Impact assessment study on a possible extension, tightening or simplification of the framework directive 92/75 EEC on energy labelling of household appliances

Appendix 2

Product studies carried out by Europe Economics, Fraunhofer-ISI, BSR Sustainability and FfE

Europe Economics
Chancery House
53-64 Chancery Lane
London WC2A 1QU
Tel: (+44) (0) 20 7831 4717
Fax: (+44) (0) 20 7831 4515
www.europe-economics.com

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1 BOILERS

Introduction

1.1 This section considers extending the energy labelling regime to boilers.

1.2 This is a plausible consideration: In the EU-25 about 206 Mtoe energy were used for residential space heating in about 182 million dwellings in 2004 (44.5 % or 91.5 Mtoe gas and 22.2 % or 45.6 Mtoe oil); the total energy demand for space heating (including non residential buildings) amounts to about 270 Mtoe. The new EU Member States are responsible for about 20 % of the final consumption for residential space heating.

1.3 The technical potential of energy labelling for boilers has been calculated based on gas and oil consumption in owner-occupied dwellings. We assume that other buildings are covered by the EPBD (Energy Performance of Buildings Directive); boilers using solid fuels or electricity are not considered.

Background

1.4 The (theoretical) efficiency of most existing boilers which are older than, e.g. 15 years, is probably 10 to 15 % lower than the newest condensing boilers available (European initiatives on labelling central heating gas boilers).

1.5 However, there is a large gap between the theoretical efficiency and the real efficiency of boilers (Felduntersuchung1). The majority of boilers are oversized (200 % -> 400 %). The part load of condensing boilers is assumed to be 38.8 %, but in tests the real average part load is measured at about 9 %.

1.6 Boilers play an important role in a building's energy performance. The real (!) efficiency of boilers is closely linked to the heating system's conditions (temperature, hydraulics, type of radiator, hot water consumption, user behaviour …); actually, less than 50 % of the overall efficiency is due to the quality of the boiler.

1.7 Workers in the relevant service companies (design, installation and maintenance) are not sufficiently trained in energy efficiency issues. They tend to promote a certain type of technology and/or energy source. There is no obligation for them to deliver specific information about energy efficiency. Even professionals are often not sufficiently trained with regard to energy efficiency concerns.

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[1] Field investigation: Wolff, Dieter u.a.: Felduntersuchung: Betriebsverhalten von Heizungsanlagen …, DBU-Projekt, 2004

1.8 About 90 % of the heating systems in Germany are not hydraulically balanced (examples show high realizable reduction potentials (electricity load (by 50%) and heat load (by 30%)).

1.9 The Energy Performance of Buildings Directive should be looked at in this context: the EPBD has been implemented in 19 EU countries (see Table 1.1).

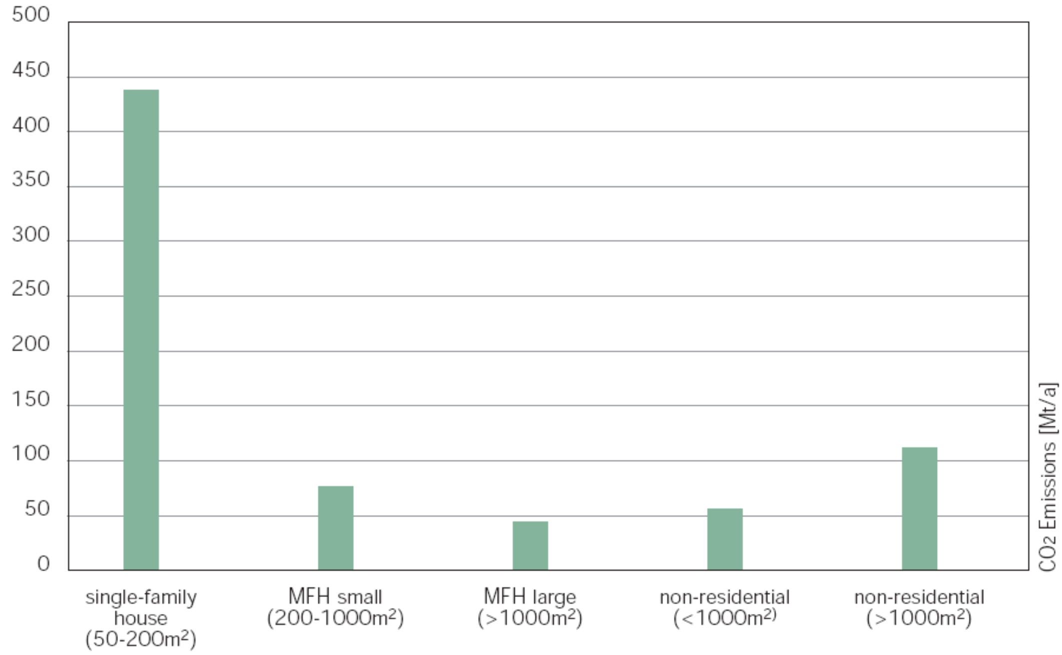
Table 1.1: Implementation of EPBD

1. Belgium (Flemish Region): status August 2006
2. Belgium (Brussels Capital Region): status August 2006
3. Bulgaria - status December 2006
4. Denmark - status August 2006
5. Estonia - status January 2007
6. France – status January 2007
7. Germany - status October 2006
8. Greece - status January 2007
9. Hungary - status August 2006
10. Ireland- status August 2006
11. Lithuania - status January 2007
12. Malta – status January 2007
13. Netherlands - status August 2006
14. Norway - status August 2006
15. Poland - status August 2006
16. Portugal - status September 2006
17. Romania - status August 2006
18. Slovak Republic - status January 2007
19. Slovenia - status August 2006
20. Sweden - status January 2007

1.10 The overall emissions savings based on EPBD have been estimated at 11 % by ecofys (2002, EU15). In future, an evaluation of the EPBD could show results in the different member states. It should be considered that the implementation in the different member states is not standardized.

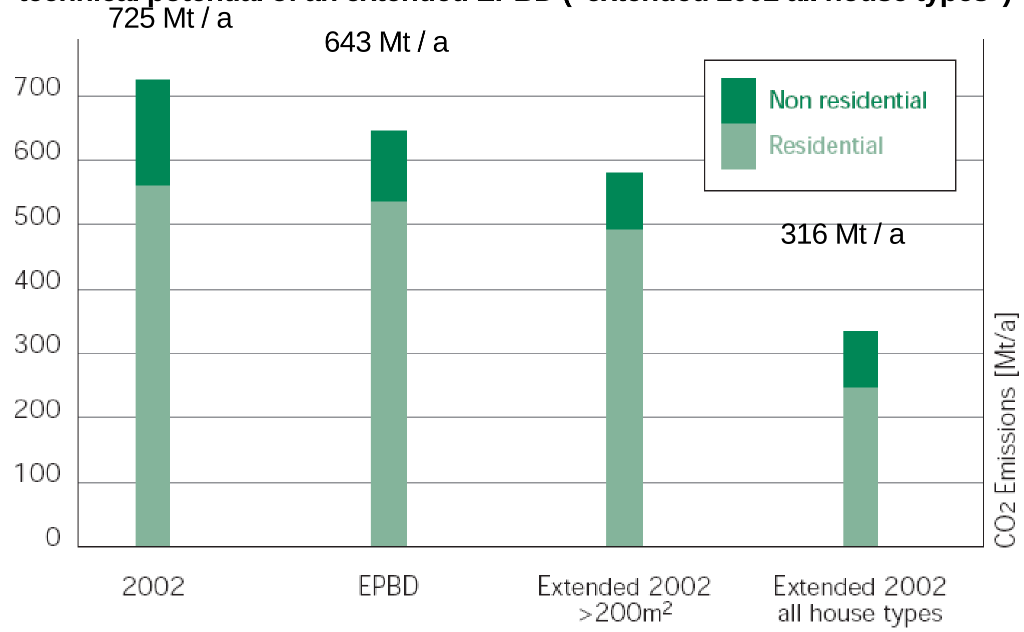
1.11 The EPBD only considers the emissions from heating systems in existing single family houses and small multi-family buildings if these are rented, sold or extensively renovated ("Major renovations of existing buildings . . . . should be regarded as an opportunity to take cost-effective measures to enhance energy performance", Directive (13)); the emissions of single-family houses are also very high compared with other buildings (see Figure 1.1). We calculate the emissions of owner occupied dwellings with oil and gas boilers to be about 170 Mt CO_2 in the year 2004 (see the following table).

Figure 1.1: CO_2 emissions of the European building stock 2002 (EU 15, ecofys)



1.12 If an extended EPBD were to consider all buildings, the technical potential for reducing emissions would be very high (see Figure 1.2); about 56 % of the CO_2 emissions could be reduced (725 Mt CO_2 "2002" -> 316 Mt CO_2 "Extended 2002 all house types"). The additional technical potential of around 330 Mt (643 – 316 Mt; see following figure) should be compared with the potential contribution of labelling.

Figure 1.2: CO_2 emissions of the European building stock 2002 (EU15, ecofys) and the technical potential of an extended EPBD ("extended 2002 all house types")



1.13 It is assumed that especially owner-occupied dwellings are not reached by the current implementation of the EPBD. This poses the question of whether a label for boilers could be helpful to bridge this gap.

1.14 The Table 1.2 below shows the energy consumption of gas and oil in owner occupied dwellings and the produced CO2 emissions (calculation based on Housing Statistics in the European Union 2004).

Table 1.2: Energy consumption (only gas and oil for space heating) and CO_2 emissions in owner occupied dwellings; total amount in the European Union (only gas and oil for space heating in residential buildings; own calculation based on "Odysee and NMC database.." and "National Board of Housing, Building …")

Energy consumption an emission (gas, oil) for space heating in	Owner-occupied dwellings	Gas	Oil	emission (gas + oil)
	%	**Mtoe**	**Mtoe**	**Mt CO2**
Austria	58%	0,7	0,9	4,4
Belgium	68%			-
Bulgaria		-	-	-
Cyprus	68%		0,1	0,2
Czech Republic	47%			-
Denmark	53%	0,3	0,3	1,5
Estonia				-
Finland	63%	0,0	0,3	1,1
France	56%	7,6	5,0	32,8
Germany	39%	8,5	6,1	38,4
Greece	74%	0,0	2,1	6,6
Hungary	92%			-
Ireland	77%			-
Italy	68%	9,5	2,8	30,4
Latvia	79%	0,0	0,0	0,2
Lithuania			-	-
Luxembourg	67%			-
Malta	70%			-
Netherlands	55%	3,2	0,0	7,5
Norway			-	-
Poland	58%	0,8	0,3	2,7
Portugal	75%			-
Slovak Republic	74%			-
Slovenia	84%	0,1	0,3	0,9
Spain	82%			-
Sweden	46%	0,0	0,3	0,9
United Kingdom	69%	15,2	1,2	38,8
Owner-occupied		**46**	**20**	**167**

1.15 As the above Table shows, the gas and oil boilers in owner-occupied dwellings are responsible for about 170 Mt CO2 each year (106 Mt from gas and 61 Mt based on oil).

1.16 The heat losses in the housing stock can be calculated at about 30 – 40 %, and the boiler losses are assumed to be about 10 – 20 % (see Table below; calculation based on Table 17 MEEUP / gas and oil-fired CH Boilers). The result is a technical potential of less than 20 Mt CO2 (10.1 Mt CO2 emissions from gas and 7.8 Mt CO2-emissions from oil) if it is assumed that boiler losses can be reduced by 70%:

- The efficiency losses for new installed boilers range between 1083 kWh/ year (gas) and 1813 kWh / year (oil, see Table 17 in MEEUP – Product cases report);

- The "best condensing gas boilers" in the field investigation (Wolf,D: Felduntersuchung..) still might have boiler efficiency losses of about 200 – 500 kWh / year (or 3 – 7 kWh / m² floor area, see Figure 19 in the field investigation). We therefore estimate annual boiler efficiency losses of 350 kWh (gas) or 550 kWh (or 55 litre oil) for labelled boilers.

- When we compared the boiler efficiency losses of "best gas boilers" (350 kWh, gas) with the average of 1083 kWh (see table 17 in MEEUP Product Cases Report) a reduction of around 70% in the case of a gas boiler labelling seems realistic. The same value was calculated for oil boilers.

Table 1.3: Energy losses of the whole heating systems and gas- or oil–fired boilers in owner occupied dwellings

Technical potential of labelling in dwellings		**Gas**	**Oil**
Heating System Loss	**Stock**	**32.2%**	**36.9%**
Boiler Loss	**Stock**	**13.6%**	**18.2%**
Reduction potential space heating referring to **reduction of boiler losses up to 70 %**		**10%**	**13%**
Technical potential (residential)	***Mt CO_2 / a***	***10.1***	***7.8***

1.17 This technical potential of almost 20 Mt CO2 / a (10.1 based on gas and 7.8 based on oil see Table) should be compared with the potential of the "extended EPBD" calculated at 330 Mt by ecofys. As a result about 5 % of the realizable technical potential of the "extended EPBD" could be achieved just by labelling the boiler quality (without changing the energy source or shifting to renewables). In this context it should be mentioned that a label might give an incentive to retain the energy source.

1.18 Taking into account the lifespan of boilers, the technical potential of labelling boilers could amount to one million tonnes CO_2 reduction each year.

Possibilities, examples and limits of energy labelling for boilers

1.19 The idea of energy labelling for boilers is not a new one.

1.20 In Denmark, for example, gas boilers are evaluated on the basis of the calculated total energy consumption (gas and electricity).

1.21 Energy labelling and the new requirements of the 2006 Danish Building Regulations (based on EPBD) are relevant in this context. The Danish Building Regulations of 2006 introduced new requirements for gas boilers aiming to promote the best boilers (with full-load and part-load efficiencies of above 96 % and 104 %, respectively). This means that in future only condensing gas boilers will be permitted on the Danish market if boilers have to be replaced or in new buildings (23rd World Gas Conference, Amsterdam 2006).

1.22 In Austria, the “Austrian Environmental Label” is awarded on the basis of low emissions.

1.23 In Belgium there are voluntary labels based on quality marks for gas and oil boilers.

1.24 In France, voluntary labels are self-imposed by manufacturers to anticipate any product requirements legislation and in view of the appearance of more restrictive norms (Eco-design of CH-Boilers, Task 1 Report, Annex).

1.25 In Germany there are different labels for quality (norms and safety) and for environmentally-friendly products.

1.26 The Netherlands has a voluntary “HR”-labelling scheme for the net calorific value (HR: 101 %; HR+: 104 %; HR++ 107 %). The use of the NCV is sometimes confusing because efficiency values based on this can be greater than 100 % since this artificial value does not consider condensing heat (which is about 10 % when using gas).

1.27 In UK information about the efficiency of boilers are published on a website (www.sedbuk.com): SEDBUK stands for "Seasonal Efficiency of Domestic Boilers in the UK", and is an industry standard for measuring the thermal efficiency of a boiler.

1.28 In the US, the “Annual Fuel Utilization Efficiency (AFUE)” calculation is based on the gross calorific value (GCV, which is used worldwide apart from in the EU and Taiwan). The Minimum Energy Efficiency Performance Standards (MEEPS) for gas-fired residential boilers is 80 % and the US Energy Star levels are 85 % for non-condensing and 95 % for condensing boilers (these star values are 10 % higher when translated into the NCV, i.e. $95\%_{(NCV)}$ for non-condensing and $105\ \%_{(NCV)}$ for condensing boilers). Apart from the difference between NCV and GCV, there are also differences in the heating technology to be considered. In the USA many buildings have an air heating system – in the EU “wet” central heating boilers are normally used.

Impact of energy labelling for boilers

1.29 We did not conduct an independent detailed analysis to examine the possible impacts of extending the energy labelling scheme to boilers.

1.30 A special energy label for the different energy sources could help to reduce CO2 emissions by up to one million tons per year if adequate test standards were available. But – in most cases - this would “fix” the actual energy source used in the building. Without optimization of the heating system in the case of replacement, this procedure could easily determine a suboptimal situation over the lifetime of the new boiler (oversized boiler, hydraulic faults, high temperature …). The better way would be an audit of the whole heating system including the boiler and considering alternative heating technologies.

1.31 One universal energy label for all energy sources based on CO_2 emissions could be misleading: e.g. only wood-fired boilers and solar collectors would be labelled class A (and there would then be small incentive to improve, e.g. wood-fired boilers which already carried the A label).

1.32 But such a universal CO_2-based label would provide incentives to shift from fossil to renewable energy carriers.

1.33 One universal energy label for all energy sources based on the primary energy demand could be misleading: Normally gas- and oil-fired boilers have higher energy efficiencies than wood-fired heating systems as result of the different qualities of the energy sources.

1.34 One universal energy label for all energy sources based on the Net Calorific Value could be misleading: Only gas (and perhaps some oil) fired boilers would probably qualify for an A label.

Conclusions

1.35 There is a fear of providing misleading information if only boilers – one part of the heating system – are labelled: the high efficiency of a boiler is the result of high efficiency in the heating system as a whole.

1.36 As the real average part load is about 50 % or 20 % of the assumed theoretical part load, labelling only the boiler could fail to identify a suboptimal heating system. The result in many cases (without an audit and changes to the heating system) would be that the customer would feel reassured but would still receive an oversized bill! Only the sellers of oversized boilers and the suppliers of gas or oil would stand to gain from this label.

1.37 There is also a fear of confusion:

(a) The efficiencies above 100 % are misleading: a solar collector would never have an efficiency above 100%.

(b) Some individual EU Member States already have voluntary energy labels for gas boilers.

1.38 “Central Heating Boilers are part of the heating system and there are few products where it is obvious that the environmental impact and the improvement potential are so clearly dependent not only on the efficiency of the product under standard conditions, but also on the way it interacts with the system” (Methodology Study Eco-design …1.25 MEEEUP, 28.11.2005).

1.39 A label cannot respect the different climatic zones in the EU or the local situation: burning wood in an area far away from the forests which provide the timber would induce longer transport and thus more CO_2 emissions associated with this. Using solar collectors in areas with a high degree of natural shading would also be very inefficient installations.

1.40 As a result of these considerations our proposal is to label the total heating system with additional directives to promote renewable energy. Some aspects are

(a) Shade, e.g. from trees, could reduce the efficiency of an (A-Label) solar heating system and the energy gain from (A-Label) windows (especially in winter

(b) On the other hand, a broad-leafed tree could reduce the energy demand for air conditioning in summer or could be – in many cases - a good substitute of a (A-Label) electric cooling system.

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2 ELECTRIC MOTOR SYSTEMS

Energy Efficient Electric Motor Systems

Aims of the case study

2.1 The possibilities of extending labelling to non-household products is being considered and electric motors and electric motor systems in the commercial and industrial sectors have been analysed as one example of a "non-household product". Therefore, the focus lies on the expected implications that accompany this extension of the target group from household appliances to industrial technologies.

2.2 The case study is not intended to provide a detailed action plan for designing a new labelling scheme, but it will evaluate the pros and cons as well as identify the most important aspects and possible problems of a future label. Therefore, stakeholder interviews were also conducted. Furthermore the study will give an overview of comparable international legislation, show recent market trends and give an estimation of the impact in terms of the achievable saving potential.

2.3 The focus of this study will be on electric motors. The possibilities to label the whole motor system will also be discussed in the following chapter and is addressed in the interviews.

Electric motors and electric motor systems

2.4 The analysis of labelling possibilities and the discussion with several experts revealed that the question of whether it is advantageous to label the whole motor system or only the motor and how system boundaries can be defined cannot be answered comprehensively within this study. Instead a summary of this discussion will be given.

2.5 To make the discussion transparent, motor systems are classified into three groups (compare Brunner et al. (2007):

(a) The electric motor itself, including its cooling system, which is normally a built-in fan and counted as part of the motor.

(b) The core motor system including the motor controls such as adjustable speed drive plus the mechanical transmission system and the directly driven equipment (e.g. a pump or a fan). In most cases, this core motor system is sold as one distinct product, e.g. a pump or a fan. While the same definition is used in the EuP interim report on fans (Radgen et al. 2007) a system definition that excludes the motor is used in the EuP interim report on pumps (Falkner 2007). This difference is due to the fact that pumps are not often sold with an incorporated motor, because the motor has to be chosen according to the load situation. In contrary, fans are in general sold as a distinct product including the motor.

(c) The entire motor drive system: whole systems such as the building air conditioning system with ventilation and cooling equipment, the heating system with pumps and valves, the transport system with elevators, escalators, lifts and conveyor belts, etc.

2.6 In general, it can be observed that the complexity and heterogeneity of the system increase considerably going from (a) to (c), as do the energy savings achievable.

2.7 In our analysis we focused our attention on the first of these groups. We briefly discuss group (b) but, given the extreme heterogeneity of the systems used in industry, we do not assess group (c). For example most compressed air or pump systems vary from company to company in terms of system design and products used – basically due to varying production techniques and requirements. This heterogeneity would make a labelling scheme too complex to be efficient and a systematic analysis of saving potentials impossible. Nonetheless, it must be kept in mind that in many cases significant energy savings can be realised by optimising the whole system and by a better match with the required energy service.

2.8 The interviews indicated the same fact: Saving potentials for the whole motor system are estimated as much higher than for motors only (estimations go up tenfold). But none of the interviewees considered labelling an appropriate instrument for tackling motor system efficiency because the systems are too heterogeneous.

2.9 Even the so-called core motor system (b) is very heterogeneous and a systematic analysis is beyond the scope of this study.

(a) The discussion with experts showed that the labelling possibilities for these products have to be assessed for a distinct product, as is the case for the EuP Directive, and cannot be assessed in general for all electric motor systems.

(b) Also the question of system boundaries has to be addressed for each product class and cannot be defined in general.

2.10 As a consequence of the discussions and the first results, the focus of this study will be on the electric motor itself. Some examples of the core motor system will be taken into account as well when appropriate.

Background

2.11 Electric motor systems account for about 70 per cent of the electricity consumption in industry and for about 38 per cent in the commercial sector (Almeida et al. 2001), which shows their importance for policies concerning energy efficiency.

2.12 According to De Keulaner et al. (2005), the economic energy saving potential in electric motor systems represents 7 % of total EU electricity consumption. This figure is based on the outcomes of the EU-SAVE studies on electric motors (Almeida et al. 2001; Almeida et al. 2000; Radgen 2002; Radgen, Blaustein 2001) and was calculated for the EU-15 in 2000.

Legislation on the labelling of electric motors

2.13 When assessing the legislative situation, not only labelling schemes shall be regarded, but also minimum energy performance standards (MEPS), because they are often used together and are based on similar classifications and testing methods.

Labelling in Europe

2.14 The European Commission and the European Committee of Manufacturers of Electrical Machines and Power Electronics (CEMEP) have agreed on a voluntary labelling scheme. Although the scheme is voluntary, most European manufacturers participate in it. It has been in operation since 1999 and classifies electric motors in three distinct groups (most efficient: eff1, least efficient: eff3).

(a) The sole criterion used for this classification is electric motor efficiency, tested according to EN 60034-2. Motor system aspects are not considered for determining the motor efficiency and the power range of motors that are included ranges between 1.1 and 90 kW.

(b) In line with its voluntary character, manufacturers can classify their own products and compliance is only monitored by competitors. Penalties, besides exclusion from the scheme, do not exist.

(c) When asked about the main strengths of the CEMEP labelling, the interviewees mentioned its simplicity first and foremost; the scheme is well understood and has low running costs.

(d) When asked about the main weaknesses, more diverse answers were given, ranging from the self classification of manufacturers and insufficient inspection to not being compatible internationally.

Labelling and MEPS legislation worldwide

2.15 In the USA, MEPS for electric motors were published in the Energy Policy Act (EPAct) in 1992 and enforced in 1997. The scheme covers motors in the range from 1 to 200 hp. According to Boteler, R. (2005), about 70 per cent of total electric motor sales in the US were affected by this standard. The EPAct standard is comparable to the EFF1 class in the European CEMEP labelling scheme in terms of motor efficiency.

(a) The NEMA[2] premium efficiency standard was launched in 2001. This new standard sets considerably higher efficiency levels than the EPAct standard and it further

[2] National Electrical Manufacturers Association

includes a wider range of products (1-500 hp instead of 1-200) while the testing methods used are the same for both standards. It is important to mention, that the NEMA premium is not a MEPS but the labelling of motors that are more efficient than the EPAct minimum standards. For further information on the NEMA premium standard, see Boteler, R. (2005).

2.16 MEPS have been in force in Australia since 2001 with progressive requirements. Three phase induction motors between 0.73 and 185 kW that are either manufactured in or imported into Australia must fulfil minimum requirements in terms of efficiency.

(a) The MEPS was revised in 2006 to achieve better harmonization with other international standards - above all the American and Canadian standards - and to adjust efficiency classes. In the course of this adjustment, the “high efficiency class” of 2001 became the new minimum standard (now comparable to EPAct and CEMEP EFF1) and a more ambitious class was created to define “high efficiency motors”, which is comparable to the American “NEMA premium” class. A detailed description of the standards used in Australia is available from Ryan P. et al. (2005).

2.17 The Brazilian labelling scheme was created based on the experience with the American labelling scheme and its implementation process. According to Soares (2005), approximately 80 per cent of the electric motor market in Brazil are covered by the scheme. A detailed analysis of the scheme’s influence on the electric motor market and the cost-effectiveness of energy-efficient motors has been done by Garcia et al. (2007).

2.18 Even more countries use MEPS for electric motors. For a more detailed analysis it is referred to Almeida et al. (2007)

Comparison

2.19 The requirements of the labelling schemes described above are summarized in the following table. It can be observed that the coverage of the schemes varies in some criteria. This results in certain electric motors, which are included in the scheme in some countries, not being covered by the scheme in other countries. Some aspects shall be pointed out, but for a more detailed analysis of the legislative situation, please refer to De Almeida et al. (2007).

(a) It can be observed that the scope of the European labelling scheme in terms of rated power, number of poles and maximum voltage is considerably lower than it is in other countries. Consequently, the European labelling covers a smaller share of the market than other schemes do, and thus leaving some potential for energy savings aside.

(b) Furthermore, some countries use MEPS in combination with the labelling of highly-efficient, above standard motors. The opposite is true in Europe, where only labelling is applied and this is done only voluntarily.

(c) In a global comparison, the European "high efficiency class" EFF1 can be regarded as standard efficiency. For example in the US, this European high efficiency level has already been in force as a minimum standard since 1997.

Table 2.1: Comparison of criteria determining the inclusion of motors in labelling schemes and Minimum Energy Performance Standards (MEPS)

	CEMEP (EU-labelling)	EPACT (US)	NEMA (US)	Australia / New Zealand	Brazil	IEC proposal
MEPS / Label	Labels voluntary	MEPS, mandatory	Label	MEPS mandatory	MEPS mandatory + label	
Rated power range	1.1–90 kW	0.74 - 147 kW (1-200 hp)	0.74 - 368 kW (1-500 hp)	0.74 - 184 kW (1-250 hp)	0.74 - 184 kW (1 to 250 hp)	0.75 - 370 kW
Poles	2 and 4	2, 4 and 6	2, 4 and 6	2, 4, 6 and 8	2,4,6 and 8	2, 4 and 6
AC / DC	AC		AC		AC	AC
Voltage	400 V	230 and 400 V	<= 600 V	<= 1100 V	<=600 V	< 1000 V
Testing method	IEC 60034-2 "summation of losses"	IEEE 112-B	IEEE 112-B	IEC 61972-1 (=IEEE 112-B) and IEC 60034-2 "summation of losses"	Based on IEEE 112-B and IEC 62893	IEC 60034-2

Table 2.2: Motor Energy Performance Standards (MEPS) and the market penetration of energy-efficient motors

Efficiency Level*	Designations based on Test Method		Minimum Energy Performance Standards *(estimated in-country % market share)***	
	IEC 34 – 2	IEEE / CSA	Mandatory	Voluntary
Premium		NEMA Premium		Australia (10%) Canada, US (16%) China – 2010
High	EFF 1	EPAct, the Level, JIS C 4212	Australia – 2006 Brazil – 2009 Canada, US (54%) China – 2010 Mexico	Australia (32%) Brazil (15%) China (1%) EU (7%) India (2%) Japan (1%)
Standard	EFF 2	Standard	Australia (58%) Brazil (85% >20 after 2009) China (99%) Canada, US ~30% exempt	EU (66 non-CEMEP, 85 of CEMEP agreement members) India (48%) Japan (99%)
Below Standard	EFF 3			EU (28% non-CEMEP, 8 CEMEP) India (50%)

*Normalised, taking differences in test methods and frequencies into account.
** Based on information from standards workshop and EEMODS, September 2005.
Note: NEMA – National Electrical Manufacturers Association; CEMEP – European Committee of Manufacturers of Electrical Machines and Power Electronics; CSA – Canadian Standards Association, EPAct – Energy Policy Act; EEF – European efficiency levels; IEC – International Electrotechnical Commission; IEEE – Institute of Electrical and Electronics Engineers; JIS – Japanese Test Standard.
Source: Brunner and Niederberger, 2006.

Source: (IEA 2007)

Harmonization and alignment

2.20 As electric motors are traded on a global market, differing national performance standards, testing methods and labelling requirements make it more and more difficult for producers to offer their products on different markets. Thus, activities have been initiated to reduce market barriers by globally harmonizing standards and testing methods.

2.21 At the moment the (IEC) is working on establishing globally accepted standards for testing methods and for efficiency classes which are summarized below.

(a) The proposed classification shall comprise four distinct efficiency levels called IE1 to IE4. The IE1 will be comparable to EFF2 (CEMEP) and IE2 is based on EFF1 (50Hz) and the American EPAct (60Hz) requirements. The US NEMA Premium class serves as the basis for the premium efficiency class IE3. A super-premium class, IE4, has been proposed but not yet standardised due to a lack of market and technological information.

(b) The power rating proposed shall range between 0.75 and 370 kW. For motors with lower power, it is argued that these are mostly used in short-time applications, have very low energy consumption and consequently only small saving potentials. For motors above 370 kW, the saving potential is also assumed to be marginal as these motors are mostly sold directly to end-consumers who are aware of their high electricity consumption and running cost. The losses of high power motors have to be minimized from a technical point of view as well in order to prevent the motors overheating.

(c) Motors with 2, 4 and 6 poles shall be covered. For 8-pole motors it is argued that their market share is already marginal (~ 1%) and expected to fall still further.

(d) A testing standard (IEC 60034-2) was developed and adopted in 2006 (Brunner et al. 2007). This standard (or a compatible national standard) is already in use in some countries (see table above).

Conclusions

2.22 European efficiency classes seem to be low when compared with other countries' labelling schemes. Also the possibilities for enforcement, like monitoring and penalties, seem comparatively weak in Europe.

2.23 The characteristics of schemes vary between countries. This concerns the requirements for motors to be included in the schemes as well as testing standards and aspects of compliance and enforcement.

2.24 From the manufacturers' viewpoint, international compatibility is an important aspect and was emphasised by the interviewees. This concerns the present – it is already difficult for European manufacturers to be price competitive on the US market – but also the future, when strict MEPS will be in force in even more countries.

2.25 The IEC is currently working on a global standardization of efficiency classes and testing methods, but how they are used in labelling and MEPS worldwide still depends on national decisions.

The electric motor market

2.26 When looking at the life cycle costs of electric motors, it can be observed that the initial investment represents only a small share of total costs. By far the largest share is due to running costs.

2.27 Thus, in general, investments in energy-efficient electric motors typically pay off after one year when buying a new motor, and after 1 to 3 years when replacing an old motor with a more efficient one (Brunner et al. 2007). Of course these figures are estimations, depending on full load hours, the electricity price, any price premium for highly-efficient motors, efficiency gain and so on. But the general conclusion is that investments in high efficiency motors are nearly always cost-effective. For a more detailed analysis of motor life cycle costs, see Almeida et al. (2007)

2.28 The best available analysis of the electric motor market in Europe (EU-25) is in Almeida et al. (2007). Their main outcomes can be summarised as following.

(a) 96 % of motor shipments were AC motors, the rest were DC motors.

(b) 87 % of AC motors revenues in 2006 were attributed to 3 phase induction motors

(c) 4-pole motors have a share of about 50 to 70 % of the AC 3 phase motors market. 2-pole motors account for 15 to 35 % (6-pole 7-15 % and 8-pole 1-7 %)

2.29 Almeida et al. (2007) expect the following market trends:

(a) The market share of DC motors is expected to decline still further because of the advantages of 3 phase induction motors which cost less and need less maintenance.

(b) Only the market share of brushless permanent magnet DC motors is expected to grow, depending on the cost of the magnetic materials. Especially in the lower power ranges, these motors are considerable more efficient than the 3 phase induction motors.

(c) The demand for AC 3-phase induction motors is expected to rise slightly.

(d) In general, the increased use of variable speed drives (VSD) is expected to have a considerable influence on market developments. For example single phase motors can be substituted by 3 phase motors driven by a VSD.

2.30 Brunner et al. (2007) report that 80 to 90 per cent of electric motors of low and medium power range were not directly sold to end-users, but to original equipment manufacturers (OEMs) who then incorporate the electric motors in another product such as, e.g. a fan, a compressor etc. Thus, the market structure for electric motors is fundamentally different to that of products already covered by the labelling Directive, like dryers or washing machines, where households directly purchase the labelled product.

(a) The fact that most motors are sold to OEMs, for whom running costs are less important than the purchasing cost, was also raised by the interviewees as an important aspect.

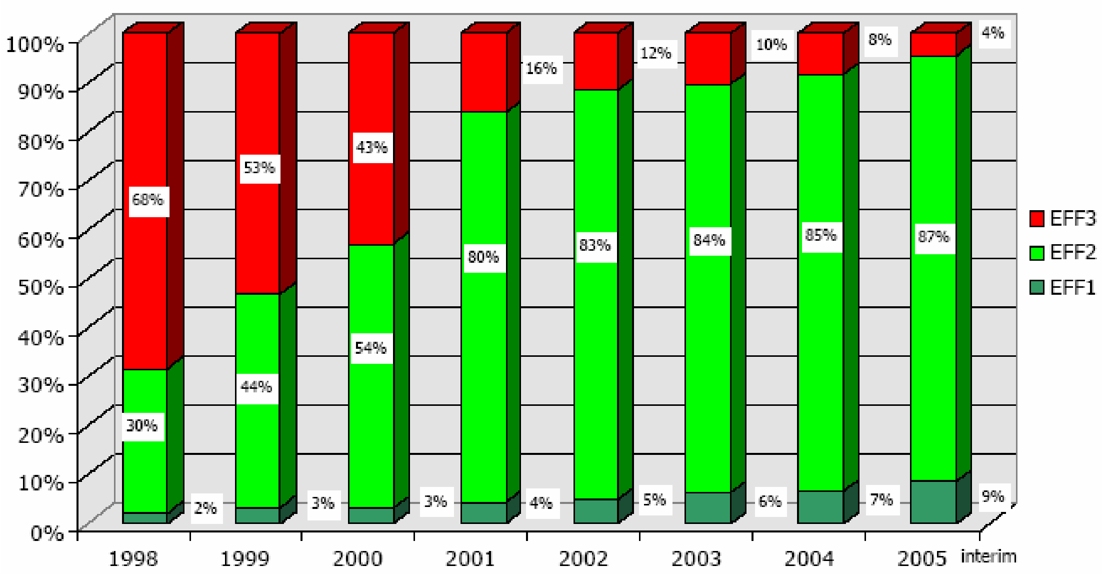
2.31 Two main consequences can be identified from the high share of sales to OEMs:

(a) There is a considerable loss of information when OEMs incorporate the motor into another product. As a result, end-users do not know which or even how many motors are part of the product that they actually purchase.

(b) OEMs are more interested in the purchase cost of the motor than in low running or even life cycle costs.

2.32 It is still being discussed whether it would be a solution to label the core motor system in which the motor is included, because motor systems are also often not sold directly to end-users. In any case, these peculiarities of the motor market have to be considered when designing an effective labelling scheme.

Figure 2.1: Motor sales under the scope of the Voluntary Agreement of CEMEP



Source: (de Almeida et al. 2007)

2.33 As shown in the above figure, the market share of EFF3 motors (least efficient motors) has decreased considerably since the voluntary labelling scheme (CEMEP) started operation in 1999. The scheme was accompanied by a voluntary agreement of motor manufacturers to halve the sales of EFF3 motors until the end of 2003.

2.34 One indicator for the success of the voluntary labelling scheme in promoting the diffusion of EFF2 motors in place of EFF3 motors is the comparison of market shares of motors that are covered by the labelling scheme with motors that are outside the scheme. For the latter, the market share of EFF3 motors was still 27 % in 2005, which is 4 times higher than it is for electric motors covered by the scheme (see figure below).

2.35 However, the share of EFF1 motors increased only slowly to 9 % in 2005. That their market share could be much higher becomes obvious when comparing the European and the US markets for electric motors (see figure below). About 70 % of electric motor sales in the US-scheme were classified as equivalent to EFF1 or higher, which is 7 times the equivalent figure in Europe. In the interviews, several reasons for this difference were mentioned:

(a) The most important reason is the MEPS EPAct, which is in force since 1997 combined with financial incentives to compensate for the price premium of efficient motors.

(b) Technically, the higher the frequency is the lower are the motor iron and friction losses. Thus, with 60Hz as in the US it is relatively easier and cheaper to produce efficient motors than it is in Europe for 50 Hz.

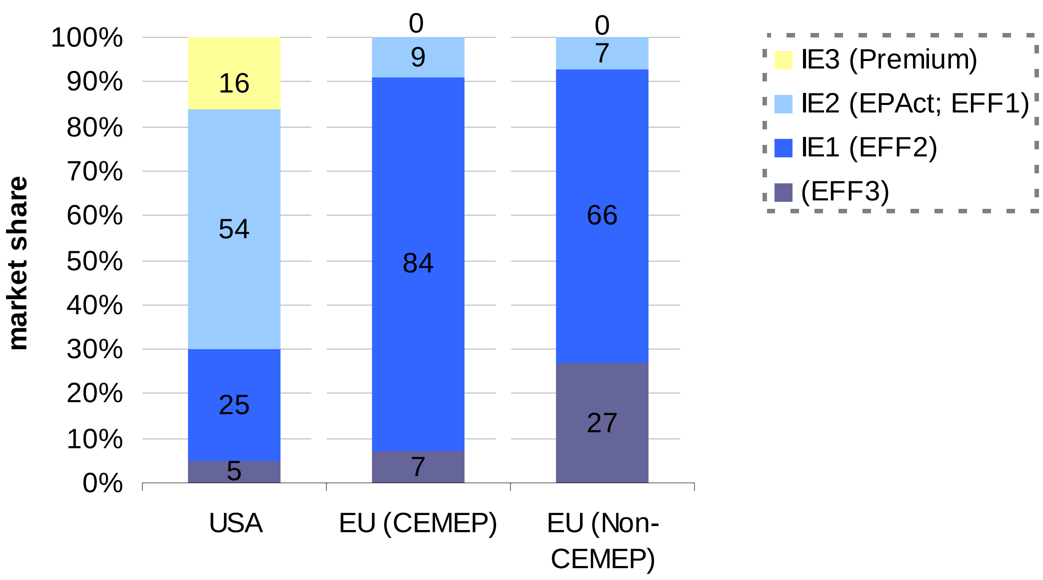
(c) While the policy on motor efficiency concentrated already in the 90s on the efficiency of the motor itself, in Europe the focus was more on the whole motor system.

(d) Also the general price level for electric motors could have played a role. As the price level in the US is higher than in Europe, the price premium for efficient motors appears lower for the consumers.

2.36 As a reason for the weak development of EFF1 sales, Almeida et al. (2007) refer to the price premium for EFF1 motors which is 20-30% above EFF2 motors in combination with the fact that the motor market is basically an OEM market. In contrast, the price did not vary much from EFF3 to EFF2 motors, so this barrier was not present and EFF2 motors were able to gain large market shares. The same argumentation was also presented by some interviewees.

2.37 The market share of EFF1 (and better) motors is higher in countries like Brazil or Australia than in Europe. For more detailed information see de Almeida et al. (2007).

Figure 2.2: Comparing US and European motor sales in 2005



Source: numbers from (Brunner et al. 2007)

Conclusion

2.38 The voluntary labelling scheme succeeded in reducing the market share of the least efficient motors (EFF3) by replacing them with EFF2 motors.

2.39 The scheme did not promote the diffusion of more efficient motors, as seems possible when comparing US and European market shares. The market share of EFF1 motors increased only slowly by about 1 percentage point per year.

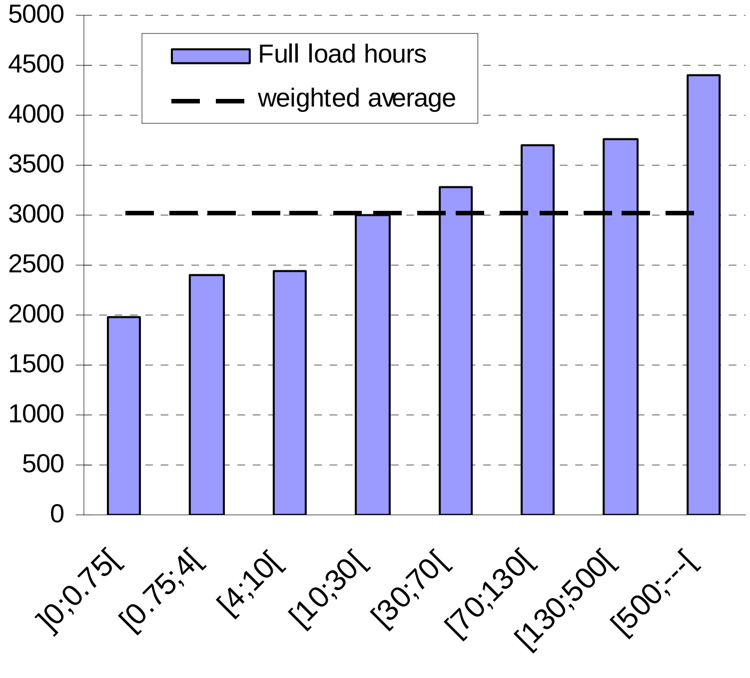
Analysis of the possibilities for further energy savings

Electric motor stock

2.40 There are not many data available on the stock of electric motors in the EU. Some characteristics of the motor stock can be shown, mainly based on the data given in Almeida et al. (2001).

2.41 The distribution of full load hours over motor power class is shown in the figure below. A constant decline in full load hours to about 2000 hours per year can be observed for motors with less than 0.75 kW. Full load hours become important when looking at the lifecycle costs of electric motors.

Figure 2.3: Full load hours by power class of AC polyphase induction motor stock in industry and tertiary sector (1996, EU-15)

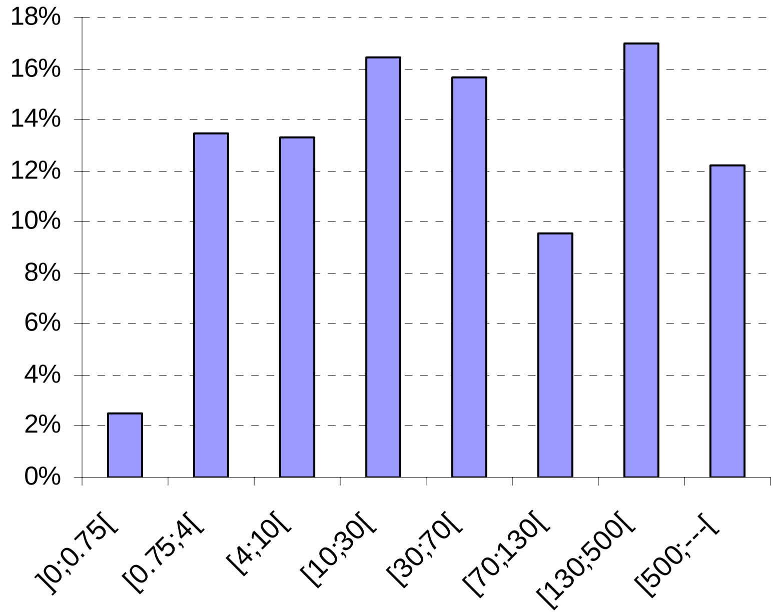


Data from 1996 for EU-15 (Almeida et al. 2001)

2.42 How electricity consumption is spread across the motor power classes is an important indication for what proportion of electricity consumption is covered by a labelling scheme. In the case of CEMEP labelling, which covers all motors with a power rating between 1 and 90 kW, the data used indicates that 45 to 68 % of electricity consumption in AC polyphase induction motors is covered by the scheme (see also the figure below).

Furthermore, it should be noted that AC polyphase induction motors represent more than 90 % of total motor electricity consumption (Almeida et al. 2001).

Figure 2.4: Electricity consumption by power class of AC polyphase induction motor stock in industry and tertiary sector (1996, EU-15)



Data from 1996 for EU-15 (Almeida et al. 2001)

Energy savings

2.43 The impact analysis of a new labelling scheme needs some comments on definitions and restrictions.

(a) The efficiency classes proposed by the IEC as an international standard were used to calculate the saving potentials.

(b) To calculate the baseline electric motor electricity consumption, it was assumed that 70% of the motor stock fulfil the IEC requirements and are included in the labelling scheme. About 20% have a power rating outside the range of 1 to 370 kW and 10% are not AC induction motors and consequently outside the labelling scheme.

(c) For the impact assessment only the additional electricity savings above the "business-as usual" savings shall be considered. Although the share of IE1 (EFF2) motors in the motor stock will increase in the future, this is not regarded as an impact of a new labelling scheme because this would occur even without changing the current labelling. Thus, IE1 efficiencies are used as the baseline for the calculations.

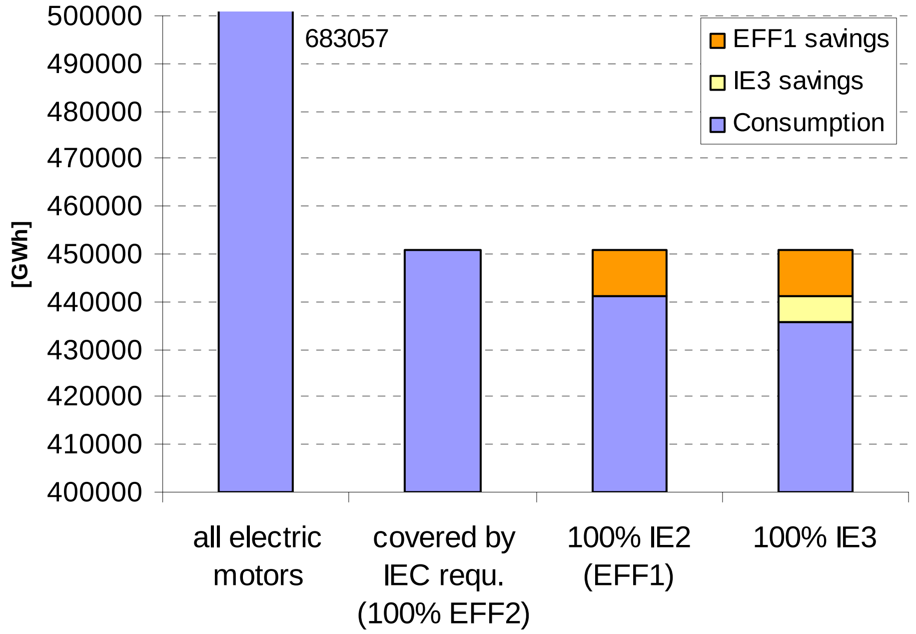
(d) The saving potentials were calculated in two steps. The first assumes the replacement of IE1 (EFF2) by IE2 (EFF1) motors. The second assumes the replacement of IE2 by IE3 motors. IE4 motors, which are even more efficient, are not considered in the scenario because of a lack of sufficient market and technological data.

(e) Consequently, the additional energy savings achievable by introducing the mandatory labelling scheme are determined by the diffusion of IE2 and IE3 motors. Of course, this does not mean that the introduction of a labelling scheme will automatically lead to an increase in the market share of IE2 or IE4 motors, but this approach makes it possible to calculate the maximum saving potential.

(f) Development over time is not considered in the analysis. The figures are based on electricity consumption in 2004. It should be noted that electric motors have an average lifetime of about 12 to 20 years, depending on their power rating and thus it can take 20 years for the motor stock to be completely replaced. Of course, also relatively new but less efficient motors can be replaced by more efficient ones, in many cases with an amortisation period of less than three years.

(g) The figures on the stock of electric motors (like full load hours and energy consumption) are taken from Almeida et al. (2001) because more recent figures are not available. As these figures were for the EU-15, they were adapted to the EU-25 by assuming that the motor share in electricity consumption is the same in the new as in the old member states.

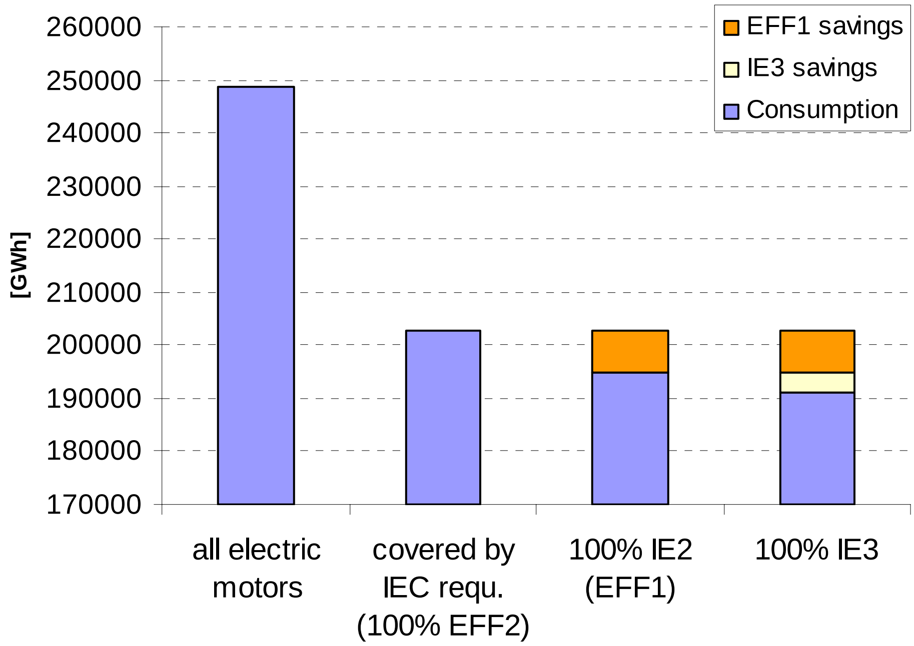
Figure 2.5: Resulting saving potential in industry (EU-25)



Source: own calculations based on (Almeida et al. 2001)

2.44 The resulting saving potentials for the industrial sector are shown in the above figure. Considering the assumptions made, saving potentials of 9548 GWh/a (for replacing all IE1 by IE2 motors) and 5532 GWh/a (replacing all IE2 by IE3 motors) were calculated. In total, the saving potential represents about 2.2% of industrial electricity consumption.

Figure 2.6: Resulting saving potential in the tertiary sector (EU-25)



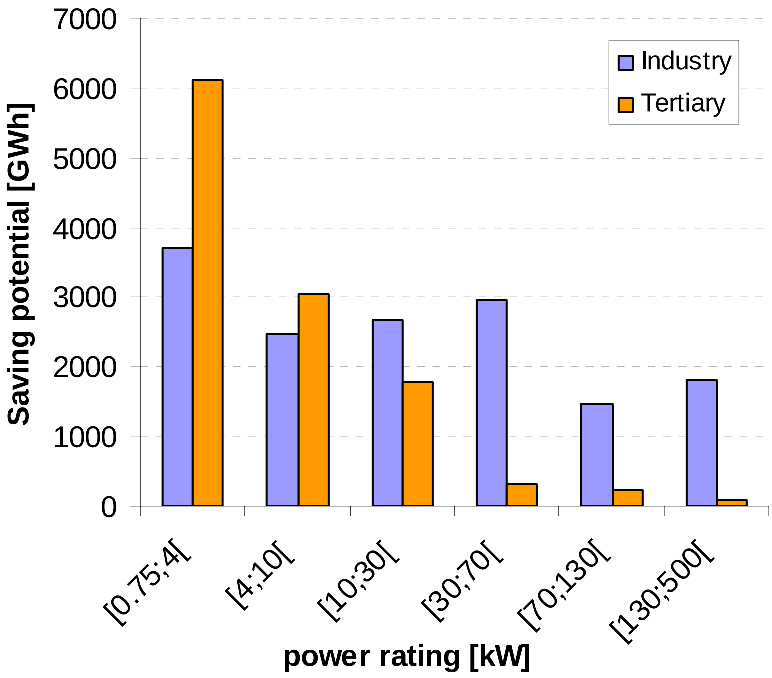
Source: own calculations based on (Almeida et al. 2001)

2.45 The saving potentials for the tertiary sector are given in the above figure. Here, saving potentials of 7859 GWh/a (for replacing all IE1 by IE2 motors) and 3654 GWh/a (replacing all IE2 by IE3 motors) were calculated. In this case the total potential represents about 4.6% of electricity consumption in the tertiary sector.

2.46 It is noticeable that the relative saving potential in the tertiary sector is double that of the potential in the industrial sector. The most obvious reason for this outcome is the higher share of motors in the tertiary sector which fulfil the labelling requirements. In industry, a high share of electricity is consumed by motors with a power rating above 370kW, which was chosen as the upper boundary of the labelling scheme.

2.47 When allocating the saving potentials to motor power classes, it can be observed that the bulk of saving potentials in the tertiary sector is in the lower power ranges (see figure below). This is due to two reasons. The higher share of electric motors in the lower power range (compared to industry) and the larger efficiency differences between the classes. While efficiency levels range from 93% to 95% for motors with 90kW, the range for motors with 1.1 kW is 75% to 83% (both cases from IE1 to IE3). Thus efficiency gains are much higher in lower power classes.

Figure 2.7: Saving potential for 100% IE3 motors distinguished by power class (EU-25)



Source: own calculations based on (Almeida et al. 2001)

2.48 The savings calculated should be interpreted as a theoretical maximum for the market transformation to IE3 motors (taking the restrictions given above into account), but this market transformation will not necessarily be achieved by a labelling scheme, even if the scheme is mandatory. It is most likely that only some of the motor buyers are influenced by the scheme to choose a more efficient product. It is even possible that the scheme has no influence at all, despite the existing saving potential.

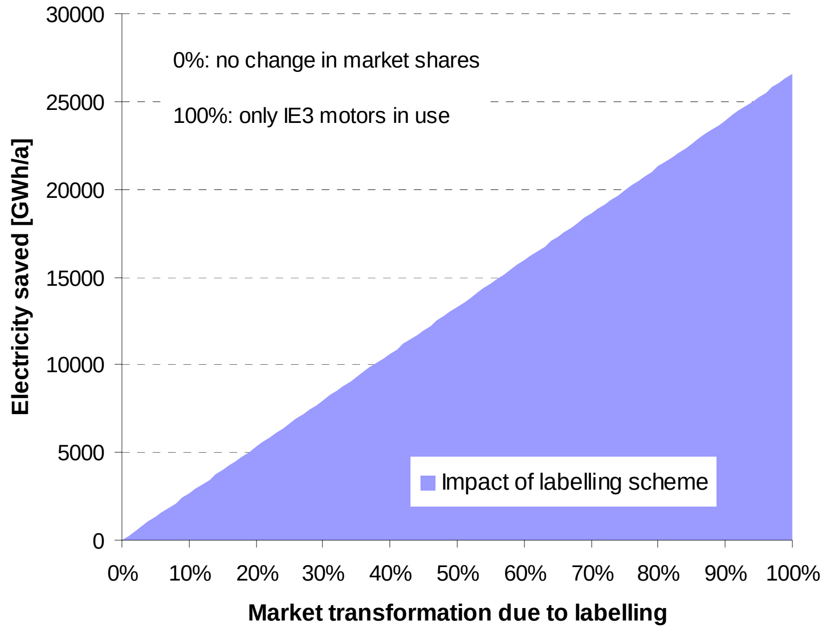
2.49 In the following two figures, the possible energy savings are shown depending on the degree of success of the labelling scheme in transforming the market towards premium efficiency motors (IE3). Two scenarios were assumed:

(a) In the first scenario only labelling is considered. The highest efficiency class is Premium efficiency (IE3).

(b) In the second scenario labelling is used in combination with MEPS on IE2. Thus, the savings achievable by labelling are determined by the success in increasing the use of IE3 motors instead of IE2 motors, which represent the minimum standard.

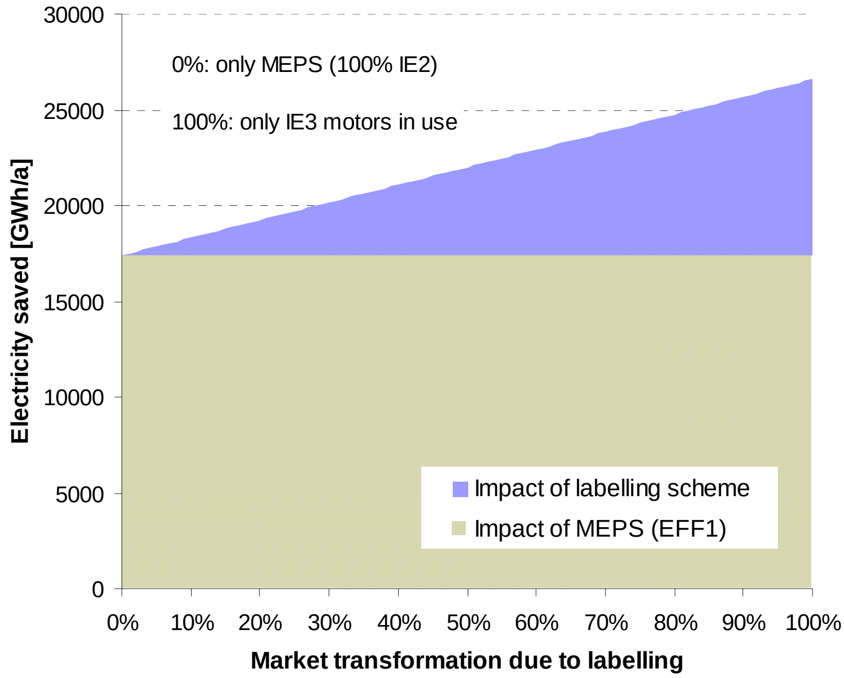
2.50 In the two figures, the percentage values on the x-axis represent the share of electric motors stock in which labelling was decisive for the choice of more efficient motors.

Figure 2.8: Share of theoretical savings achievable by a labelling scheme (Industry and tertiary sector)



Source: own calculations based on Almeida et al. (2001)

Figure 2.9: Share of theoretical savings achievable by a labelling scheme in combination with MEPS on IE2 (Industry and tertiary sector)



Source: own calculations based on Almeida et al. (2001)

2.51 It should be noted that the calculations and results are subject to simplifications and several restrictions concerning data availability. Thus, the figures should be taken as a first estimation of possible savings .

Comparison to with results of other studies

2.52 It shall be shown briefly how the results of our study can be interpreted especially in comparison to the EU-SAVE II study by Almeida et al. (2001). In detail, following aspects have to be considered:

(a) As the aim of our study is to calculate the impact of a labelling scheme we considered only the motor stock that would be covered by the scheme. Therefore we used assumptions on the design of the scheme. Two important restrictions are the inclusion of motors from 1.1 to 370 kW which are AC polyphase induction motors. These restrictions exclude approximately 30% of the motor stock from the impact assessment. In the above mentioned SAVE study, also motors above 370 kW were considered, resulting in a higher saving potential.

(b) The efficiency classes used for the calculations are diverting slightly. While we used the newly published IEC classes, in the SAVE study slightly higher values for the most efficient motors were used.

(c) In the SAVE study motor electricity consumption was forecasted for 2015 with 945 TWh for the EU-15. We calculated with a consumption of 931 TWh in 2004 for the EU-25

A monetary estimate

2.53 It is estimated that the price premium from IE1 to IE2 motors is about 20-30% and from IE2 to IE3 another 20-30% (de Almeida et al. 2007). As already mentioned, running costs make up the lion's share of the life cycle costs of electric motors. Thus it is generally acknowledged that in most cases energy-efficient motors have a payback period of less than three years, depending of course on their running time.

2.54 A more detailed analysis has been performed by Almeida et al. (de Almeida et al. 2007). They compared the life cycle costs of standard motors with premium efficient ones. They assumed four different scenarios on full load hours (2000, 4000, 6000 and 8000) and distinguished between three different motors in terms of rated power (1.1 kW, 11 kW and 110 kW). Some chosen results of the analysis are presented here:

(a) The share of electricity costs in total life cycle costs is calculated to range from 93.3% to 98.7% for standard motors with a power rating of 1.1 kW at 2000 load hours and 110 kW at 8000 load hours, respectively. For high efficiency motors these figures are some percentage points lower.

(b) The lifecycle costs of IE2 and premium efficiency motors were lower than they were for standard-motors (IE1) for all three power ratings and four load hour scenarios. For more detailed results, see Almeida et al. (de Almeida et al. 2007).

Interaction with other characteristics

2.55 Another point that has to be considered when analysing energy savings is the energy used to produce the motor (also called 'grey energy').

2.56 Copper is cited as one example for possible changes in material composition and their impacts on life cycle energy consumption. For example power losses can be minimized by increasing the amount of conductor material in the stator and the rotor (Emadi 2005 p.37). As this conductor material is normally copper, the production of high efficiency motors requires greater amount of copper than are needed for standard motors. Since the production of copper is itself energy-intensive, the life cycle assessment of high efficiency motors is negatively affected.

2.57 Almeida et al. (2007) calculated the environmental life cycle impacts of IE2 and IE3 motors compared to standard motors. They found that most impacts on the environment are lower for the IE2 and IE3 motors. The energy losses over the lifetime of IE3 motors are about 30 to 50 per cent lower compared to standard motors.

Conclusions

2.58 Concerning the CEMEP labelling, further savings cannot be expected because EFF3 motors have nearly vanished from the market and the progress of EFF1 motors is still slow. This is not expected to change in the near future as their price premium (approximately 15-25% compared to EFF2) is still too high.

2.59 The estimation of the impact of a labelling scheme is subject to many uncertainties that all depend on the level of compliance. It is theoretically conceivable that there is no compliance at all and thus that the labelling scheme has zero impact. The maximum electricity savings for two scenarios are calculated based on the recommendation of the IEC on efficiency classes. For both scenarios only the motors covered by the scheme were considered (1 to 370 kW):

(a) If the average efficiency of the European motor stock would shift from IE1 to IE2, this would lead to annual electricity savings in the range of 17407 GWh/a.

(b) A shift from IE2 to IE3 would further save 9186 GWh/a. These figures should be interpreted with care, keeping in mind the assumptions on the calculations given in the last chapter.

2.60 Some factors that influence the impact of labelling of electric motors are discussed in the following.

(a) The price premiums from IE1 to IE2 and from IE2 to IE3 motors are about 15-25 per cent but the life cycle costs of more efficient motors are still lower than those of standard motors.

(b) If consumers do not have information on motor efficiency, it is more difficult for them to consider running costs (i.e. life cycle costs) in their purchase decision.

(c) OEMs buy about 90 per cent of all electric motors sold. This fact could counteract the intended impact of a labelling scheme, as they have less interest in low running costs than end-users.

(d) Another aspect was raised in the interviews. From the manufacturer's point of view, ambitious motor labelling would be an incentive for R&D spending on efficient motors, since offering high efficiency motors in their product range is also a question of the company's image.

2.61 Concerning the question of whether the "motor only" or some kind of "motor system" could be labelled, the following aspects were found to be important:

(a) The labelling of the whole motor system from power supply to end-use is generally considered inappropriate as the systems are too heterogeneous.

(b) The labelling of some kind of core-motor system like a fan or a pump is considered to be more efficient, because here it would be possible to define homogeneous and comparable groups of products. The EuP studies could be taken as an initial basis.

(c) For the labelling of "motors only", internationally applicable efficiency classes and testing standards already exist (published by the IEC) as well as experience with the CEMEP labelling.

(d) Overall, it has to be kept in mind that potential energy savings are the highest if the entire motor system is involved. The savings achievable from improving motor efficiency alone are restricted by a theoretical maximum efficiency.

2.62 Another important aspect raised by the interviewees is international comparison.

(a) Most MEPS and labelling schemes worldwide are more ambitious than the European labelling scheme CEMEP.

(b) European manufacturers wishing to sell on international markets, for example in the US, have to fulfil strict regulations on MEPS, while the regulations for foreign companies on the European market are relatively low.

(c) European manufacturers cannot be competitive in the field of high efficiency motors (e.g. IE2 or IE3) with manufacturers from countries with higher MEPS because European manufacturers only produce high efficiency motors in comparatively small numbers and thus cannot realise cost reductions due to mass production.

(d) The differing standards and testing methods increase the transaction costs for manufacturers selling their motors in different countries.

2.63 The issue of MEPS is also important for the discussion of labelling. These are closely related to labelling which is often seen as the first step towards MEPS which are then easier to establish if efficiency classes and testing methods have already been established. In the US, for example, a MEPS is used in combination with the labelling of even more efficient motors.

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FfE Forschungsstelle für Energiewirtschaft e.V.

Case Study: Server

Project: "Labelling of Household Appliances"

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Auftraggeber:

FhG-ISI

Kontakt:
Am Blütenanger 71
80995 München
Tel.: +49 (0) 89 158121-0
Fax: +49 (0) 89 158121-10
E-Mail: info@ffe.de
Internet: www.ffe.de

Wissenschaftlicher Leiter:
Prof. Dr.-Ing. U. Wagner

Geschäftsführer:
Prof. Dr.-Ing. W. Mauch

Projekt-Manager:
Dipl.-Phys. R. Corradini

3 SERVERS

Starting point

3.1 The operation of servers and data processing centres is compulsory for the supply of data and online services. Due to the enormous growth in this field, the number of servers and respective energy consumption has increased. In addition to this, the specific electrical power consumption for each server has increased with the utilisation of powerful components. The need for servers, also in small and medium sized companies, and further upgrading of existing data processing centres will progress continuously in the future. A change in this development is not predictable; hence an increase in the number of servers and specific energy consumption has to be considered in the future. For thin-client networks, additional servers are often required which leads to further increase of server numbers in the event of the implementation of more thin-clients.

3.2 Contrary to other economic sectors, there is no or little public awareness for energy reduction or energy costs in the IT sector. The reason for this is that availability- and safety issues are more important than everything else and generated costs for data processing centres are rarely billed separately. Often, the IT related costs are accounted for the remaining building services.

3.3 Therefore, it might be reasonable to implement a labelling similar to the household appliances labelling. If, and which possible energy saving potentials thereby emerge, is identified in more detail in this study.

Current status EU-27

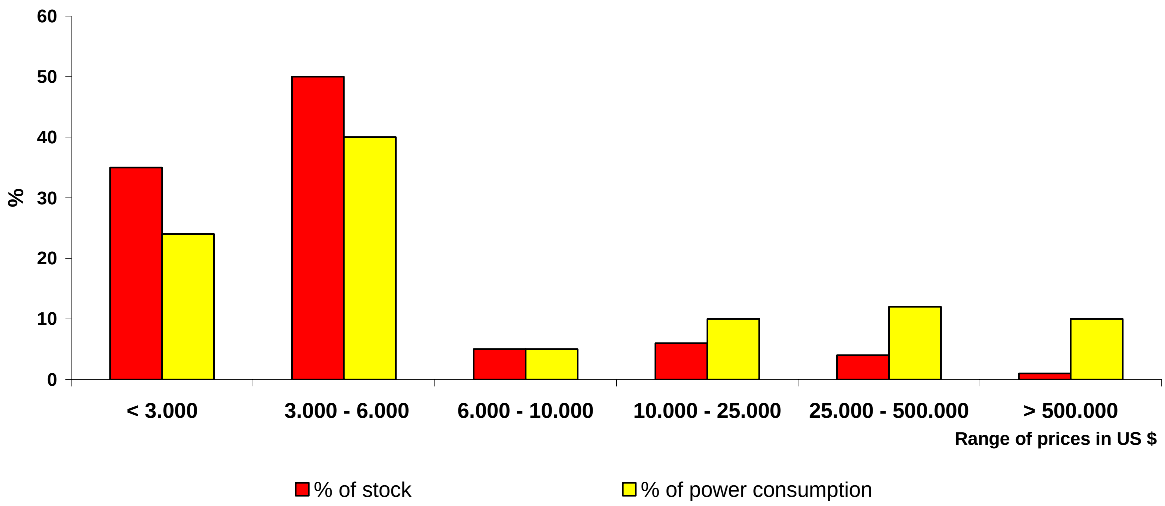
Stock figures

3.4 Due to differing hardware configurations, it is more appropriate to classify the stock of servers in the EU-27 according to purchase costs and to individual performance features. On the basis of the International Data Corporation (IDC) it is distinguished between Volume Server, Mid-range Server and High-end server /EES 07/. Volume servers are distinguished between further four subcategories because they have a great fraction of the overall stock (around 96 %). An estimate of the server stock figures, the energy consumption and the average power for the year 2006 is illustrated in Table 3.1. /EES 07/

Table 3.1: Estimation of server stocks, consumption and average power in EU-27 /EES 07/, /own calculations/

Designation	Price margin in US $	% of stock (estimated)	% of power consumption	Installed servers	estimated power consumption [TWh/a]	Average power [W]
Volume Servers	< 3.000	35	24	2.490.530	3,8	176
	3.000 - 6.000	50	40	3.557.900	6,4	205
	6.000 - 10.000	5	5	355.790	0,8	257
	10.000 - 25.000	6	10	426.948	1,6	428
Mid-range Servers	25.000 - 500.000	4	12	284.632	1,9	770
High end Servers	> 500.000	< 1	10	71.158	1,6	2.567

Figure 3.1: Relations between energy consumption and server stocks in EU-27



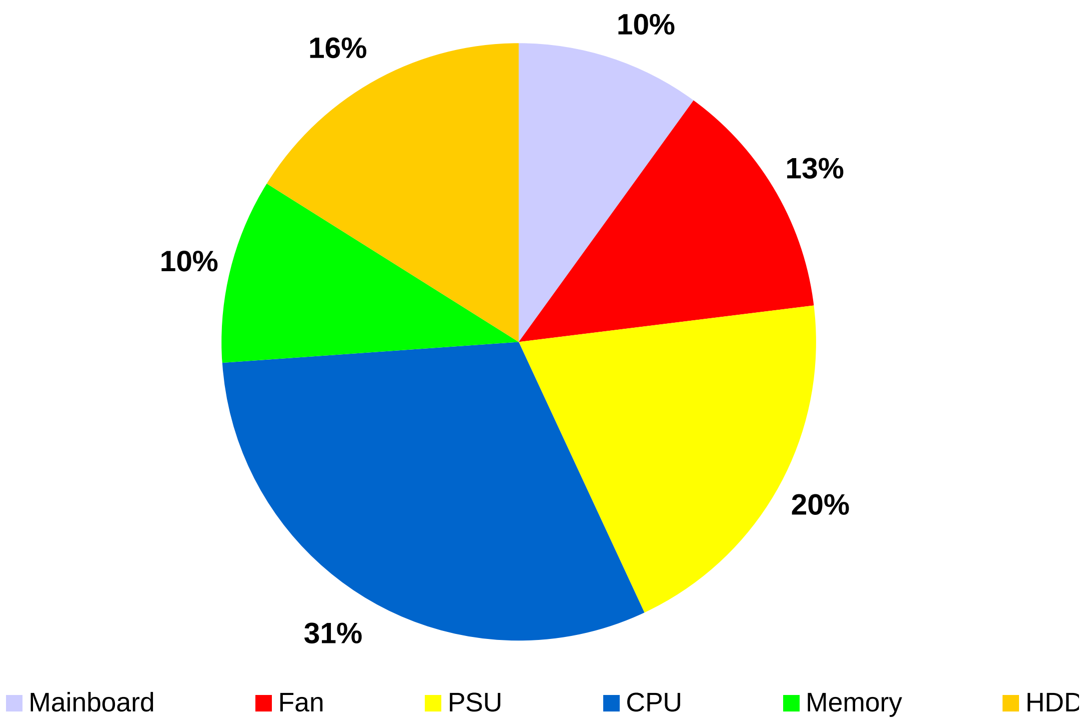
3.5 Figure 2-1 illustrates the coherences on a percentage basis between stock of server and energy consumption for every server classification.

3.6 Since the volume-server represent approximately 96 % of the server stock and cause around 80 % of the energy consumption, they exhibit the most interesting market segment in regard to labelling. In the following, this field is analysed in more detail. Many of the statements can be assigned qualitative to mid-range and high-end server.

Components

3.7 To measure quantifiable saving potentials in servers it is necessary to consider respective components separately at first. Since the utilisation of various servers vary strongly depending on task, demand and configuration, it is only possible to state approximate mean values which are listed in Figure 3.2. This distribution is covered with statements of leading manufacturers.

Figure 3.2: Energy consumption of a typical Volume Server /FSC 07/



Saving Potentials

3.8 Below, the essential components and possible saving potentials are described in more detail.

CPU (Central Processing Unit)

3.9 The CPU is the component with the highest energy demand. It consumes around 30 % of the overall energy demand. In the past, a power increase could only be achieved through clock speed and hence greater electricity consumption. In the past few years it became possible to enhance computing power and reduce the use for electrical power at the same time.

Multi Core CPU

3.10 Multi Core technologies with two or more processing cores ensure more arithmetic performance and run with slower clock speeds than conventional single core processors. Since the end of September 2007 quad core processors are available. Compared to dual core technology, they offer a computing power that is increased by 35 % while using 20 % less energy. Hence, the energy related specific computing power could be increased by around 60 %. The readiness for marketing of processors containing 8 cores is expected to happen in 2008. The specific energetic savings for this new technology are envisaged to be in the same range. Similar efficiency improvements could be achieved by multiplication of the cores, however, 16 cores or more require a modification of the instruction sets and architecture of the processors to reach that aim.

Power Management

3.11 Further energy savings are feasible by the utilisation of power management systems. They reduce the power consumption of processors when the demand is low. It is for instance possible to reduce the clock speed or parts of the processor can be switched off completely as for demand based switching. The possible energy savings are heavily dependent on the user profile of the server and the CPU respectively and amount to around 40 – 60 % of the CPU and 15-20% of the server energy demand respectively.

PSU (Power Supply Unit)

3.12 The energy efficiency of today's power supplies in server systems is heavily dependent on operating conditions. Most of the power supplies ensure an efficient operation only when running at full capacity. New power supply units with active power factor compensation operate with acceptable energy efficiency also when running at low capacity. The new power supply series of IBM for instance offers more than 80 % of efficiency at a system utilisation of 20 % and an efficiency of 90 % at a system utilisation between 40 % to 70 %. The expected energy savings in power supply units are likely to reach 50 %.

Cooling Fan

3.13 The re-designed active cooling fan by Hewlett Packard is one of the most promising to reduce cooling energy demand of servers. Contrary to the currently used fans, cooling air is injected into the server. This results in a positive pressure, which transports heat out over the slots in the server housing. Furthermore, there is the possibility to design the fan according to the thermal requirements of the processor. In addition, the active cooling fans with a smart control are able to cut electrical energy demand by 50 % in comparison to traditional cooling fans /ITB 06/.

Innovative Storage Devices

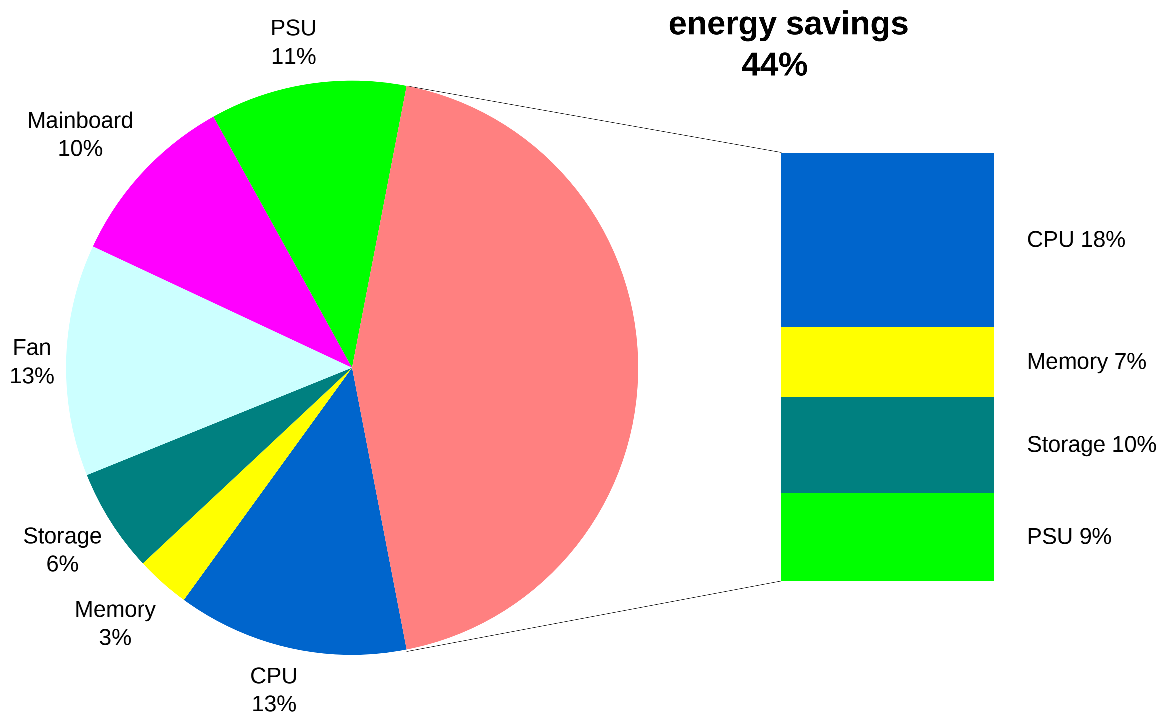
3.14 Actual hard drive disks with moving parts are generally used. Solid state drives are data storage devices without any moving parts. Solid state drives commonly comprise of either NAND flash or SDRAM. The energy consumption of SSD storage devices is about four times lower than conventional hard drive disks. Intel wants to apply SSDs for server applications from 2008 onwards. The main problems with SSDs at the moment are high purchase costs and the limited ability to rewrite them /SIL 07/.

3.15 Another technology is called Hybrid Devices which uses a big flash ram in addition to a standard HDD. So it is possible to reduce the writing frequency as well as the usage frequency of the rotation hard disk system. The energy saving possibility is less than SSD but reasonably /MCT 07/.

Effects of server labelling

3.16 Theoretically it would be possible to reduce the electrical consumption in server systems up to 40 % only by energy optimised components with the same arithmetic performance (interviews with leading manufactures). The highest energy saving potentials can be achieved by reducing the energy consumption of CPU, Storage and PSU. Figure 3-1 illustrates in confrontation the energy saving potentials of the particular server components, as well as the total energy savings for an optimized server in industrial fabrication. In the future, the technological development of the components will enable an increase of the performance per Watt by up to 50 % compared to today's commonly used systems. It is expedient to innovate a labelling for servers but it would have to be adjusted every one to two years. As yet, it cannot be declared which part of energy saving potentials could be reached without product labelling.

Figure 3.3: energy saving potentials of today's standard volume server /FSC 07/, /own calculations/



3.17 The highest saving potentials however exist in efficient improvement of data centres. As the contingent of physical servers is reduced to a minimum, the virtualisation of server systems are the most probable to significantly reduce energy consumption (outlook). Such arrangements however are based on software technical solutions and can not be influenced by classic product labelling.

Outlook

3.18 Apart from the components which influence the energy demand, the efficiency of a server is mainly dependent on its direct and indirect environment and utilisation. Considering also secondary energy consumptions such as air conditioning it is obvious that the system ‘data processing centre’ is often complex and influenced by many elements. The adjustment and dimensioning of the components is as important as their spatial distribution. By an optimised planning and adjustment of the periphery, there are often savings possible that are comparable with savings achievable through optimisation of server components. Here, the savings are partly even significantly higher.

Facts

- Server operate at only 5-10 % of their capacity
- Power consumption in stand-by modus is around 70 % of full capacity

Virtualisation/consolidation

- More virtual servers possible on one real server
  - Reduction of the number of servers
  - Better utilisation of the servers used
  - Reduction of the inefficient part load/stand-by
  - Demand-oriented switch-off of individual server corresponding to the load or time of day by automatic migration of virtual server during operation

Blade-server

- Electrical supply of all servers in the rack by joint mains adapter
  - Reduction of the necessary mains adapter
  - Demand-oriented switch-off of individual mains adapter corresponding to the load
  - Minimisation of inefficient part load of mains adapter

Air conditioning

- The energetic demand of air conditioning equals approximately the energy consumption of server
  - Doubling of energy demand of data processing centres

   - The efficiency of most of the air conditioning systems deteriorates quickly through pollution and other
   - Continuous maintenance for perpetuation
   - Optimisation of flow conditions/separation of warm and cold air in the server room
   - Every K of temperature rise of the conditioned air reduces the energy consumption by around 5 %
   - Increase of the temperature up to 26 °C is normally feasible
   - With optimal load and ventilation conditions, even 30 °C are feasible without putting a secure operation at risk
      - Power Capping
      - Dynamic Smart Cooling

Dynamic smart Cooling

- Air conditioning systems with variable temperature and mass flow required
- Measuring of rack- temperatures
- Adjustment of temperature and air flow to respective load

Water cooling

- Water cooling is several times more efficient than air cooling
- Downside: danger of leakage
- Remedy: direct cooling of processors by means of volatile coolants in a closed circuit
   - Efficient heat removal by local use of latent heat of the coolant (still under way)

Free cooling

- Reduction of the energy input for air conditioning by the use of adequate ambient air for cooling
- Air conditioning required only above a certain minimum temperature

Heat recovery

- During the heating period, the waste heat of the server can be used as room heat

- Reduction of the energy input for air conditioning
- Additional energy and cost savings for heating

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4 NON-ENERGY USING PRODUCTS

Introduction

4.1 This section considers the possibility of extending the Energy Labelling regime to those products that are non-energy using in nature, but contribute to a reduction of overall energy usage: so-called "non-energy using products". Examples of such products include double glazing, cavity wall insulation, more efficient vehicle tyres, metering devices, tank/pipe insulation and energy-saving paint. These products are, in a sense, static and will not contain complex microchips or other IT-style devices (which require energy). They may, however, use batteries in the case of metering devices.

4.2 If it quite plausible that if these products also came with an energy label similar to that of energy using products, consumers would be able to make a better informed decision and purchase those products that will have the largest impact on reducing their overall energy consumption, and thereby carbon emissions.

4.3 In this section we consider two examples of non-energy using products: double glazing for windows and tyres for vehicles. We discuss how the energy labelling regime might be extended to these products and what is already being done currently. The section has benefited from various stakeholder discussions we have had.

Double glazing and energy efficient windows

Background

4.4 Windows play a crucial role in a building's energy performance rating. In a sense they are a "weak link" in building's design offering less resistance to heat flows compared to walls, ceiling and floors. Despite comprising a relatively small surface area, windows are the area of greatest heat loss (and gain) and air leakage.

4.5 The potential energy savings available through the upgrade of window units has been researched extensively, for example in a THERMIE report titled "Major Energy Savings, Environmental and Employment Benefits by Double Glazing and Advanced Double-glazing technologies". It has been estimated that windows can account for as much as 30 per cent of a building's heat loss.[3]

4.6 The energy performance of a given window is measured by it ability to resist heat flow, know as its insulating value. This is defined by its R-value, or more commonly the U-value.[4] The methodology for U-value derivation is set out in the European Standard

[3] Quoted in Energy-Efficient Windows, Engineering Extension, January 2000

[4] In older French and German technical literature, the U-value is often referred to as the "coefficient k" or "k-wert".

EN673. The largest the U-value, the poorer the energy efficiency of the window, as it indicates more heat will flow through the window.

4.7 Within windows there are a number of different ways in which they are glazed. Glazing is defined as the glass panes in a window. Glazing can be done in a number of ways, and these are summarised below:

Table 4.1: Types and characteristics of window glazing

Type of glazing	**Remarks**	**Where found**
Window type		
Single clear glazing	While it allows for the greatest daylight transmission, the single glazed unit means that, compared to other window types, the heat loss in winter is the most and the heat gain in the summer is the most.	This is commonly found in domestic residencies.
Tinted glazing	Tinted glass is made by altering the chemical composition of glass with additives, primarily to reduce glare and solar heat.	These are normally found in commercial buildings.
Multiple-pane glazing	In the case of double-glazing, two layers of glass are separated by a spacer providing increased thermal resistance to heat loss and heat gain in summer. There is a slight visible loss in light transmission. One way of improving thermal performance is to fill the space between panes by either argon or krypton gas. Adding third and fourth panes is effective, albeit with diminishing returns.	These are found in domestic residences and commercial buildings.
Characteristics		
Low-emissivity (low-e) coatings	Low-e coatings refer to a microscopically thin, transparent layer of metal or metal oxide applied to the window glazing to reduce the transfer of heat, whilst allowing for undimmed transmission of sunlight.	
Thermally improved edge spacers	In multiple plane units, the glazing layers must be held apart by edge spaces, which in turn need to accommodate expansion/contraction of glazing layers due to seasonal variation. Historically, edge spacers were made from aluminium. However, given that aluminium is a good thermal conductor, this meant that much of the benefits of double glazing were eroded. More recently, stainless steel has been used to reduce conduction.	

4.8 The proportion of conventional double glazed windows has been steadily increasing in the EU15 Member States, and by 2001 represented nearly 50 per cent of total stock.[5]

[5] See Bauchot, "Energy, Environmental and Economic Benefits from Advanced Double Glazing in EU Dwellings", Glass Processing Days 18-21 June 2001

4.9 Currently, the European windows industry is heavily promoting low-e double glazing as a product to improve energy efficient and help the EU meet various international environment commitments.

4.10 The table below sets out the associated U-values for each type of glass (glazing) and window (which includes the glazing and frame).

Table 4.2: Thermal behaviour of different types of glazing

Window type		**U-value W/(m^2.K)**	**Balance U value W/(m^2.K)***
Single glazing	Glazing	5.7	3.4
	Window	4.7	3.1
Double glazing (air filled)	Glazing	2.9	0.8
	Window	2.7	1.3
Low-e double glazing (argon filled)	Glazing	1.2	-0.5
	Window	1.4	0.3

** based on EN ISO 14438 applied to moderate climate zone*

Reproduced from Energy & environmental B=benefits from advanced double glazing in EU buildings, GEPVP 2005

4.11 It should be noted that already contained in building regulations for windows, there are standards that need to be adhered to. Related to this is the take up of the EC Directive 2002/91/EC on the Energy Performance in Buildings. This has details of a standard methodology to be applied for calculating total energy performance of a building. This means that in the future it is unlikely that there will be specific requirements for individual elements of a building (i.e. windows) to be measured separately for their contribution to energy efficiency. The table below summarises building regulation details for windows in selected EU countries.[6]

[6] One should stress that building regulations are constantly changing in many Member States (for example the proposed requirement for all new UK homes to be zero carbon) and so the information listed in the table may not be accurate at the date of publication.

Table 4.3: Building regulations with respect to windows for new build homes (2005)

Member state(s)	**2005 standard practice**
Austria	Low-e double glazing with argon
Baltic States	Triple glazing or low-e double glazing
Belgium	Ordinary double glazing
Denmark	Low-e double glazing
Finland	Triple glazing
France	Low-e double glazing
Germany	Low-e double glazing with argon
Greece	Double glazing with a move to low-e
Italy	Ordinary double glazing
Luxembourg	Low-e double glazing
Netherlands	Low-e double glazing
Poland	Low-e double glazing
Portugal	Double glazing
Slovakia	Low-e double glazing
Spain	Double glazing
Sweden	Triple glazing
UK	Low-e glazing

Note: for Nordic countries, triple glazing often entails low-e with argon

4.12 It is perhaps not surprising that the northern European Member States have the low-e glazing as part of their standard practice.

Statistics

4.13 Within the EU, it is estimated that around 40 per cent of energy demand comes from the building sector.[7] At the level of EU25, the total amount of CO_2 emitted by buildings amounts to 765 million tonnes.[8]

4.14 The table below shows window areas it the existing house stock (2000) in EU15 Member States.

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[7] Source: GEPVP
[8] Ibid.

Table 4.4: Window areas in existing housing stock (2000)

Member state	Number of dwellings (million)	Window area per dwelling (metre squared)	Window area (million square metres)		
			Single glazed	Double glazed	Low-e double glazed
Austria	3.60	20.00	-	26.00	46.00
Belgium	3.90	23.00	41.10	43.50	4.40
Denmark	2.60	13.30	0.13	29.13	5.30
Finland	2.40	10.00	-	9.00	15.00
France	27.50	14.20	170.40	213.00	7.10
Germany	35.60	21.60	207.40	429.80	130.70
Greece	3.00	15.00	42.00	3.00	-
Ireland	1.25	18.00	14.04	8.10	0.35
Italy	27.30	15.00	306.00	97.50	6.00
Luxembourg	0.22	22.50	2.00	2.50	0.43
Netherlands	6.55	21.00	59.40	66.40	11.60
Portugal	4.60	11.70	47.97	5.85	-
Spain	20.00	15.00	247.50	51.75	0.75
Sweden	4.20	15.00	-	44.10	18.90
UK	25.30	18.00	165.60	277.20	12.60
Total			**1,303.54**	**1,306.83**	**259.13**

Source: GEPVP

4.15 It should be recalled that while non-energy using products such as double glazing can play a part in improving energy efficiency, their initial manufacture does release C02 into the atmosphere. For example, the manufacturing of one square metre of low-e double glazing leads to the release of 25kg of CO_2 into the atmosphere. However, this is offset by the fact, that on average, the CO_2 per year saved from low-e double glazing is calculated at 91kg (or 25 kg for industrial/commercial users).[9]

4.16 However, one must note to achieve such savings the windows must be replaced. The issue here is that, typically, consumers do not replace windows regularly and are not easily induced to do so. A study by Caleb Management Services for EuroAce noted the following replacement rates for windows.[10]

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9 Ibid and EuroAce.

10 Assessment of potential for the saving of carbon dioxide emissions in European Building stock, 1998 for EuroAce

Table 4.5: Window replacement rates for selected EU Member States

Member State	Years to full replacement
Belgium	20
France	32
Germany (former FRG)	20
Italy	100
Spain	60
Netherlands	20
UK	30

Source: EuroAce

4.17 As the above table shows, the differences in average replacement rates differ significantly across different Member States. This suggests that unless there is an accelerated programme of replacement, any energy labelling scheme for windows would take a long time to show its effects across the EU.

Examples of energy labelling in windows

4.18 The concept of energy labelling for windows is not a new one. Window energy rating schemes are currently in operation outside the EU in the USA, Canada, Australia and New Zealand. Within the EU, there are a number examples of energy labelling schemes that have been piloted, or are now in practice, which we will now discuss.

The UK

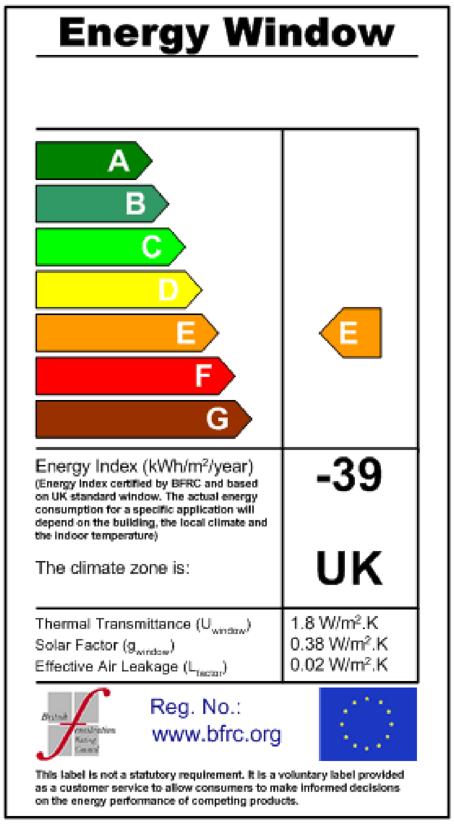
4.19 The "golden age" of double glazing in the UK was during the 1970s. This was the era of the ubiquitous double glazing salesman and most new windows were sold via this method. During the 1980s, the main selling point for double glazed windows was their security aspects, before the 1990s and onwards which refocused selling efforts on energy reduction potentials.

4.20 A voluntary energy rating label now exists in the UK for windows. The label grew out of research project initiated by the British Fenestration Rating Council (BFRC). Energy ratings for all windows (including double glazing) were first launched in the UK in March 2004 by the BFRC. Initially, 115 window units were rated, and at the time of writing this figure had grown to 450 window units with over 90 participating companies.

4.21 The rating system is not dissimilar to the wider energy labelling system. A window's energy rating is determined by a formula which accounts for its total solar heat transmittance, its U-value, and air infiltration. The result of the formula is then placed along a range from A-G. The label refers to the entire window, not just the glass. However the label does not take account of how the window is installed and this may cause the window to be less energy saving in practice than in theory.

4.22 An example of a label is shown below:

Figure 4.1: Window rating label in the UK



4.23 As the label notes, this is not a statutory requirement. It is intended to help builders and consumers make informed decisions about window purchases and assist them in product comparisons.

4.24 It should be noted that the label only refers to replacement windows, which is by far the largest segment of the windows' market.[11]

4.25 Under the 2002 Building Regulations (Part L) for new domestic houses, windows were categorised as a "controlled element" with stipulated minimum U-values. The updated 2006 Building Regulations further set out standards for whole houses and individual components. The SAP rating is used, as detailed in Part L of the Building Regulations. We have been informed that at as long as windows met grade E standards they will pass for the overall house. However, for some show-houses higher grade windows are used as promotional tools. As the UK moves to zero carbon new homes it is inevitable that

[11] The size of this market was reported to be largely static with only a minor decline in recent years.

windows will be examined by developers to see if they can contribute to targets — it will be their cost which determines whether or not they are chosen.

4.26 The BFRC energy labelling scheme for windows has now also become recognised by the Department for Environment, Food and Rural Affairs as part of the wider Energy Efficient Commitment scheme (EEC).[12] Windows with an energy label grade of C or better can now be included under EEC. Further the UK Energy Saving Trust has endorsed band C or above windows as being able to display their "Energy Efficiency Recommended" logo (EER).

4.27 The BFRC reports that due to the association of the EER logo with band C, most manufacturers are initially aiming to produce C-rated windows. It should be noted that D-rated windows are still above the minimum level for regulatory compliance. In terms of operating costs, there is said to be only a slight cost differential between grade C and D windows — but one should note there are differing developmental and capital costs. There is still said to be a large step up in costs from grade C to B.

4.28 Only a limited number of manufacturers have achieved the A-rating for their windows and these products remain a very high-cost solution and command large premiums. Indeed, we have been informed that using triple glazing to achieve an A-grade has a number of negative externalities such as health and safety concerns when opening and closing.

4.29 However, one should be careful not to overestimate the extent of the labelling regime. While it is true that most windows marketed are grade C or below, this only refers to those windows that have labels. A large proportion of the windows market remains unlabelled.

4.30 In the UK, testing of windows is carried out by independent agencies on behalf of the BFRC. Testing is carried out either physically (hotbox) or, more commonly, via a computer simulation whereby manufacturers give their designs to a modeller who simulates conditions to derive a rating.

4.31 Visit checks can also include checking machinery, contracts with suppliers and control systems. These are done annually. Some re-visits have occurred, but at the time of writing the BFRC has only stripped one manufacturer of its energy label rating.

4.32 While it is still in its initial stages, within the UK, energy labelling for consumers is said to be yielding positive results. It was argued that consumers are becoming savvier when making window purchase decisions, with energy efficiency being a real decision factor.

[12] EEC is an obligation placed on electricity and gas supply companies to achieve energy savings in households. Companies are given targets to meet and thereby must assist customers to install energy saving measures through various mechanisms, such as subsidies.

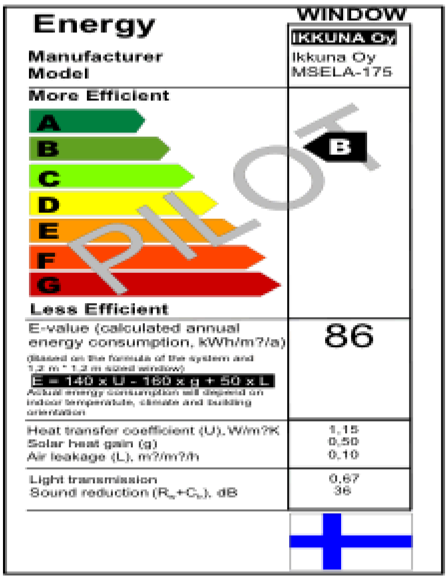
Evidence was citied which suggested consumers have a higher willingness to pay for more efficient windows.

Finland

4.33 In article by Hemmilä, it is noted that a pilot window energy rating (label) scheme took place in Finland between 2002 and 2004.[13] The rationale for having a rating scheme was simple: it was argued that while the existing building regulations did already set maximum U-values for windows, non-professional buyers did not understand the link between the U-value and energy consumption and so were only basing their purchase decision on price.

4.34 Accordingly, an energy label (similar to that used in the UK) was devised. An example is shown below:

Figure 4.2: Pilot window rating label in Finland



4.35 The pilot was carried out with eight window manufacturers producing 200 window types. The eight manufacturers were said to represent between 70 and 80 per cent of the total Finnish window market.

4.36 The experiences of the pilot were generally positive. Even when the relationship between U-value and energy efficiency was explained to them, buyers expressed a preference for the energy label. In order to avoid manufacturers creating their own labels and rating

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13 Hemmilä, K "Experiences of Piloting Window Energy Rating System in Finland", Glass Processing Days 2005

system, it was recommended that the labels should be produced by a third party rating organisation (as in the case of the UK).

4.37 The article by Hemmilä concludes that it is too early to tell if an energy rating label for windows will truly transform the market towards energy efficient windows. However, the Finnish experience suggests that having a label on windows, similar to other products, can be an effective marketing tool to encourage the purchase of more energy efficient non-energy using products.

Denmark

4.38 A survey carried out in Denmark in 2001 noted that less than 20 per cent of consumers chose energy-efficient windows when refurbishing their windows.[14] While for new dwellings, building regulations did outline standards to be met, there were no such standards for existing dwellings. In response, a campaign called "Project Window" was initiated to promote more efficient window purchases.

4.39 As part of Project Window, the government made it possible to obtain subsidies to encourage the development and take-up of energy efficient glass in the domestic and public sector.

4.40 The Centre for Building Components at the Danish Technological Institute is the body responsible for setting labels for windows and glazing. The label is similar to that used in Finland and the UK, although the definition of bands differs in places.

Table 4.6: Energy Sheet for windows and panes in Denmark

Label	Description
A, B and C	A, B and C panes are ranked as energy efficient panes and are provided with an energy label. A, B and C panes supply heat energy to houses: that means more solar energy flowing in through the pane than heating escaping out through the pane, measured over a heating season.
D, E, F and G	D, E, F and G panes are not ranked as energy efficient panes. As a guide, G is equivalent to single glazing, and an F pane is equivalent to standard double glazing.

Source: Danish Energy Agency (reproduced in Lorentze)

4.41 Further campaigns have taken place in Denmark to encourage the take up of more efficient window types, such as low-e coatings.

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14 Quoted in Lorentze, C "New Danish Glass Descriptive Code: Energy Labelling", Glass Processing Days, June 2001

Impact of energy labelling in windows

4.42 We have not carried out any detailed analysis of our own to examine the possible impacts of extending the energy labelling scheme to windows. Rather, in this section we discuss some existing publications which have considered the issues. We note, that in general, very little independent recent research has been carried out examining the isolated impact of energy labelling for windows and the effect this might have economically, socially and environmentally.

4.43 The European Association of Flat Glass Manufacturers (GEPVP) have shown the benefits of replacing single and double glazed windows with double glazed low-e double glazed windows for EU15 Member States. One might argue that such a scenario might occur under a system of energy labelling whereby consumers decide to choose the higher band windows beyond band C. In such a scenario, the GEPVP note the following benefits in terms of energy delivered, carbon and monetary savings.

Table 4.7: Benefits of upgrading all EU windows to low-e double glazing for EU15 on thermal insulation

	Annual savings over single glazed windows			Annual savings over double glazed windows		
Member State	**MGJ**	**M€**	**Mtonnes CO_2**	**MGJ**	**M€**	**Mtonnes CO_2**
Austria				9.39	129.47	0.69
Belgium	27.81	270.93	2.09	10.44	101.75	0.79
Denmark	0.12	2.87	0.01	9.68	228.19	0.69
Finland				3.69	39.22	0.33
France	118.19	1,675.92	9.66	52.42	743.35	4.29
Germany	175.21	1,795.40	11.75	128.84	1,320.23	8.64
Greece	19.20	314.92	1.60	0.49	7.98	0.04
Ireland	10.01	69.33	0.87	2.05	19.72	0.18
Italy	150.43	3,100.27	10.31	17.01	350.53	1.17
Luxembourg	1.29	10.90	0.10	0.57	4.84	0.04
Netherlands	37.73	361.57	2.14	14.96	143.42	0.85
Portugal	19.08	343.93	1.99	0.83	14.88	0.09
Spain	104.39	1,508.26	9.74	7.75	111.90	0.72
Sweden				15.25	237.66	1.68
UK	111.55	834.03	7.51	66.26	495.39	4.46
Total	**775.00**	**10,315.43**	**57.77**	**339.62**	**3,948.54**	**24.63**

Source: GEPVP

4.44 The above figures relate to energy demand remaining static — if energy consumption were to increase, then the benefits would be less.

4.45 One would think that the benefits would be even greater with the inclusion of the additional 12 Member States of the EU.

4.46 Of course the above assumption relies on the assumption that all new windows are of the most energy efficient variant (low-e double glazing) which would be the top end of an energy labelling system. In reality, due to financial constraints, consumers may not always purchase the most efficient band A window, instead choose only band C — this will obviously reduce the above benefits.

4.47 As noted in the statistics section, even when accounting for emissions generated during production of the window, there remains a net benefit of the product.

4.48 The table below summarises qualitatively the expect benefits and costs of the energy labelling scheme, if applied to windows. Obviously, before any harmonised pan-European scheme comes into effect a much more rigorous impact assessment would need to be carried out.

Table 4.8: Costs and benefits of extending energy labelling scheme to windows

Cost	Benefit
Cost of implementation, enforcement and monitoring	Reduction in carbon emissions due to reduced energy consumption*
Possible reduction of choice for consumers as manufacturers only focus on most energy efficient (costly) windows	Net monetary gain to consumer
Cost of developing pan-European standard	Encourage innovation in developing new types of windows

** assuming consumers do not react to lower energy bills by increasing their energy consumption to pre-energy label levels.*

4.49 We would not expect there to be a significant employment effects as the industry size would not change as a result of labelling — only the produce would.

Viability

4.50 When asked, all stakeholders commented favourably about extending an energy labelling regime across the EU. It was noted that while the framework could be extended, the grades themselves would differ from country to country. This is because, for example, northern European countries seek windows which gain heat (and reduce the need for heating), which is the opposite of the requirements (low solar gain) of southern European countries. Further, local building traditions, e.g. shutters, also need to be taken in to account. Energy labelling would need to be regional (either within countries or cross-border).

4.51 However, it was noted that at present, the move towards more energy efficient windows and correspondingly energy labelling is largely supply and policy driven. There is little direct consumer pressure for more energy efficient windows. However, the motivation for manufacturers is to have a unique selling point to gain competitive advantage over their competitors.

4.52 For this reason, it was suggested by one stakeholder that tax breaks might also be worthwhile in encouraging take up of higher rated windows (e.g. grade C or above).

4.53 Given that most manufacturing of windows' major components (i.e. glass) is done locally, stakeholders did not identify there to be any internal market issues with a common energy labelling framework.

4.54 In terms of future proofing, stakeholders admitted that short of constant revisions, this is not an easy task. However, it was estimated that collectively the EU is at least 15 years away from a situation when most windows are at least a C grade — the inference being that future proofing is not an immediate concern.

4.55 Other points raised included the fact that energy labelling cannot work in isolation from how the windows are installed. Incorrect installation or sub-standard installation components may lower the energy efficiency properties of the windows. Further, the energy labelling scheme would only apply to domestic windows — a similar scheme would be required for public and commercial buildings.

Conclusions

4.56 In this section we have reviewed the elements of the EU windows market and examined the potential impacts of extending the existing energy labelling scheme to the windows market. Our concluding points are as follows:

(a) While double glazing and low-e double glazing are becoming more commonplace, there still exists huge scope for these non-energy using products given the area of window glass in the EU;

(b) Individual EU Member State already have minimum standards for windows contained in their building regulations for new build and, in some cases, existing dwellings.

(c) Some individual EU Member States already have voluntary energy labels for windows.

(d) Further research is required to conclusively determine whether the benefits of extending the scheme would outweigh the cost, although initial analyses suggest they would.

(e) Respondents all agreed that a common energy labelling framework is feasible and desirable in the EU.

Energy Efficient Tyres

Background

4.57 The US National Research Council estimates that at least 80 per cent of the fuel energy that goes into cars and trucks is used to overcome frictional, thermal and other losses.

4.58 Roughly a quarter of these losses are due to rolling resistance, i.e. the resistance that occurs when an object rolls.

4.59 According to a study undertaken by the French tyre manufacturer Michelin[15] 90 per cent of the rolling resistance is caused by the deformation of the tyre or the deformation of the ground while a tyre is rolling. The deformation causes the tyre to heat up and therefore a net energy loss due to increased temperature. This loss is usually referred to as hysteresis loss in the technical literature.

4.60 There are two other factors that influence rolling resistance: aerodynamic drag and microslippage. Aerodynamic drag is caused by the fact that, by rolling, a tyre creates friction with the air while microslippage refers to frictional forces between the tyres and the wheel rim. Aerodynamic drag accounts for up to 15 per cent of rolling resistance (depending on tyre size and speed) while microslippage for less than 5 per cent.

4.61 Mathematically the force of rolling resistance (*F*) is given by $F = C \cdot N$ where *N* is the normal force (the mass of the vehicle multiplied by gravity acceleration and divided by the number of wheels) and *C* is the coefficient of rolling resistance.

4.62 Tyre manufacturers sometimes publish details on the coefficient of rolling resistance associated with the tyres they produce.

4.63 Since only one of the three components (and not the major one) of rolling resistance depends on speed, it is reasonable to assume that rolling resistance does not depend on speed, therefore the coefficient of rolling resistance is always reported as independent of speed.[16]

4.64 There are many factors that affect the coefficient of rolling resistance among which there are:

(a) Material of the tyre: tyres with higher sulphur content tend to have lower rolling resistance

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[15] Michelin, The Tyre: Rolling resistance and Fuel Savings, Clemont Ferrand, 2003

[16] However at high speeds (> 130 Km/h) rolling resistance and speed are inversely related.

(b) Dimensions: larger tyres have less flex in sidewalls and lower rolling resistance

(c) Tyre pressure: low pressure in tyres results in more flexing of sidewalls and higher rolling friction. On the other hand over-inflating tyres does not lower rolling resistance as they may skip and hop over the road surface.

(d) Size: smaller tyres have, ceteris paribus, higher rolling resistance than larger tyres.

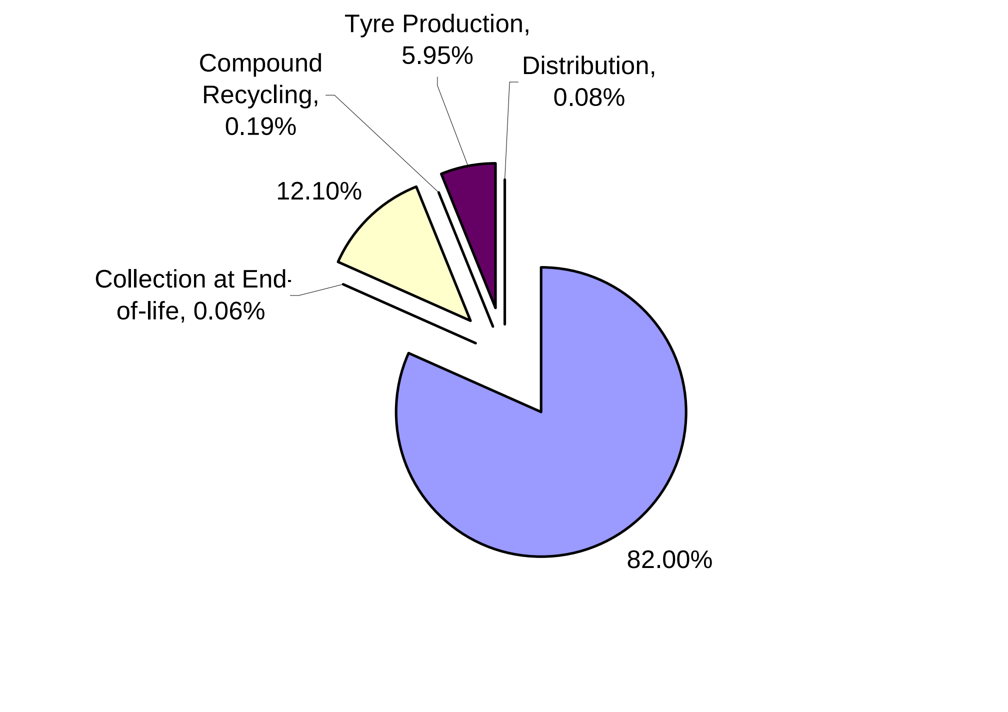
4.65 Clearly, the more resistance an engine is required to overcome, the larger the amount of fuel it will use to move the car. Therefore although the tyre itself does not directly use energy, after the completion of the manufacturing process, it has a potentially large impact on fuel consumption and can therefore contribute to energy efficiency.

4.66 In addition an analysis conducted by the Italian tyre manufacturer Pirelli revealed that fuel consumption is by far the largest contribution to the overall energy impact of tyres.[17] As can be seen in Figure 3.3 82 per cent of the total energy consumption of tyres is attributable to fuel consumption.

4.67 It seems therefore reasonable to focus on fuel efficiency to reduce the energy consumption of tyres.

[17] Reported in Green Seal's, Choose Green Report:, Low Rolling Resistance Tyres, March 2003

Figure 4.3: Distribution of Tyre Energy Consumption



Source: Pirelli SpA

4.68 Given the size of the market, for both tyres attached to newly produced vehicles and the replacement for old tyres, the potential energy savings stemming from the adoption of low rolling resistance tyres is considerably large.

4.69 Within the industry the terms low rolling resistance tyre and energy efficient tyre are used almost interchangeably and so are used within this report.

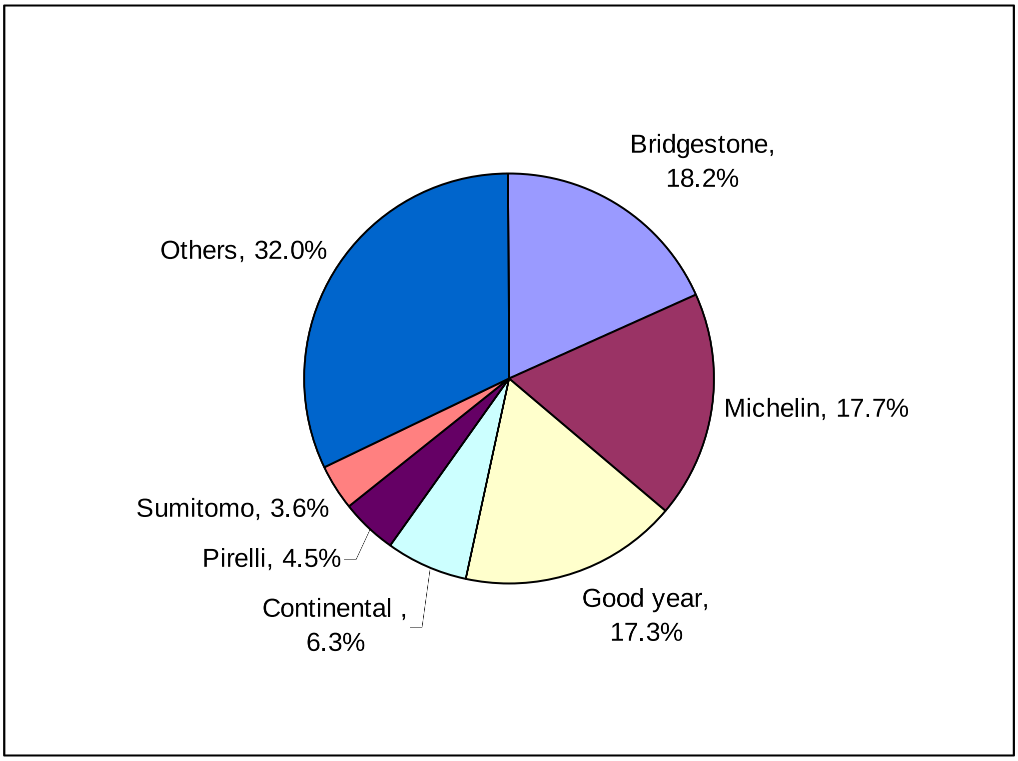
The tyres market

4.70 Specific disaggregated data on the tyre market in Europe are not currently available. The Eurostat website reports some aggregated data on production, import and export of tyres but, for many countries does not report the data because of confidentiality reasons.

4.71 As we will see in this section the international tyre market is dominated by very few players and reporting precise data on production would often imply the disclosure of information that is confidential for these companies.

4.72 For our purposes, we were therefore forced to rely on alternative sources such as, annual reports of manufacturing companies and data published in other reports.

Figure 4.4: Global Market Shares of Tyre Manufacturers



Source: Tire Business

4.73 Figure 3.4 reports the global market shares of the major tyre manufacturers. The share of the three major producers is 53.2 per cent. The picture is different on the European market. As shown in Table 3.9 Michelin sell nearly half of their production in Europe, the share is even higher for Continental and Pirelli, while North American and Japanese manufacturers are, not surprisingly, more focused on their own domestic markets.

Table 4.9: European Sales as a Share of Total Sales by Company in 2006

Manufacturer	Share
Michelin	49 %
Bridgestone	17 %
Good Year	30 %
Continental	67 %
Pirelli	54 %
Sumitomo	8 %

Source: Michelin Factbook 2007

4.74 The high degree of concentration in the tyre market implies that it could be easy to introduce a labelling scheme effectively as only a limited number of producers would be required to adapt to the new requirements.

4.75 The tyre market is usually divided into two separate segments: original equipment (OE) and replacement. In the USA the type of tyres found on these two segments is remarkably different, while in the EU the same tyres are found on both segments of the market.

4.76 The Corporate Average Fuel Economy (CAFE) standards require the vehicle fleet produced by each car manufacturer in the US to meet minimum miles-per-gallon ratings. In order to meet these requirements manufacturers usually equip their cars with low rolling resistance tyres. However once the vehicle is sold it is not subject to the fleet standards anymore and therefore it is up to the vehicle owner to choose the replacement tyres once the original ones deplete.

4.77 The demand in the two markets is thus different: low rolling resistance tyres are much more demanded in the OE market. American consumers focus on other characteristic of the tyre such as handling and traction and are probably unaware of the possible savings obtainable with low rolling resistance tyres.

4.78 In the EU there is no big difference between the type of tyres found in the OE and replacement market as consumer tend to replace the tyres of their vehicles with the same model or brand.

4.79 Regarding the impact of cars and motorcycles on pollution and emission the European Commission estimated that, in 2005, their consumption in the EU was around 170 Mtoe (Million Tons of Oil Equivalent). This figure represents almost 10 per cent of total energy consumption.[18] Average fuel consumption per vehicle has decreased over the last years but trends that see heavier and higher performance cars entering the market, accompanied by an increase in car usage and in car numbers imply that total demand may well increase in the future.

4.80 Although increasing the penetration of low rolling resistance tyres in the US market would have larger global effects given the different nature of the replacement market, it is likely that the effects would be significant even in the EU.

Low rolling resistance tyres performance

Energy savings

4.81 A number of analyses have been carried out, mainly by tyre manufacturers to estimate the reduction in fuel consumption achievable through the use of low rolling resistance tyres.

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[18] See European Commission, Doing More with Less, Green Paper on Energy Efficiency, 2005

4.82 A notable exception in the sense that the analysis has been conducted by a governmental institution rather than by a party involved in the market is represented by the Department for Transport (DfT) in the UK. In 2006 the DfT published a leaflet entitled *Save Fuel with Lower Rolling Resistance Tyres*, which summarises the results of track tests that it has carried out to estimate the reduction in fuel consumption due to the utilisation of energy efficiency tyres in trucks.

4.83 Three different trials were performed:

(a) In the first trial two identical Volvo FH12 tractor units were coupled to two identical tri-axle semi-trailers and both vehicles were loaded to 37.7 Tonnes GTW. The two vehicles were then driven at 50 mph (80.5 Km/h) four one hour with standard tyres and then with energy efficient tyres. Fuel consumption improved by 7.6 per cent and 5.2 per cent respectively in the two vehicles.

(b) In the second trial two identical Volvo FL320 tractor units were coupled to two identical tri-axle curtain-sided semi-trailers and both vehicles were loaded to 38 Tonnes GTW. The two vehicles were then driven for 15 laps around the track (five laps at 37 mph (60 Km/h) five laps at 50 mph (80.5 Km/h) and five laps at 56mph (90 Km/h)) both with standard tyres and then with energy efficient tyres. Fuel consumption improved by 7 per cent and 7.2 per cent respectively in the two vehicles.

(c) In the third trial an artic comprising a Volvo FM320 tractor unit coupled to a tri-axle box van was loaded to 38 Tonnes GTW. The vehicle was then driven for 15 laps around the track (again five laps at 37 mph (60 Km/h) five laps at 50 mph (80.5 Km/h) and five laps at 56mph (90 Km/h)) both with standard tyres and then with energy efficient tyres. Fuel consumption improved by 8 per cent with energy efficient tyres.

4.84 These figures are in line, if not slightly higher than many of the savings that the manufacturers themselves claim. For instance, Michelin claimed in 2003 that energy saving represent 3.2 per cent for the urban cycle and 5.1 per cent for driving on major and minor roads.[19]

4.85 The difference between the Dft and Michelin's estimates is due to mainly two reasons: further technological advances since 2003 and extrapolation from track to normal road conditions.

4.86 An issue that emerged as crucial in our study is the interaction between fuel efficiency and tyre pressure. A vehicle with tyres that are properly inflated exhibits lower consumption than a vehicle with over- or under-inflated tyres.

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[19] Michelin, The Tyre: Rolling resistance and Fuel Savings, Clemont Ferrand, 2003

4.87 The Rubber Manufacturers Associations claims that a 1 psi decrease from optimal pressure can cause a 1.1 per cent in rolling resistance and that under-inflation of tyres in cars and trucks in the U.S. leads to a decrease in fuel efficiency of 1 per cent.[20]

4.88 Along the same lines, in a presentation for a Workshop held at the International Energy Agency a Michelin representative claimed that tyres are under-inflated by 0.2 to 0.4 bar on average for private cars and 0.5 bar for commercial vehicles, leading to an increase in fuel consumption of 1 to 2.5 per cent in private cars and 1 per cent in commercial vehicles.[21]

4.89 An appropriate tyre pressure is also important because efficient tyres reach their full saving potential only if they are properly inflated. Therefore failing to do so could undermine the positive effects of the adoption of low rolling resistance tyres.

4.90 For instance, the Italian specialist magazine Quattroruote published in August 2006 the results of a test it conducted on the Variano circuit where fuel consumption was measured using a car with properly inflated tyres and then the same car with tyres at the wrong pressure. Depending on how deflated the tyres were, fuel consumption could be as much as 15 per cent higher.

A monetary estimate

4.91 On their website Michelin published a simple calculator that estimates the savings obtainable by switching to a low rolling resistance set of tyres.[22] To estimate the potential savings the user is required to input the number of kilometres covered in one year and the average fuel consumption.

4.92 Based on a vehicle that covers 10.000 Kilometres in one year, with an average consumption of 13 Km per litre and assuming an average price per litre of fuel of 1€ and a fuel consumption performance improved by 5.0 per cent the use of energy efficient tyres would imply a net saving for the user of roughly 38 € per year.

4.93 It is important to bear in mind that this figure refers to private savings. Taxes are a major component of the price of fuels and therefore the social benefits would be overestimated by the above figure.

4.94 On the other hand the reduction in fuel consumption would also imply a reduction of CO_2 emissions (roughly 96 Kg per year in the above example) which would not be captured by the price of fuel.

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[20] See California Energy Commission, California State Fuel-Efficient Tire Report: Volume II, January 2003
[21] Pennant, C. The Challenge of Energy Efficient Tyres, available at http://www.iea.org/Textbase/work/2005/EnerEffTyre/Penant.pdf
[22] See http://www.michelin.co.uk/uk/front/affich.jsp?codeRubrique=23092004102701

Potential savings

4.95 We have calculated the potential savings of the use of low rolling resistance tyres in the EU25 using the projections contained in the PRIMES dataset and performing a similar calculation to that contained in the Michelin model described above.

4.96 The PRIMES dataset reports five-yearly projections on transport activity by mode up to 2030. We have interpolated these projections to obtain an annual figure. We have only considered travel by private cars, excluding public means of transport and motorcycles.

4.97 In addition, since transport activities in PRIMES are measured in passenger kilometres (pkm), to avoid double counting, we assumed that, on average, there are 1.2 passengers in a car.

4.98 We calculated the potential savings as the savings that would be realised if all car trips were taken on cars on energy efficient tyres from 2008 and assuming that no car currently runs on efficient tyres. In addition, since we are interested in estimating social impacts we have also assumed that 60 per cent of the price of fuel is determined by taxes and excluded these amounts from the calculations. We have also discounted the savings (both the monetary savings and the CO_2 savings) using a 4 per cent discount rate as suggested by the European Commission.

4.99 All other assumptions on average fuel consumption, total fuel price and percentage savings due to efficient tyres are exactly the same as in the above model.

4.100 We therefore estimate a total net present value of potential savings (net of taxes) in the EU25 from 2008 to 2030 of €100 billion and a net present value of total potential savings in terms of CO_2 emissions of 600 billion Kg.

Interaction with other characteristics

4.101 Fuel efficiency is an important characteristic of a tyre; however there are clearly other desirable properties hat a tyre should have such as safety, duration, traction, handling etc.

4.102 One of the major objections that manufacturing companies raised in the past with regards to the adoption of minimum standards of rolling resistance was that a low rolling resistance could only be obtained at the expenses of other characteristics of the tyre.

4.103 Over time it is clearly possible to improve all characteristics at the same time but in the short term it would be wrong to focus on only one characteristic.

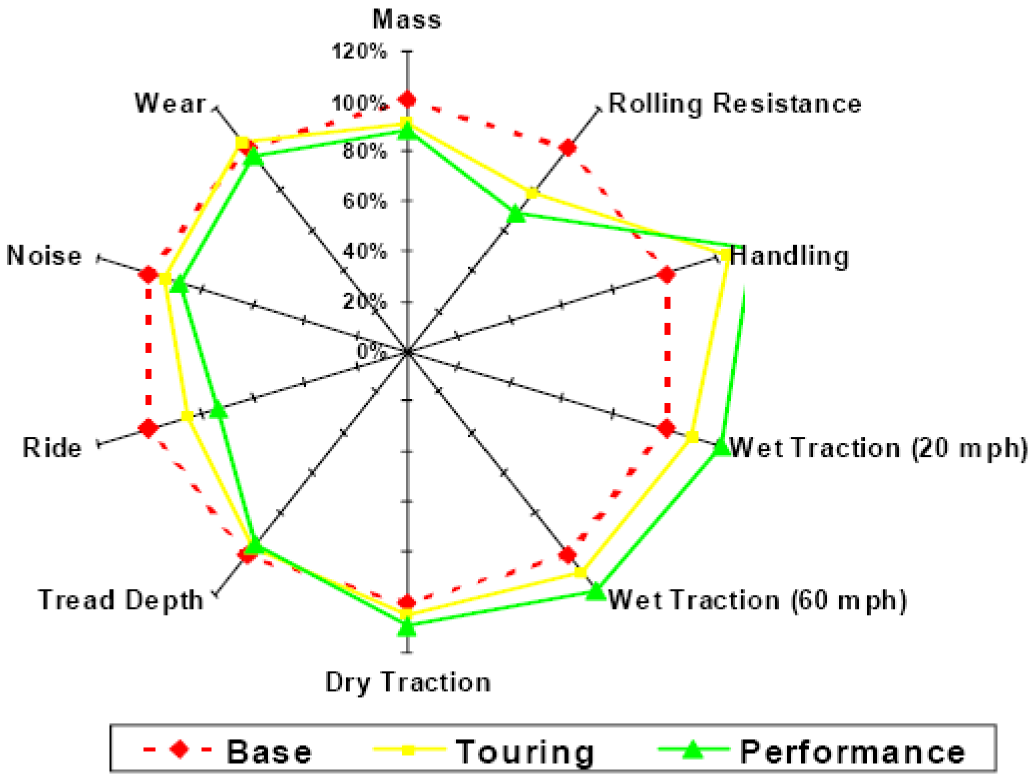
4.104 Luckily, over the last few years, according to a number of different studies presented in a workshop held at the International Energy Agency in 2005[23], the trade off between energy efficiency and other characteristics seems to be very much reduced at least for the "base" tyres. Significant differences remain for high performance tyres.

4.105 Figure 3.5 reports the results of a study conducted by the American consulting firm Energy and Environmental Analysis that illustrate the point. For a basic tyre a low rolling resistance does not compromise considerably the performance of the tyre in other fields such as handling, wet traction and noise. On the other hand for a touring tyre and even more so for a high performance tyre improved performance in terms of handling and traction can be obtained only at the expenses of rolling resistance and ride.

4.106 As an additional example the German magazine Auto Motor und Sport published in June 2007 the results of a high sped test carried out to examine the safety of various tyres. It reports that some tyres manufactured in China, although scoring reasonably well in terms of energy efficiency and rolling resistance performed badly in terms of safety. They needed considerably more space to break and some of the tyres even exploded during the test.

[23] See http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=227

Figure 4.5: Performance Trade offs by Tyre Type



Source: Duleep 2005

The labelling of tyres

4.107 The possibility of labelling tyres has been discussed in the past at the EU level. However, so far none has been introduced in the market.

4.108 Manufacturers are worried that giving information only on rolling resistance could distort the attention of consumers and force them to lose sight of other characteristics.

4.109 As we have seen above, for a given technology there is a trade off rolling resistance and other characteristics.

4.110 The majority of the goods that are currently subject to the European label are almost perfect substitute e.g. a refrigerator does not have any other distinctive characteristic than refrigerating, therefore the amount of energy it consumes is a very important feature in choosing which refrigerator to buy. On the other hand a tyre is not valued just because it improves the efficiency of a car but because of the performance in many other aspects.

4.111 This implies that labelling tyres could be much less effective than labelling white goods.

4.112 The recent trend in the public opinion that sees “being green” as more and more important could partially compensate the above mentioned effect and switch consumer preferences to a point where low rolling resistance is seen as a very important characteristic of a tyre.

4.113 According to a study of the National Resources Defence Council[24] in the USA, the most important characteristics considered in the purchase of a new vehicle are durability, safety and warranty, while fuel economy and emissions are seen as less important.

4.114 In the remainder of this section we briefly discuss the experience of the USA and Canada in the labelling of tyres.

USA

4.115 In the US there is no specific system for the labelling of tyres at the moment. However the Environmental Protection Agency launched in 2004 the SmartWay transport partnership with the freight industry that has the objective to increase energy efficiency while significantly reducing greenhouse gases and air pollution.

4.116 The main focus of the program is on trucking and railroad freight companies. They are evaluated according to their environmental and energy practice and those that meet the criteria are authorised to use the SmartWay logo.

4.117 At the moment none of the criteria is related to low rolling resistance tyres but having wide-based tyres or an automatic tyre inflation system can contribute to obtaining the certification. However there is also an "other" category that could be used to incorporate the use of efficient tyres in the evaluation procedure.

Canada

4.118 In Canada, the government owns the EcoLogo label that is a multi attributable environmental certification mark. More than three hundred categories of products have been classified using this logo. The label is not mandatory but is just based on voluntary applications from manufacturers.

4.119 Up to may 2007 Terrachoice, the agency responsible for the implementation of the program, provided the Ecologo certification for energy efficient tyres. However the certification is no longer available. We have investigated the reason why this has happened by contacting the agency.

4.120 In a nutshell Terrachoice realised that there was no interest from manufacturers to get the certification notwithstanding the relatively low cost of obtaining it. Evidently, market

[24] See www.nrdc.org

players in Canada believed that the choice was based on characteristics other energy efficiency.

Italy

4.121 A specific initiative related to the labelling of tyres is not present in Italy. However, ENI, the major Italian energy company formerly owned by the state and in which the Ministry of the Economy still has a 20 per cent stake launched a campaign called ENI30PERCENTO (ENI 30 per cent).

4.122 The campaign is essentially made up of 24 “pieces of advice” to save energy and save up to €1600 in a year for the average Italian household. The piece of advice number 20 and 21 relate to tyres and read respectively: “check the pressure of your tyres at least once a month” and “prefer fuel saving tyres.”

4.123 The initiative has been launched very recently (May 2007) and it is therefore difficult to evaluate how effective it has been. However Pirelli SpA, the major Italian tyre manufacturer and an important player in the global market, decided to participate in the campaign.

4.124 Although it is clear that there are also marketing considerations to be made the above initiative shows that the industry is interested in promoting energy efficient tyres.

Stakeholders views

4.125 As part of our study we have also interviewed a limited number of stakeholders to hear the opinions of the industry participants on the possible introduction of an energy efficiency label on tyres.

4.126 We have also interviewed the European Tyre and Rubber Manufacturers association (ETRMA), which represents all European tyre manufacturers. They provided the official position of the industry in respect to the introduction of a label for tyres.

4.127 All stakeholders agreed that it is difficult to predict how effective a label on tyres would be and pointed out that the major effect would most likely be on consumer awareness.

4.128 Stakeholders also mentioned that a voluntary label on cars had been introduced in the UK two years ago but with mixed results while no European scheme (even on a voluntary basis) exist.

4.129 Stakeholders agreed that a label could positively influence the efforts made by manufacturers to produce more energy efficient tyres but had mixed views with regards to the effects on price. Some felt that manufacturers would increase the price of tyres as a result while some claimed that the effect would be minimal.

4.130 All stakeholders believed that consumer would trust the information provided on the label and that it could influence their decisions. However price was felt to be the major single factor determining the decision of buying a tyre. In addition some stakeholders pointed out that a label that only focused on rolling resistance leaving aside other characteristics (such as safety) would distort consumers' perceptions of the overall quality of a tyre.

4.131 With regard to compliance to and enforcement of a label stakeholders generally felt that responsibility should fall on Member States and maybe on the industry itself. However it was felt that sanction should be imposed at an EU-wide level to avoid discrimination in various national markets.

4.132 Most stakeholders believed that the accreditation system should be run by the Type Approval Authorities in various Member States on the basis of the New European Driving Cycle.

4.133 The ETRMA would favour the introduction of a label with four bands (e.g. A to D) and two dimensions, i.e. energy efficiency and wet grip. The ETRMA believes that in such a way consumers would have a clearer picture of the overall quality of a tyre.

4.134 Although we agree that providing information on other characteristics is necessary, we believe that four bands are not likely to be sufficient to provide adequate information to consumers. It is possible that the overwhelming majority of tyres would end up in the top class in a very short period of time making the use of the label redundant. An A to G scale should be used in this case as well.

Conclusions

4.135 In this section we have reviewed the effects of low rolling resistance tyres on fuel consumption and summarised the main elements of the global tyre market. We have also attempted to examine the potential impacts of extending the existing energy labelling scheme to the windows market. Our concluding points are as follows:

(a) Low rolling resistance tyres can reduce fuel consumption by at least 3 per cent and as much as 7 per cent. Other factors, such as appropriate tyre inflation are, however very important.

(b) Low rolling resistance is just one of the many important characteristics on the basis of which a tyre should be valued. Others are, e.g. handling and traction.

(c) There does not seem to be a labelling scheme for energy efficient tyres in place anywhere in the world. Canada had a voluntary scheme up to May 2007 but repealed it because of lack of market interest.

(d) The high concentration of the market seems to suggest that the implementation of a labelling scheme should be reasonably straightforward at the EU level.

(e) Further research is required to conclusively determine whether the benefits of extending the scheme would outweigh the cost, and the most important point regards the importance of fuel efficiency in the decision process that leads to the purchase of a tyre.