refrigeration compressor	Other applications or no data
[0,75 4[	969.400	395.300	2	8	19	35	6	0	30
[4 10[	162.100	158.600	2	11	15	40	14	0	17
[10 30[	84.900	164.100	5	19	11	36	16	2	10
[30 70[	32.000	112.800	2	22	5	40	19	2	10
[70 130[	12.200	73.700	3	13	12	50	12	0	10
[130 500[	7.800	141.700	3	20	20	30	16	0	11
Total	**1.268.400**	**1.046.308**							

Table A6.5: Estimated total number of units of "other" types of drives per power range in 1998.

Number of units

Power range (kW)	**AC induction motor integrated drive**	**Brushless DC Drive**
[0,75 4[	191.200	85.300
[4 10[	29.900	15.500
[10 30[	1.500	7.800
[30 70[	0	3.100
[70 130[	0	1.500
[130 500[	0	300

Table A6.6: Total number of units and sales value by technology in 1998.

Technology	**Number of units**
AC Induction Motor Drive — Discrete Drive	1.268.400
AC Induction Motor Drive — Integrated Motor/Drive	222.600
Brushless DC Drive — Discrete Drives	113.500
Total	1.604.500

Table A6.7: European average total prices per kW, by power range, in 1998.

Power Range (kW)	Average Price (Euro/kW)	Cost of Installation (Euro/kW)	Total Price (Euro/kW)
[0.75 4]	237	142	379
]4 10]	180	90	270
]10 30]	140	56	196
]30 70]	95	33	128
]70 130]	94	28	122
]130 500]	92	23	115

Table A6.8: European average total prices per kW, by power range, in 2015, assuming a 5%/year price decrease.

Power Range (kW)	Average Price (Euro/kW)	Cost of Installation (Euro/kW)	Total Price (Euro/kW)
[0.75 4]	99	59	158
]4 10]	75	38	113
]10 30]	59	24	83
]30 70]	40	14	54
]70 130]	39	12	51
]130 500]	38	10	48

Table A6.9: VSDs Average Savings (%)

	Average Savings (%)	Applicability (%)	Already Applied (%)	Technical Potential * (%)
Pumps	35	60	9	51
Fans	35	60	7	53
Air Compressors	15	30	5	25
Cool. Compressors	15	40	4	36
Conveyors	15	60	8	52
Other Motors	15	60	5	55

Table A6.10: Percentage of motors in which the application of VSDs is cost-effective in each surveyed industrial sector.						
VSDs	Non-Metallic Minerals	Paper and Cardboard	Food, Beverage and Tobacco	Basic Chemistry	Machinery and Metal	Iron and Steel
Pumps	36	38	26	37	27	32
Fans	39	35	34	40	28	38
Air Comp	19	18	15	19	13	18
Cool Comp	0	27	18	27	0	27
Conveyors	15	33	0	18	0	13
Other Motors	36	41	25	40	0	39

Table A6.11: Basic data used to assess the potential savings in the tertiary sector

	Average Savings (%)	Applicability (%)	Already Applied (%)	Technical Potential * (%)
Pumps	35	60	7	53
Fans	35	60	5	55
Refrigeration	15	30	3	27
Air Conditioning	15	40	3	37
Conveyors	15	60	7	53
Other Motors	15	60	3	57

* Percentage of motors in which the application of VSDs is cost-effective

A ‘reality check’ of the projections used in this report can be made based on the economic data from annual reports and financial projections of the three major motor and drives manufacturers.

ABB

ABB is a global and EU market leader in both motors and drives in the Swiss-Swedish ABB group. The group has revenue of around €29 billion, EBIT of €4 billion and had 112.000 employees in 2007. ABB has five major divisions, with the production of low voltage motors and drives being part of the Automation Products division. The table below gives a split up by division.

Table A6.12: ABB Key Characteristics (ABB 2007 Annual report and ppt presentations)

	Revenues 2007		EBIT 2007		Cost base 2007, from previous		Employ-ment 2006	Employment by sales share EU (46%)	EU revenue 46%
	bln. Euro	%	bln. Euro	%	bln. Euro	%	#	#	bln. Euro
Power Products	8,70	30%	1,48	37%	7,22	29%	30.000	13.800	
Power Systems	5,22	18%	0,44	11%	4,78	19%	13.000	5.980	
Automation Products	**7,83**	**27%**	**1,36**	**34%**	**6,47**	**26%**	**30.500**	**14.030**	**3,60**
Process Automation	5,80	20%	0,64	16%	5,16	21%	24.000	11.040	
Robotics	1,16	4%	0,08	2%	1,08	4%	4.500	2.070	
Total	**29**		**4**		**25**		**112.000**	**46920**	

Note: In division Automation products ABB makes AC/DC motors, drives, power electronics for low, medium and high voltage

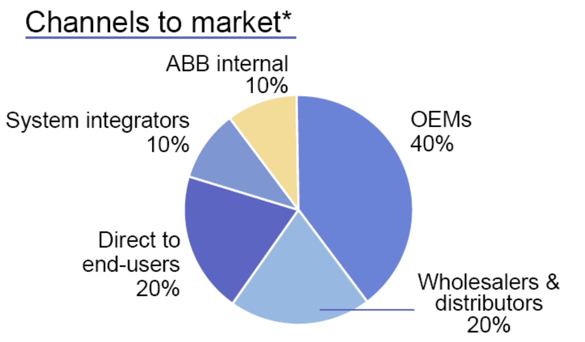
Motor factory ABB Motors Oy (Report 1999) had 674 staff and 125 Meuro revenue in 1999 (0 185 mln. Eur/employee)

Note that of the 14.000 employees in the EU partitioned to Automisation Products only a part, i.e. the low voltage AC 3-phase induction motors plus their drives, are in the scope of the Ecodesign. As a rough guess this may be 30-40% of total-, i.e. 4000-5000 employees of which perhaps 60% on motors (2.500-3.000) and 40% (2000) on drives. If ABB indeed has an EU market share of 27% (see hereafter) it would mean around 9.000 manufacturing jobs to be attributed to motors and 6.000 manufacturing jobs in variable speed drives (excl. OEM) in the sector as a whole. Employing the same multipliers to the revenues, a sector turnover of currently €1,7-1,8 bln. in LV AC motors (€ 0,2 mln./employee) seems plausible. It also shows, especially when taking into account the much higher growth rate, that including the production of VSDs in the equation for the VSD/IE3 sub-option, currently with a turnover of around €1,2 bln., can make a considerable impact.

ABB estimates that the global market for all its products amounts to €190 billion in 2007, with Europe taking up €67 billion (35%). Europe constituting 46% of ABB's revenue, average EU market share of ABB would be about 27% overall. In 2011 the market is expected to be worth of €255 billion (+34%) with Europe taking up €83 billion (+24% growth).[46]

[46] http://www02.abb.com/global/abbzh/abbzh250.nsf/041c9590e18b53eac1257148004393a5/bae1494294c9ca7ac1257344003dcfcb/$FILE/ABB%20strategy%202011_Media%20presentation.pdf.

The figures below, from ABB strategy presentation 2007, show ABB market channels and relative market position within the atomisation products sector worldwide (EU being 46% of revenue).



* Expressed as percentage of total 2006 Automation Products orders

Market position[1]

Business line	1	2	3
Drives and power electronics	ABB	Siemens	Rockwell
Low-voltage systems[2]	ABB	Schneider	Siemens
Motors and machines	ABB	Siemens	WEG
Industrial low-voltage products	Schneider	Siemens	Rockwell/ ABB
Installation material[2]	Schneider	Legrand	ABB
Instrumentation	Emerson	Yokogawa	Endress+H/ ABB

[1] ABB estimates, based on orders received [2] IEC standard

Figure A6.1: ABB Market Channels and Market Position (ABB 2007)

In its strategy until 2011, ABB foresees a 6% annual market growth rate (and an ABB revenue growth of 8%) for the automaon products sector. For the whole group, ABB expects to increase its revenues by 24% over the 2007-2011 period and create as much as 20.000 new jobs. Energy efficiency is expected to be a major market driver and VSDs are widely advertised as an important solution.

The figure below shows the global market shares in the production of drives. Market shares of European manufacturers will of course be much higher in the EU (ca. factor 2).

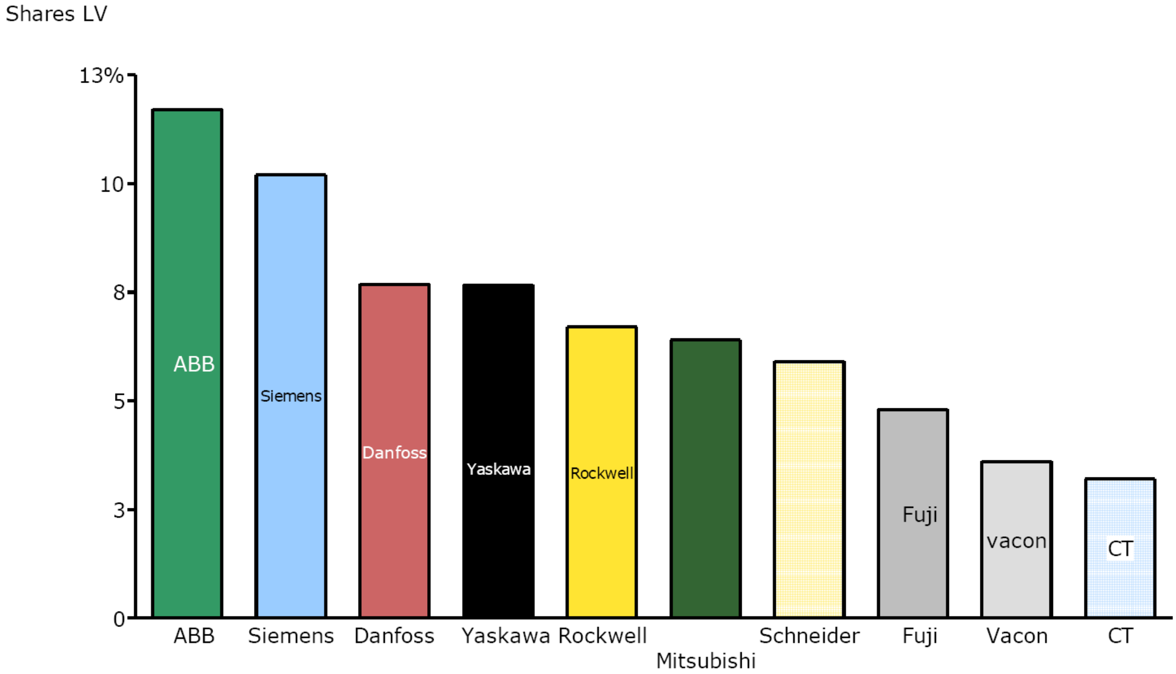


Figure A6.2 Global AC Drives Market Share 2007 (Industry source through EC)

Siemens

Siemens Automation and Drives (Siemens A&D) reports 2007 sales of close to €15,4 billion. It divides its markets differently from ABB, i.e. in factory automation (€57 billion), process automation (€47 billion) and electrical equipment for buildings (€24 billion). It claims being in number 1 position in the first and in 3d and 2d positions respectively in the others. The Siemens annual sales growth rates in the last three years are 12, 31 and 18% in part due to acquisitions, but certainly also induced by autonomous market growth. In the fiscal years 2005-2007, the number of employees has grown by 25.000 from approximately 60.000 to 85.000. Specific annual turnover rate per employee is € 0 181 million. In Europe Siemens A&D employs 22 production sites of which 11 in Germany. Furthermore it has production sites in the US (14), Canada (3), Latin-America (5) and Asia (9). Detailed partitioning of employment and revenues to motors and drives is not possible from published company data.

Danfoss

Danfoss Group reports 2007 net sales of €3 billion Euro (22,1 million DKK), EBIT of 7,2% and 22.323 employees. Annual net growth rate was 18% over 2005-2007. Danfoss Drives, specialised in frequency converters and within the scope of the VSD/IE3 sub-option, is a part of the Motion Control division. Danfoss produces gear motors in the same division, silicon power and solar inverters. Other Danfoss divisions are in refrigeration & air conditioning and heating. Danfoss owns a 38% share in Sauer-Danfoss Inc. (mobile hydraulics, off-road vehicles, etc.).

Net sales of the Motion Control division were € 0,58 billion and employed 3.859 employees. The division realised around 60% of sales in the EU. Danfoss drives is the largest business unit. When assuming two thirds of revenues for the Drives business unit this means 2000-2500 employees of which 60%, i.e. 1200-1500 working for VSDs in the EU (EU turnover of 0,22 billion, which gives € 0,15 million/employee).