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IMPACT ASSESSMENT

Accompanying the document

COMMISSION REGULATION (EU) …/… laying down ecodesign requirements for electric motors and variable speed drives pursuant to Directive 2009/125/EC of the European Parliament and of the Council

and repealing Commission Regulation (EC) No 640/2009

{C(2019) 2125 final} - {SEC(2019) 334 final} - {SWD(2019) 344 final}

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ACRONYMS AND ABBREVIATIONS

AC	Alternating Current (changing direction periodically at a certain frequency - as in the public electricity grid)
ATEX	Motor suited for EXplosive ATmosphere
BAU	Business-as-usual (describing a scenario without any further intervention)
CEMEP	European Committee of Manufacturers of Electrical Machines and Power Electronics (industry association representing motors and drives manufacturers at EU level)
DC	Direct Current (constant direction - as in a battery)
GHG	Greenhouse gas
IA	Impact Assessment
IE	International Efficiency; class defining minimum energy efficiency based on international standards (IE1: standard / IE2: high / IE3: premium / IE4: super premium)
IEC	International Electrotechnical Commission; global standardisation organisation
kW	kilo Watt, 10^3 Watt (unit of power)
kWh	kilo Watt hour, 10^3 Watt per hour (unit of energy)
LCC	Life cycle cost over the whole lifetime of a product, including purchase cost and energy costs
LLCC	Least life cycle cost; used to determine the energy efficiency requirements that minimise costs of a product for its whole lifetime.
MEErP	Methodology for the Ecodesign of Energy-related Products[1]
$MtCO_2eq$	Mega tonne CO_2 equivalent, 10^9 kg of gas equivalent to potency of CO_2 (unit of greenhouse gas emissions)
MSA	Market Surveillance Authority (in charge of enforcing ecodesign regulation in a Member State)
NGO	Non-Governmental Organisation
TWh	Tera Watt hour, 10^{12} Watt per hour (unit of energy)
VSD	Variable Speed Drive
yr	Abbreviation used as denominator for units expressed per year (e.g. TWh/yr)

Notes:

- Annex 1 contains a glossary with the technical terms used in this Impact Assessment.
- Annex 8 contains a section on acronyms specifically used in that Annex.

[1] Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP) PART 1: MATERIAL EFFICIENCY FOR ECODESIGN - Final report to the European Commission - DG Enterprise and Industry 5 December 2013.

This report commits only the Commission's services involved in its preparation and does not prejudge the final form of any decision to be taken by the Commission.

1. INTRODUCTION

The Ecodesign Directive 2009/125/EC[2] plays a key role in the European Union's efforts to achieve its energy efficiency target of 20% energy savings by 2020, as well as the 32.5% 2030 target[3]. It is estimated, that with energy savings of around 2000 TWh, the Ecodesign Directive will deliver almost half of the energy savings needed to achieve the 2020 target. It is expected to contribute further to the 2030 target, up to a quarter of the remaining effort to be achieved relative to a business-as usual scenario. The Ecodesign directive is thus a key instrument within the EU's energy policy and Energy Union strategy.

Ecodesign measures also reinforce the free circulation of goods on the EU internal market generate savings for the end-users, and contribute to innovation and EU industry competitiveness. Electric motors represent the single largest electrical end use, representing about half of the EUs electricity consumption. Electric motor systems were identified in the 2005 Ecodesign Directive as a key product group to be investigated. As a consequence, Commission Regulation (EC) 640/2009[4] on ecodesign requirements for electric motors (amended by regulation 4/2014[5]) was developed (hereafter 'the motor regulation'), with a view to regulate the motors with the largest saving potential, i.e. asynchronous induction AC motors[6]. These are widely used, especially in industrial applications because they are rugged, reliable and economical.

It should be noted that regulating the performance of electrical motors is not specific to the EU. Countries around the world from US to Australia, China and Turkey have regulated those since the late 90ies. A global standard developed by the International Electrotechncial Commission (IEC) is available since 2008[7].

The current EU Regulation 640/2009 foresees that:

- From June 2011 on, motors with a rated output of 0.75 - 375 kW must meet the International Efficiency class 2 (IE2) efficiency level.
- From January 2015: motors with a rated output of 7.5 - 375 kW must meet IE3 efficiency level - or the IE2 efficiency level and be equipped with a variable speed drive (VSD).
- From January 2017: all motors with a rated output of 0.75 - 375 kW must meet the IE3 efficiency level or the IE2 efficiency level in combination with a variable speed drive.

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[2] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products.

[3] Political agreement reached on 19 June 2018 between negotiators from the Commission, the European Parliament, and the Council. See press release here http://europa.eu/rapid/press-release_STATEMENT-18-3997_en.htm

[4] Commission Regulation (EC) No 640/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors

[5] Commission Regulation (EU) No 4/2014 of 6 January 2014 amending Regulation (EC) No 640/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors

[6] The terms used to designate electric motors are rather technical and the reader not familiar with them is invited to read the glossary presented in Annex 1.

[7] IEC 600034-30:2008 Efficiency Classes of Single-Speed, Three-Phase, Cage-Induction Motors, updated in 2014

As part of the impact assessment, an evaluation of the existing motors regulation has been carried out. The results can be found in annex 5. It shows that indeed a significant transformation of the motors market under the scope of the regulation occurred, when energy efficiency standards were introduced in 2011 and 2015 - with IE 1 (and below) motors falling in market share from 80 % in 2009 to 17 % in 2016 whilst at the same time the IE 3 premium class share rose from 0 % to 29 %. The energy savings realised in the year 2017 are estimated as 31 TWh and the corresponding GHG emissions reduction as 12 MteqCO2. The savings are expected to amount to 102 TWh per year by 2030 (see Annex 5). This is lower than the 208 TWh initially anticipated[8] but represents nevertheless about 9% of the remaining effort to reach the 325% 2030 target.

The scope of the current regulation is limited to middle-size 3-phase motors ranging from 0.75 kW to 375 kW, with 2 to 6 poles, up to 1000 volts. These are very common motors, which were perceived as easy to regulate at the time, inter alia because a technical global standard was available. This meant that the following AC induction motors were excluded:

- Small motors below 0.75 kW;
- Single-phase motors (up to a few kW maximum);
- Very large motors above 375 kW;
- Less common 8-pole motors (slower rotation speed);
- Medium voltage motors (above 1000 volts, usually above 375 kW);

In addition, a few exclusions were foreseen by precaution, for special purpose motors (brake motors, explosion-proof motors, and submersible motors).

The current scope does not include Variable Speed Drives (VSDs) that may be used to control the speed and output of the motor when the application is characterised by a variable load/speed. In such situation, the VSD allows to achieve considerable energy savings compared to mechanical means of adjusting the load/speed (e.g. a valve in the case of a motor-driven pump). However VSDs have also their own energy losses, which are currently not regulated in the EU.

The motors in the scope of the current regulation have an electricity consumption of nearly 1.000 TWh per year (2015), about twice Germany's annual electricity consumption.

Regulation 640/2009 requires the Commission to review its effectiveness and appropriateness in light of technological progress within seven years after its entry into force, i.e. by August 2016. The Commission undertook a review study and presented the results to the Ecodesign Consultation Forum on 29 September 2014.

This report outlines the outcome of the review process, proposes several policy options that result of the review process (such as reinforced requirements and scope extension), evaluates the associated impacts, and proposes a preferred policy option that allows to capture an energy efficiency potential of about 10 TWh.

More detailed procedural information is provided in Annex 2, with information on stakeholder consultation in Annex 3, and the minutes of the Consultation Forum in Annex 4.

[8] See original Impact Assessment carried out in 2008. The difference is attributed to the use of different hypothesis, more sophisticated modelling, and updated data.

2. PROBLEM DEFINITION

2.1. What is the issue or problem that may require action? What is the size of the problem?

The EU has over 8 billion electric motors in use, consuming half of the electricity produced in the Union. The sector is very heterogeneous, with a huge variety technologies, applications and sizes. The sales volume is significant (about 750 million motors a year), as is the environmental impact from energy consumption (about 2000 TWh per year) and emissions (about 800 MtCO2 eq/yr). The preparatory study established, for the products under investigation, a valuable potential for additional energy savings which can be achieved without excessive costs as the improvement of the 'average' product results in lower life cycle costs for end users (both industrial and household).

Realising even the smallest energy efficiency increase in electric motors creates significant overall energy savings with further benefits regarding the EU's energy efficiency and greenhouse gas (GHG) emission targets and its security of supply. Small gains in energy efficiency, even if leading to a more expensive motor, can result in significant cost savings for the end-user over the lifetime of the product. In industrial applications where the motor is used intensively, the energy cost can represent over a hundred times the acquisition costs.

The review study identified several problems with the current motor regulation (the reason for these problems is further explained in the next section):

1. Missed energy and monetary savings because energy efficient requirements for mid-sized motors in scope are no longer optimal

Technological progress and international developments have resulted in more energy efficient motors at lower cost, but in many instances however buyers are not benefitting from this, resulting in missed energy and monetary savings at end-user level.

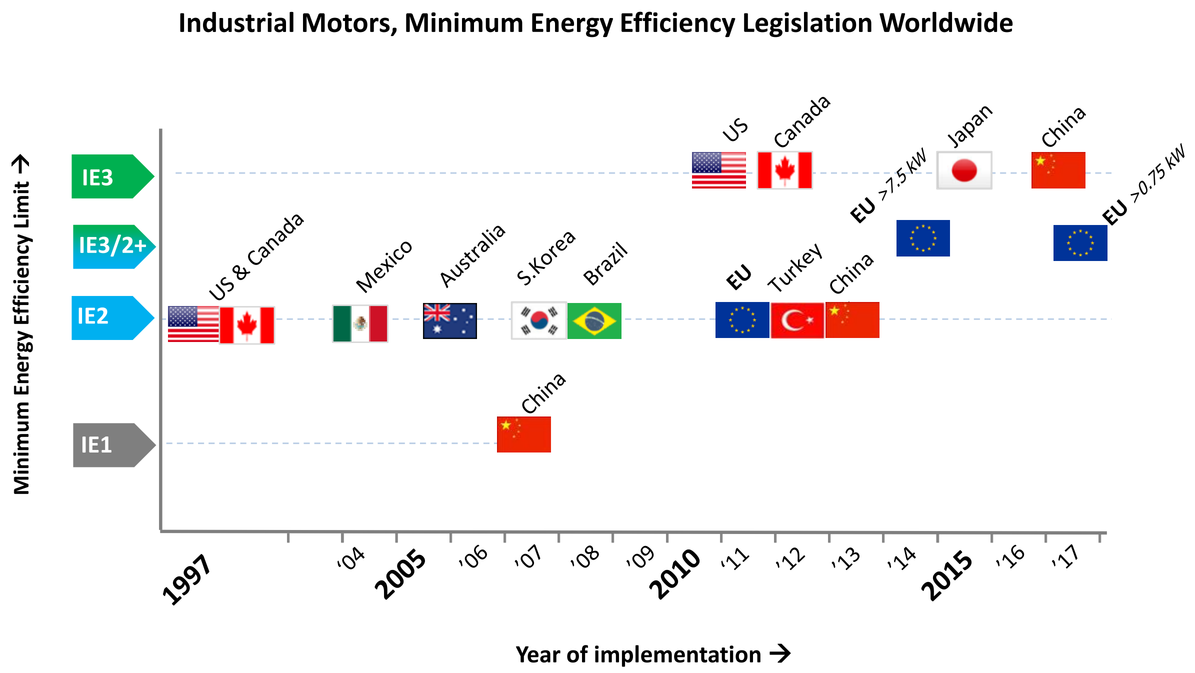

Figure 1: Minimum energy efficiency legislation for low voltage AC motors in different countries, status 2015 (Note that the IE3 regulation-plans for China were recently postponed).

The EU started regulating the minimum energy efficiency of motors after many other developed economies, and its ambition levels are behind countries such as the USA, Japan or Canada.

The current regulation requires motors in scope either to reach an energy efficiency class of at least IE3, or to reach IE2 class if the motor is supplied with a variable speed drive (VSD). The review study however demonstrated through life cycle cost assessment that IE2 motors are no longer optimal from a least life cycle cost perspective. Annex 9 presents the outcome of the life cycle cost assessments that were used in this impact assessment.

2. Inefficient motors and VSDs not within the scope of the current regulation are traded on the European market resulting in missed energy and monetary savings.

VSDs have a great potential to reduce consumption in variable load applications. However in the absence of regulation, buyers of motors or VSDs do not always purchase the 'optimum' product that would result in the lowest end-user cost over the lifetime of the product. This concerns motors not in scope, and in particular small 3-phase motors, single-phase motors as well as large 3-phase motors, 8-pole motors and VSDs. These motors consumed 440 TWh of electricity in 2015 and represent a valuable savings potential. While the scope of the current regulation – and any extension to large motors – mainly targets motors used in industrial applications, extension to smaller and single-phase motors would introduce a wide range of other applications, for example in domestic appliances where further cost-effective savings can be achieved.

Regarding VSDs in particular, recent investigations[9] indicate that drives sold by key manufacturers very often already reach IE2 energy efficiency class, which is the highest class defined in the newly published standard for VSDs[10]. However, there are less efficient drives on the market and life cycle calculations demonstrated that it would be cost-effective to purchase drives that are at least IE2.

3. Regulatory failure: IE2 + VSD difficult to enforce and actually not picked up by the market

VSD plus IE2 requirement, as an alternative to IE3, proved difficult to enforce by market surveillance authorities because actual installation of a motor with its VSD can only be verified on-site and more importantly is the responsibility of the installer and not the manufacturer – which actually runs against the general logic of Ecodesign enforcement. The Swiss regulation (which is largely based on the EU regulation) therefore did not include the IE2 + VSD option and only established IE3.

It also seems that the IE2+VSD option was not implemented in practice to a significant extent: preliminary VSD sales data for 2013-2016 do not show an increased sales uptake beyond the current trend. Finally, the performance of an IE2 motor equipped with a VSD has not necessarily the same performance as the IE3 level, as the gains induced by a VSD are application-specific: while in variable-speed applications the use of VSD can generate significant energy savings, it can generate losses when used in fixed-speed applications.

4. Regulatory failure: Risk of circumvention

During stakeholder consultation several Member States have expressed concerns that the exemptions for certain categories of mid-sized motors in the current regulation are used to supply the market with inefficient motors, creating loopholes and missed energy savings. There was therefore a need to reassess the current extent of exemptions and consider whether they need to be maintained in their full scope.

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9 Conrad U. Brunner, Rita Werle, *New technology needs - new policy - From component to systems*, presentation at the 2017 EEMODS conference (Rome, Italy)

10 IEC 61800-9-2:2017 Adjustable speed electrical power drive systems - Part 9-2: Ecodesign for power drive systems, motor starters, power electronics and their driven applications - Energy efficiency indicators for power drive systems and motor starters

As indicated in annex 5, the lost net savings resulting from regulatory failures and loopholes identified in this report are estimated as about 10 TWh per year in 2030.

2.2. What are the underlying drivers of the problem?

2.1.1. Problems 1 and 2: Market failures: Myopic behaviour, split incentives, accounting rules, installation guidelines etc.

There are several reasons why economic actors (both business and private) do not spontaneously choose the product that is the most cost-effective over the product's life-time. Standard neoclassical economic theory postulates that economic actors behave perfectly rationally. In reality, economic actors are limited by the information they have, the cognitive limitations of people's minds and the finite amount of time they have to make a decision[11]. In every company, one or multiple bounded rational individuals take the actual decision on which investment to make, e.g. which motor to buy. These investment decisions are not always the economically optimal ones in the long-term. For example, research has shown that only around 47% of all profitable energy efficiency investments recommended to firms by external auditors are actually undertaken[12,13,14,15].

The reasons for such behaviour are manifold: investments directly improving the core business, such as productivity improvements, are significantly more often undertaken than ones offering energy savings[9]. Thus, companies are less likely to undertake energy saving measures even if they have the same economic viability as other investments[16, 17]. Other reasons include the owner/employee-dilemma, where the employees of a company are optimising their actions in line with their strict performance evaluation criterions such as increasing sales numbers rather than reducing costs; this notion is supported by the observation that the reduced or missing need for profitable investments of legal entities in public or quasi-public ownership exhibit the most barriers to energy efficiency investments[12].

Further, the absence of financial risk assessment procedures for investments related to energy efficiency appears to be another market hindrance. Research shows that many companies rely on simplistic payback rules rather than standard 'net-present-value' calculations or the more sophisticated methods such as 'value-at-risk' that are common in the financial industry[18, 19]. As a result of this inadequate investment assessment, many companies require very short payback periods for energy efficient products, usually in the range of less than two years, to have a

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11 McFadden, D. (2001). Economic choices. American Economic Review, 91(3), 351-378.

12 Alcorta, L., Bazilian, M., De Simone, G. & Pedersen, A. (2014). Return on investment from industrial energy efficiency: Evidence from developing countries. Energy Efficiency, 7(1), 43-53.

13 Harris, J., Anderson, J. & Shafron, W. (2000). Investment in energy efficiency: A survey of Australian firms. Energy Policy, 28(12), 867-876.

14 Qiu, Y., Wang, Y. D. & Wang, J. (2015). Implied discount rate and payback threshold of energy efficiency investment in the industrial sector. Applied Economics, 47(21), 2218-2233.

15 Ross, M. (1986). Capital budgeting practices of twelve large manufacturers. Financial Management, 15(4), 15-22.

16 DeCanio, S. J. & Watkins, W. E. (1998). Investment in energy efficiency: Do the characteristics of firms matter? The Review of Economics and Statistics, 80(1), 95-107.

17 Schleich, J. & Gruber, E. (2008). Beyond case studies: Barriers to energy efficiency in commerce and the services sector. Energy Economics, 30(2), 449-464.

18 Abadie, L. M., Ortiz, R. A. & Galarraga, I. (2012). Determinants of energy efficiency investments in the US. Energy Policy, 45, 551-566.

19 Jackson, J. (2010). Promoting energy efficiency investments with risk management decision tools. Energy Policy, 38(8), 3865-3873.

large but irrational 'safety margin' without any further economic rationale[12, 14, 20]. These hindrances not only increase the EU's energy consumption, but also reduce the EU's overall competitiveness, resulting in suboptimal economic investment decisions.

Not only projects such as the construction of a new plant are affected by irrational investment decisions. Also the maintenance of existing installations, e.g. the replacement of broken motors in existing plants, often does not follow economic rationale: companies with flexible budgeting rules are more likely to opt for economically sensible and energy efficient replacement motors compared to the ones with strict capital rationing rules[10,21]. In the latter case each business unit has a fixed budget, and the motor with the lowest purchase price but higher running costs is selected, because the running costs come from a different budget.

In cases with low maintenance budgets, companies postpone replacement of old equipment far beyond its duty life. A survey in Switzerland found that 56% of motors operate longer than their operating life expectancy.[22] This results in old, low-efficient motors being used for much longer than planned, and motor-related equipment beyond its service life often shows higher energy consumption due to wear-and-tear. Due to budget pressure, replacement planning is often only an afterthought and parts are only replaced when they break down. Such a breakdown is then immediately an emergency situation because the production stops. The quickest and low-risk strategy is often to buy a one-on-one replacement for the old, inefficient motor as there is no time to reflect on the relevance of selecting a motor that offer better performances.

Further, many industrial motors are used in food, chemical and other process industries. The process installations are generally designed according to installation standards and guidelines like API-standards (American Institute of Petroleum engineers). These standards sometimes relate to safety instructions, but they primarily prescribe what equipment, including motors, should be used to ensure production-continuity under all circumstances. However, these standards are not yet adapted to technological developments of motors. They usually use the principle of ‘proven design’, which means that a piece of equipment like a motor can only be used after the supplier has proven that it worked satisfactorily in the same application for 20 years. In practice this means that much of the design of the equipment currently in use, including motors and drives, dates back to the 1950s. Without mandatory ecodesign requirements this practice is very difficult to change. These standards also overlook that investments in more efficient products such as motors can provide a significant boost to reliability, because modern, efficient products often offer longer lifetimes and less frequent production halts, thereby increasing a firm's productivity.[23,24]

Finally, many motors, especially smaller motors, are integrated into finished/intermediate goods, which are then further sold through the supply and distribution chain. In these instances, the original equipment manufacturers usually have no incentive to buy an energy-efficient motor, because they will not benefit from the associated running cost reductions.

20 Thollander, P. & Ottosson, M. (2008). An energy efficient Swedish pulp and paper industry - exploring barriers to and driving forces for cost-effective energy efficiency investments. Energy Efficiency, 1(1), 21-34.

21 Moya, J. A., Pardo, N. & Mercier, A. (2011). The potential for improvements in energy efficiency and CO2 emissions in the EU27 cement industry and the relationship with the capital budgeting decision criteria. Journal of Cleaner Production, 19(11), 1207-1215.

22 Werle, R. (2014). Report of the Swiss audit program "Easy". http://motorsummit.ch/data/files/MS_2014/mittwoch/580_ms14_werle.pdf

23 International Energy Agency (2014). Capturing the multiple benefits of energy efficiency. IEA publications. Paris, FR.

24 Worrell, E., Laitner, J. A., Ruth, M. & Finman, H. (2003). Productivity benefits of industrial energy efficiency measures. Energy, 28(11), 1081-1098

This is again a facet of the split incentive issue raised above. In those situations the manufacturer will usually just buy the cheapest motor that is compatible with the client's requirements. The end-user is often not informed of the energy efficiency of the motor, especially for small motors below 0.75kW for which efficiency information is often simply missing from websites and brochures. This aspect is particularly relevant for the considered scope extension (e.g. small motors integrated in domestic appliances).

The review supporting this IA found that the incentive structure depends on the intended application of the motor, as well as on the ambition level of product level regulation in place (see Annex 8 for more details on this issue).

2.1.2. Problem 3: Difficult enforcement of the VSD+IE2 option (as an alternative to IE3)

Member States and other stakeholders stated that IE2 motors equipped with VSD are not equivalent to IE3 motors, and considered this option as difficult to enforce by market surveillance authorities (MSAs). Indeed, it is most often the installers or sometimes the end-users, who decide whether to put a VSD on a motor since they know what is most suitable for the application. It is not possible to take action against a manufacturer if the installer/end-user decides not to combine the motor with a VSD even if the manufacturer instructs them do so. Checking compliance would mean that MSAs would have to significantly expand their activities and carry out on-site visits – instead of simply checking the self-declared compliance of the motor manufacturer. Without this extension of activities an effective enforcement of the option allowing a combination of a less efficient motor with a speed drive is not ensured.

2.1.3. Problem 4: Risk of loopholes in Existing Motor Regulation

Several Member States, EU industries and NGOs informed the Commission during the stakeholder consultation that certain producers/importers may exploit the current exemptions by declaring normal AC motors as ‘explosion proof’ or ‘brake’ types, thus escaping the minimum requirements. These products were originally exempted under the precautionary principle due to concerns related to the special applications where these products are used. The experience gained during the application of the Regulation showed however that the precautionary exemption is not fully justified[25]. Moreover, removing the exemption would bring the provisions in line with international standards as both types of motors (non-integral brake motors and explosion proof) are covered in the energy efficiency standard for motors (IEC 60034-30).

Fixing these issues is seen as important for the credibility and effectiveness of the ecodesign measure, will ensure the effective functioning of a level playing field for all manufacturers and will induce additional energy savings.

2.3. Who is affected by the problem, in what ways, and to what extent?

The foregone energy and monetary savings resulting from the use of inefficient motors potentially affect all users of motors, in industry, services and households - with the latter not purchasing motors directly but integrated in other products. The Society as a whole is also affected, through increased environmental impact associated with energy consumption, missed jobs in energy-efficient motor systems, and increased EU energy dependency.

25 For example normal motors are often used in an ATEX [EXplosive ATmosphere] environment and the ‘explosion-proof’ qualification is simply ensured by the addition of an external housing.

This problem also affects the motor and VSD industry, as it prevents the development of a market for more energy-efficient products that would increase industry revenues and improve its competitive edge.

The loopholes in the regulation affect the work of Market Surveillance Authorities and penalise motor manufacturers who have invested in the production of energy-efficient motors but do not get all the associated benefits due to unfair competition by those who exploit the loopholes. Loopholes also potentially affect end-users through the purchase of less cost-effective motors.

Section 6 describes in detail the impacts of the proposed policy options, covering not only energy and monetary savings for end-users, but also business revenue, GHG emissions and employment. Annex 6 provides a qualitative description of the impact of the policy options on the affected actors. The rest of the present section provides a description of the motors and VSDs market.

The largest European motor-system manufacturers are ABB (€35 billion revenue, 145k employees)[26], Siemens (€40 billion revenue, 100k employees)[27], Schneider Electric (€25 billion revenue, 170k employees)[28] and Danfoss (€4.6 billion revenue, 24k employees). These companies realise around a quarter of their revenues in motor systems, a quarter of which in the EU. All in all, the EU market for motor-systems represents a market value of around €6.5 billion (about a quarter of the global market) and 130 000 jobs. There is a strong presence of SMEs in motor installation, repair and maintenance, but not in production of motors and drives for this market segment.

The EU market for electric motors in scope is €3 billion in value and unit sales are 10 million per year. The estimated value of the market for variable speed drives (VSDs) was 2.6 billion in 2015.

CEMEP, the European industry association of motor manufacturers, estimates that in 2012 around 4 million VSDs were sold with new motors.[29] Market researcher IHS estimates that for every two new motors with VSDs a third VSD is sold as retrofit.[30] Moreover, CEMEP estimates that between 2014 and 2020 the market penetration of VSDs will grow from 25% to 50% for all industrial motors[31]. Figure 2 gives an overview of the market in unit sales for motors and drives.

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26 http://new.abb.com/investorrelations/company-profile/facts-figures (approximate 2014 data)

27 www.siemens.com/annual-report (approximate 2014 data)

28 http://www.schneider-electric.com/en/yrbout-us/company-profile.jsp

29 Pers. Comm. CEMEP, European Committee of Manufacturers of Electrical Machines and Power Electronics. www.cemep.eu

30 Preston Reine (IHS), Industrial Motors and Drives: A Global Market Update, lecture eemods'15, www.eemods15.info

31 http://cemep.eu/data/CEMEP_Energy_Efficiency_with_Electric_Drive_Systems.pdf

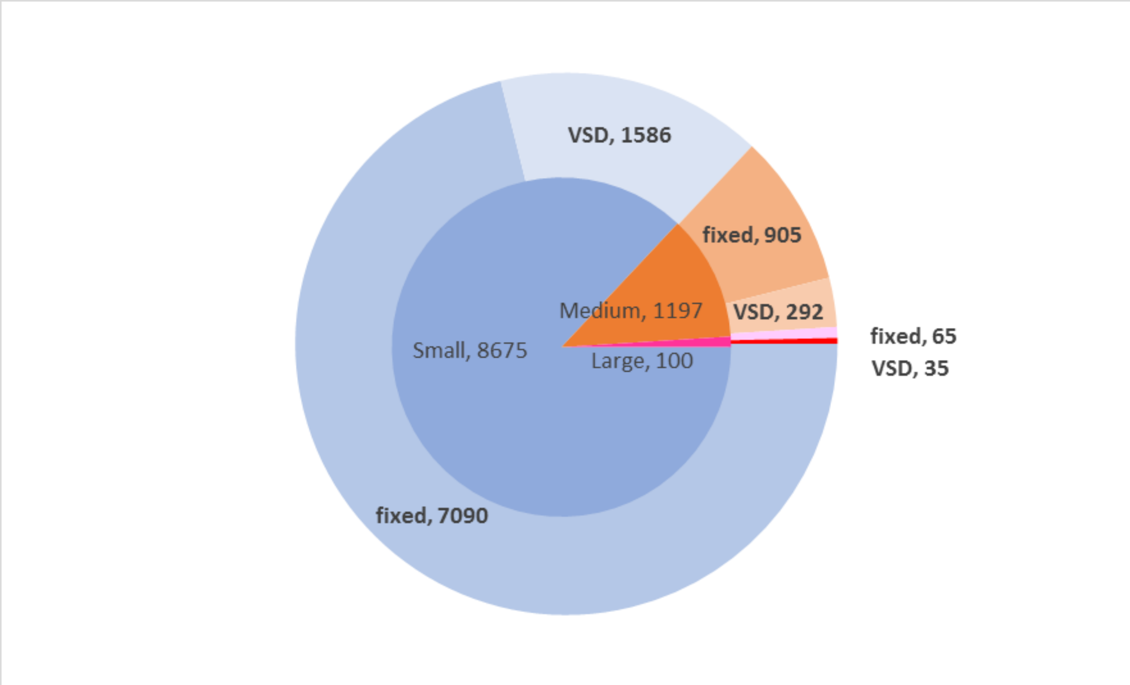
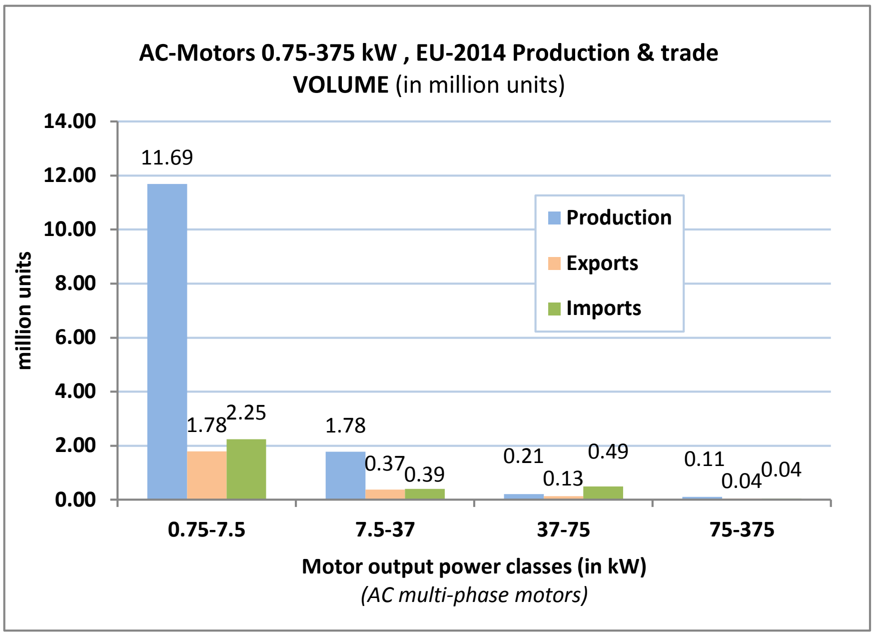


Figure 2: EU 2012 sales of motors in scope, divided by size (Small is 0.75-7.5 kW, Medium 7.5-75 kW, Large 75-375 kW) and by speed control (with or without VSD).

The EU is a net importer of industrial motors, with about a third of the motors sold in the EU being imported. For every five motors sold in the EU, one is exported. However, the average value of an exported motor is about four times that of an imported one. As a result, in terms of value, exports are worth about twice the imports, and only 20% of the value of the motors sold in the EU comes from imported motors[32]. NB: These figures do not include the motors installed in (semi-) finished goods that enter or exit the EU.

32 Figures from Eurostat (Prodcom) data for the motors in scope.

Considering all 3-phase AC motors in the range current scope (0.75-375 kW), the 2014 EU production of motors >0.75 kW is worth €5.2 billion, of which €1.45 billion is exported (see Figure 3). Imports amount to €0.59 billion where China, especially for the smaller motor sizes, is an important player (see Figure 4).[33]



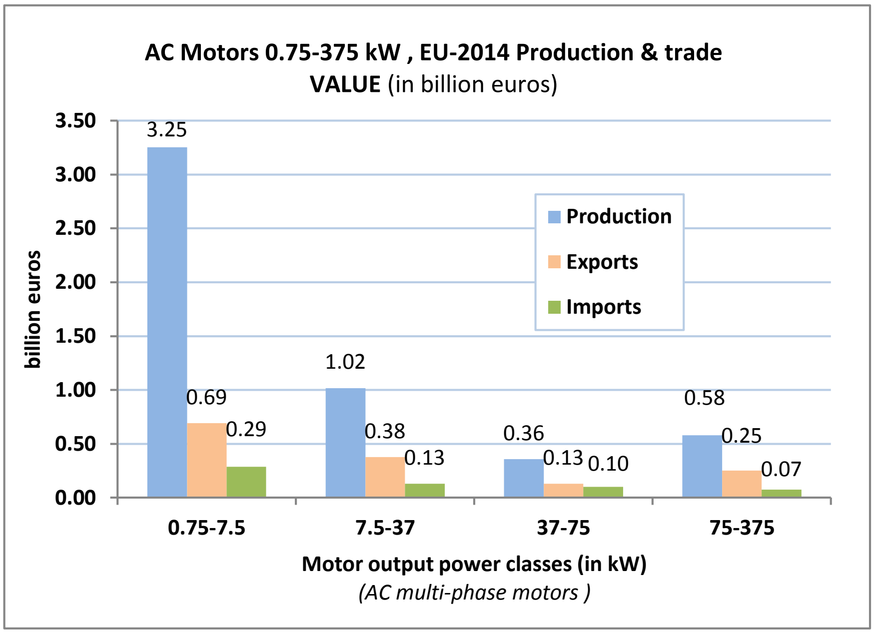


Figure 3: EU-2014 production and trade of AC multi-phase motors by size class.

Due to the importance of exports, there is a benefit for European motor-system manufacturers to update the motor regulation in line with international developments. Further, the energy efficiency standard for VSDs was recently developed by European manufacturers, and is a strong contender of becoming the world-wide standard. A possible inclusion of VSDs therefore also has an important competitiveness aspect as the design of the regulation can give the EU manufacturers in this area an important advantage. Therefore, the industry association

33 Eurostat Europroms and Eurostat HS6 International Trade Statistics, extract February 2016.

CEMEP is supporting the inclusion of energy efficient VSDs in a revision of the motor regulation.

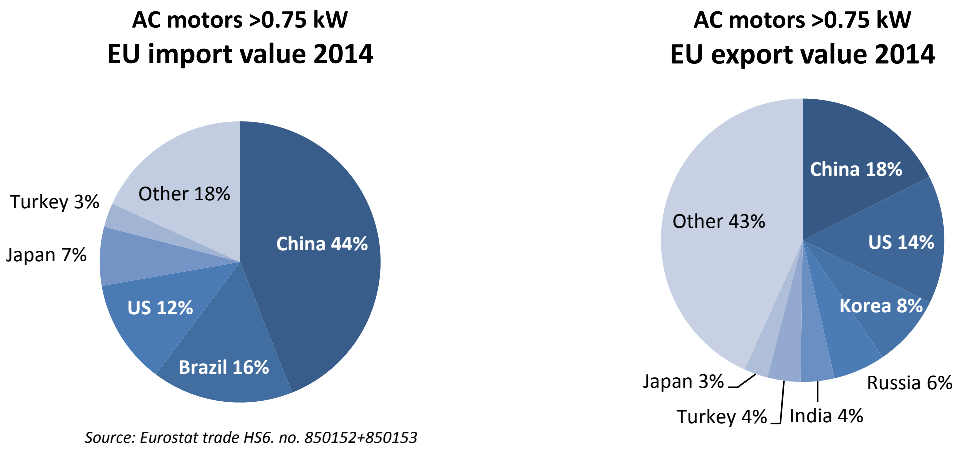


Figure 4: EU-2014 import and export share by country.

2.4. How would the Problems evolve without Intervention?

Ecodesign is a key driver for innovation in products' energy efficiency and a support to EU's technological and environmental leadership. Without requirements suited to technological progress, the future market for motors and VSDs in the EU is expected to offer less advanced (and energy efficient) technologies than in other economies. As shown in the evaluation (Annex 5), the motor regulation stimulates the sale of more efficient products, and hence makes research and development costs viable while lowering the purchase costs of efficient products due to the economics of scale.

The absence of intervention also negatively influences users of motors and VSDs through sub-optimal running costs due to missed energy savings, as well as higher purchase costs for highly efficient motors compared to a scenario with regulation. Lowering the costs for customers would have a beneficial impact on the competitiveness of EU industries using motors and VSDs.

Without an update of the regulation in line with technological progress, providing the necessary energy efficient motors for the export market would become more challenging, because manufacturers would need to invest in the development and production of more efficient motors for export while at the same time not finding buyers for these on their important European home market. China and the USA are currently in the process of introducing new minimum energy efficiency requirements. If the EU does not align its requirements, US and Chinese manufacturers will find themselves with products and production lines for which write-off will be minimal and for which there will be no longer a domestic market, but an open EU market with lower requirements where cheaper, less-efficient motors can be sold. The Union's market for small motors (below 0.75 kW) , which is out of scope of the current motor regulation, is seen as an example of possible development as they are now covered by International Standards and regulated in other jurisdictions.

In the particular case of the VSDs the EU actually has a competitive interest in creating a first mover advantage for its own industry (see above). This area is currently not regulated, but EU manufacturers have developed the basis for a potential new global standard.

The detailed analysis of the situation without any regulatory change is considered in section 5.1 (Business as usual scenario).

2.5. Compliance costs

In the process of review, it has proven difficult to obtain data from motor industry on projected or actual compliance costs (e.g. costs to re-design the motors, change production lines) in relation to energy efficiency requirements. Several reasons may be put forward for this:

- Difficulty for industry to disentangle ex-post whether an innovation was triggered by EU provisions vs provisions required on other markets. Difficulties to ex post determine whether the innovation was also (at least) partly driven by non-regulatory factors.
- Commercial secrecy;
- Legal risks (sharing cost information can be considered as fraudulent commercial practice).

Given the non-availability of compliance cost, we consider motor price increases as indicator, noting however that pricing strategies are not solely determined by compliance costs for energy efficiency, but also reflect size (kW), brand reputation, quality (longevity), production volume, service, distribution structure/margins, etc. These latter factors mean that the EU can still compete with Asia on industrial motors, despite much higher prices (prices quoted for high-quality EU motors can be more than 10 times higher than prices found on the internet for cheap motors from Asia). Prices and price increase of motors due to ecodesign measures used in his impact assessment are based on market research and stakeholder consultation (table 7.6 in Annex 7).

A price difference of 15% is not uncommon between IE3 and IE2 motors, the difference being usually higher for smaller motors (typically 20-30%) than for large motors (less than 10%). More information on product cost is provided in section 6.3.1. As sales volumes of IE3 motors increase, it can be expected that the difference will go down due to scale effects. The price increase will result in increased business revenue for motor producers, and is a consequence of redesign efforts, including investment in updating the existing production lines, as well the enhancement of the intrinsic quality of the motors (e.g. energy-efficient usually require more copper, higher quality alloys). This is described in more detail in section 6.3.3.

3. WHY SHOULD THE EU ACT?

There is clear added value in requiring minimum energy efficiency levels at EU-level. Without harmonised requirements at EU level, Member States would be incentivised to require their own minimum energy efficiencies for motors placed on their national market in the framework of their environmental and energy policies, as was the case for many products before the Ecodesign Directive was implemented, thus effectively undermining the free movement of products. Whilst it could be conceivable that every MS implements the global available IEC standard nationally, it would still not be guaranteed that the single market would not be fragmented by different energy efficiency levels, scopes and applicable dates. So the EU intervention effectively regulates those aspects and otherwise fully integrates the available international standard, hence not duplicating work carried out at global level.

The review study carried out prior to this impact assessment confirmed the efficiency of the regulation's EU-wide application (i.e. the ratio between burden and benefit) is adequate: the format of a Commission Regulation ensures immediate and simultaneous introduction of the measure in all EU Member States; motor industry testing efforts have not increased significantly with respect to the situation before the regulation where they often had to do similar efficiency tests for commercial reasons. Market surveillance effort by Member States will increase in line with an extension of scope, but on the other hand will benefit from the clarifications around the exemptions.

The legal basis for acting on an EU level through the Ecodesign Directive is Article 114 TFEU, which relates to the *"the establishment and functioning of the internal market"*. In more detail, Article 114(3) TFEU specifies that the Commission "*in its proposals […] concerning health, safety, environmental protection and consumer protection, will take as a base a high level of protection. [...] Within their respective powers, the European Parliament and the Council will also seek to achieve this objective."*

Article 194 TFEU, which amongst others, gives the EU the objective *"in the context of the establishment and functioning of the internal market and with regard for the need to preserve and improve the environment"* to *"ensure security of energy supply in the Union*" and *"promote energy efficiency and energy saving and the development of new and renewable forms of energy".*

Finally there is an in-built proportionality and significance test in the Ecodesign legislation through the procedure defined in Article 15 of the Ecodesign Directive. Articles 15(1) and 15(2) state that in case a product represents a significant volume of sales, has a significant environmental impact within the Community, presents a significant potential for improvement without entailing excessive costs, while taking into account an absence of other relevant Community legislation or failure of market forces to address the issue properly and with a wide disparity in environmental performance of products with equivalent functionality, the product shall be evaluated for an implementing measure or self-regulation. Following the procedure as defined in Article 15(3) of the Ecodesign Directive, including the analysis ('preparatory study'), it was established that electric motor systems fulfil the above eligibility criteria.

Furthermore, the preparatory process, including extensive stakeholder consultations and the Ecodesign Consultation Forum, ensured that significant negative impacts on user functionality of the product, health, safety, environment, affordability and life cycle costs, industry competitiveness were considered (including SMEs see detailed paragraph on SMEs, section 6.3.4).

The option of self-regulation has been considered, but no industry proposal was put forward. In short, during the consultations none of the Member States or any other stakeholder suggested any other option than setting minimum energy efficiency requirements at EU level.

4. POLICY OBJECTIVES

This Impact Assessment focuses on objectives specific for motors since the objectives for ecodesign in general have already been set out in the Impact Assessments for the Ecodesign Directive.

4.1. General Objectives

Following the legal basis in the TFEU, the general objectives are to:

1. Facilitate free circulation of efficient motor systems within the internal market;
2. Promote competitiveness of the EU motor and VSD industry through the creation or expansion of the EU internal market for sustainable products;
3. Promote the energy efficiency of motor systems as contribution to the EU's objective to reduce energy consumption by at least 32.5 % and domestic GHG emissions by 40 % by 2030; implement the energy efficiency first imperative established in the Energy Union strategy and

4. Increase the energy security in the Union and reduce dependency through a decrease in energy consumption of motor systems.

There are several synergies between these objectives. Reducing electricity consumption (by increasing the energy efficiency) leads to lower carbon, acidifying and other emissions to air. Tackling the problem at EU single market level enhances efficiency and effectiveness of the measure. Alignment with global test standards and thus 'teaming up' with other jurisdictions also reinforces the effectiveness and efficiency of the measure.

4.2. Specific Objectives

The specific objectives of the policy options considered in this impact assessment are to develop a policy that corrects the problems and underpinning drivers identified in the problem definition (section 2):

1. Achieve additional cost-efficient energy savings for the motors already within scope by adjusting the ambition level in line with international and technical developments;
2. Achieve new cost-efficient energy savings for motors currently out of the scope, by ensuring where possible that no more inefficient motors and VSDs are traded on the EU market and aligning with current global standards.
3. Address the issue of loopholes and exemptions for mid-sized motors.

4.3. Consistency with other EU policies

Improved energy efficiency of motors and VSDs would contribute to the EU energy efficiency 2030 target of 32.5%, and to the 40% greenhouse gas reduction target by 2030. It is fully in line with the third dimension of the Energy Union[34] ("Energy Efficiency First") in which ecodesign plays a major role. It is coherent with the Commission priorities for the internal market ("A deeper and fairer internal market")[35], as it would encourage investment in R&D and provide for a level playing field for all market actors across the Union market. It is also consistent with the latest EU priorities in terms of Sustainable Development[36] in which energy efficiency is mentioned several times, and is aligned with the 2015 EU action plan for the Circular Economy, which includes comprehensive commitments on ecodesign (see in particular section 6.2.3 of this report indicating how the circular economy perspective has been taken into account)[37]. The contribution to the 2030 energy and climate targets is quantified in section 7.

Moreover, the regulation of motors is consistent with the existing provisions on energy efficiency in buildings as well as with existing Ecodesign requirements at product level for

34 COM/2015/080 final. Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee, The Committee Of The Regions And The European Investment Bank - A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy

35 COM(2015) 550 final Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions - Upgrading the Single Market: more opportunities for people and business

36 COM(2016) 739 final. Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions - Next steps for a sustainable European future European action for sustainability

37 COM/2015/0614 final. Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions - Closing the loop - An EU action plan for the Circular Economy

products including a motor. The rules for energy efficient buildings[38] call on MS to ensure that in the case of a new construction or a major renovation heating and cooling systems in buildings (which include motors) are optimised based on cost optimal calculations, whilst the motor regulation ensures that the least efficient motors included in buildings can no longer be sold.

5. POLICY OPTIONS

In order to address the issues identified in Section 3 and to achieve the policy objectives defined in Section 4, the following policy options are considered (detailed description in the next sections):

- BAU2015: no further action, the motor regulation currently in place remains unchanged;
- Voluntary agreement;
- Energy Label;
- ECO1: increase the ambition level for the motors within the current scope (0.75-375kW): remove the IE2+VSD option;
- ECO2: Same as ECO1, but expanding the current scope to larger motors up to 1000 kW. Also single-phase AC motors and 8-pole motors are included, as well as previously exempted non-integral brake motors and explosion-proof motors. For VSDs, requirements are also set;
- ECO3: Same as ECO2 but expanding the scope of ECO2 towards smaller motors, down to 0.12 kW;

These policy proposals are based on least life cycle cost calculations and reflect the latest developments of international standards for motors and VSDs.

5.1. No Action - BAU2015

This option implies that the current regulation stays in place and is not revised. In Sections 2 and 3 it has been explained why this is problematic and action is needed. This option is retained as a baseline (BAU) scenario (see Figure 5). It is worth noting that the current BAU scenario, which is the basis for evaluating the policy options, is different from the BAU scenario from 2009[39].

The current motor regulation covers electric three-phase AC motors with output in the range of 0.75-375 kW with exemptions for special motors (i.e. ATEX, Brake, Submersibles, motors with 8 poles or more) or those intended in special temperature or pressure conditions.

For motors in the range of 0.75-7.5 kW the current regulation had initially a minimum energy requirement of at least IE2 class. Per 1 January 2017 this became either 'IE3' class or 'IE2+VSD'. The latter was already the requirement for motors in the range of 7.5-375 kW, since 2015. The 'IE2+VSD' alternative was intended to promote the use of VSDs in variable load situations; it does not regulate the energy losses of the VSD itself.

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38 Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings

39 The BAU scenario from 2009 was a scenario without any ecodesign requirements in place. The current BAU scenario incorporates the requirements of the current regulation, and also covers more product groups to allow for an assessment of the scope extension. Both BAU scenarios are therefore not directly comparable. In the following sections, all references to BAU are referring to the current BAU (2017).

BAU		Year and minimum efficiency requirements (2016 onwards)					
AC induction motor<1000		2016	2017 (now)	2018	2019	2020	onwards
0.75-7.5 kW	3 phase, LV	IE2 →	IE2+VSD/IE3 →	→	→	→	→
7.5-375 kW	3 phase, LV	IE2+VSD/IE3 →	→	→	→	→	→

Figure 5: No action BAU scenario. All requirements are introduced in the currently applicable motor regulation.

In this scenario, the efficiency for all motors is assumed to improve autonomously and slowly beyond the existing minimum requirements due to suboptimal market development but not in the pace and at the levels that a regulation would achieve. The improvement pace is set based on similar energy efficiency improvements in the past.

This scenario implies that no requirements for VSDs are set and that MSA s will need to continue enforcing the IE2 plus VSD option.

5.2. Voluntary Agreement

A voluntary agreement, which is to be given priority according to the Ecodesign Directive, has not been proposed by industry. Minimum mandatory requirements are already in force for these products and in case of substituting those by a voluntary agreement there would be a risk of free riders in case not all actors present on the market would sign such an agreement and comply with it.

In any case, with no proposal put forward by industry, there is no voluntary agreement that would meet the conditions of the Ecodesign Directive and this option is thus discarded from further analysis.

5.3. Energy Label

An alternative to minimum energy efficiency requirements could be the use of energy labels according to the Energy Labelling Regulation[40]. These provide energy efficiency (linked to running costs) and other relevant information (e.g. on noise, water consumption, performance) to consumers. However, in almost all cases the motors in scope are purchased by professional buyers and are supplied to end-users as component of finished goods such as household appliances, industrial equipment, etc. Professional buyers may not always choose the most efficient motor for several reasons (as discussed in earlier sections), but these reasons do not usually involve lack of information or understanding of that information. A relatively small number of industrial motors, mostly as spare parts, are acquired through wholesale/retail channels. A larger fraction, in particular for integration in components or end-products, is purchased directly from the motor manufacturers that provide detailed information regarding product characteristics including on energy efficiency.

An energy label under the Energy Labelling Regulation would thus create administrative burden while offering little, if any, possible gain and is thus discarded.

5.4. ECO1 Proposal

The ECO1 proposal does not change the scope of the existing motor regulation, but requires all motors in scope to be aligned to the international IE3-level as of 15 January 2021 (see Figure 6). This aligns the requirements with current global trends and technological progress.

[40] Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU

ECO1		Year and minimum efficiency requirements (2016 onwards)					
AC induction motor<1000		2016	2017 (now)	2018	2019	2021	onwards
0.75-7.5 kW	3 phase, LV	IE2 →	IE2+VSD/IE3 →			IE3	→
7.5-375 kW	3 phase, LV	IE2+VSD/IE3 →				IE3	→

Figure 6: Proposed new energy efficiency requirements for ECO1 scenario.

The current regulation offers the possibility to either place an IE2-motor combined with a VSD or an IE3-motor on the Union's market. The IE2+VSD provision has proven difficult to enforce, which means that IE2 motors can be still be placed on the market without any guarantee that they will be effectively driven by a VSD. Based on revised life cycle cost calculations, the review study demonstrated that mid-sized IE2 motors are not cost-efficient any more. The ECO1 scenario therefore removes the IE2-motor plus VSD option. Under this option the energy use of the VSD s as such is not regulated.

5.5. ECO2 Proposal

This proposal is similar to the ECO1 proposal in that it includes the same new minimum energy efficiency requirements for the motors in the current scope. But the ECO2 scenario also extends the scope to larger motors and motors previously excluded, in line with developments in other jurisdictions. ECO2 is based on the findings of the motor regulation's review study, and takes into account comments from the Ecodesign Consultation Forum. This scenario does not consider the small motors under 0.75 kW.

The scenario also covers the energy efficiency of a VSD rather than their sole addition to a motor. This is supported by industry association CEMEP, and European manufacturers specifically developed an energy efficiency standard to allow for the VSDs' inclusion[41]. Furthermore, the scenario includes some previously exempted special purpose motors, which are also covered by minimum energy efficiency standards in the USA, and for which the exclusion is no longer justified (see section 2.2.3).

The most important additions to the ECO1 proposal are therefore:

- Larger low-voltage motors in the range 375-1000 kW are included and have to reach IE3-level from 15 January 2021.
- 8-pole motors are included from 1 July 2022, and have to achieve the same requirements as 2-4-6 poles motors.
- Single phase motors are included and have to reach IE2-level from 1 July 2022.[42]
- The energy efficiency of VSDs is included with a minimum requirement of IE2-level from 15 January 2021.
- Minimum efficiency requirements applicable to standard motors will also apply to special purpose motors (non-integral brake motors and explosion-proof (ATEX) motors) from 1 July 2022, with the exception of Exe increased safety motors (IE2 level).

Figure 8Figure 7 provides an overview of the scope of ECO2 and the related minimum energy efficiency requirements.

Figure 7: Proposed requirements and timing in ECO2 proposal.

[41] VSD are covered by the new IEC EN 61800-9-1

[42] Relevant for motors up to about 7.5 kW. Larger motors are always 3-phase.

ECO2		*Year and minimum efficiency requirements (2016 onwards)*					
AC induction motor <= 1000 V		**2016**	**2017**	**2018**	**2021**	**2022**	**onwards**
0.75-7.5 kW	3 phase, 2/4/6 pole	IE2 →	IE2+VSD/IE3 →		IE3 →		
7.5-375 kW	3 phase, 2/4/6 pole	IE2+VSD/IE3 →			IE3 →		
375-1000 kW	3 phase, 2/4/6 pole				IE3 →		
0.75-1000 kW	3 phase, 8-pole					IE3 →	
0.75-1000 kW	ATEX/non-integr. brake					IE3 →	
0.75-1000 kW	Increased safety Exe					IE2 →	
0.75 - 7.5 kW	1 phase					IE2 →	
Variable speed drive		**2016**	**2017**	**2018**	**2021**	**2022**	**onwards**
0.75-1000 kW					IE2 →		

5.6. ECO3 Proposal

This proposal is similar to the ECO2 proposal but it extends the scope towards small motors, down to 0.12 kW (both 3-phase and single phase) that are currently not regulated. These motors have to reach IE2-level from 1 July 2022. For VSDs, scope and requirements are similar to ECO2.

As for the other ECO options, the required energy efficiency levels are based on life cycle cost analysis (see Annex 9). The ECO3 scenario is also in line with developments in other jurisdictions and based on the findings of the review study, and takes into account comments from the stakeholders.

Figure 8: Proposed requirements and timing in ECO3 proposal.

ECO3		*Year and minimum efficiency requirements (2016 onwards)*					
AC induction motors <= 1000 V		**2016**	**2017**	**2018**	**2021**	**2022**	**onwards**
0.75-7.5 kW	3 phase, 2/4/6 pole	IE2 →	IE2+VSD/IE3 →		IE3 →		
7.5-375 kW	3 phase, 2/4/6 pole	IE2+VSD/IE3 →			IE3 →		
375-1000 kW	3 phase, 2/4/6 pole				IE3 →		
0.75-1000 kW	3 phase, 8-pole					IE3 →	
0.75-1000 kW	ATEX/non-integr. brake					IE3 →	
0.75-1000 kW	Increased safety Exe					IE2 →	
0.75 - 7.5 kW	1 phase					IE2 →	
0.12-0.75 kW	**1 & 3 phase**					IE2 →	
Variable speed drives		**2016**	**2017**	**2018**	**2021**	**2022**	**onwards**
0.75-1000 kW					IE2 →		

The extension to small motors implies that motors included in electrical household appliances are also concerned. Comments received during the stakeholder consultation from manufacturers of such products were extensively considered (see section 6.6).

Regarding the small 3-phase motors, LCC calculations indicated that there could be an economic justification for requiring IE3, but not as compelling for the larger 3-phase motors (see Annex 9 which shows that IE3 is more economical than IE2 in only 8 out the 12examined cases). Although IE2 and even IE3 are already commercially available from larger manufacturers, requiring IE2 would already necessitate a significant market transformation as these motors are not yet available from many of the smaller manufacturers that exist in the UE. Considering the other arguments put forward by the industry (e.g. see sections 6.6) and the fact that IE3 is not 100% economically compelling, sticking to IE2 for these motors is seen as a reasonable choice until a possible revision of the regulation.

5.7. Common provisions (miscellaneous)

A few improvements to the current text of the regulation are proposed for all ECO options. They are not expected to have a measurable impact but are meant to facilitate enforcement or avoid possible problems:

- Inclusion of 60 Hz motors: there is at the moment virtually no market in the EU for 60 Hz motors since the entire EU grid is operated at 50 Hz. However some stakeholders pointed to a risk of loophole if 60 Hz motors were placed on the market and operated by VSDs (at 60Hz or other frequency relevant for the application).
- The methods to calculate the energy efficiency of motors are to be adapted according to the latest international standards.
- To clarify the concept of continuous duty, a reference is to be made to the applicable international standard.

5.8. Other Sub-Options Considered and Discarded

5.1.1. Inclusion of medium-voltage motors

Currently only low voltage motors (i.e. below 1000 volts) are regulated. However, quite a few large motors (in the range 375-1000 kW) used in heavy industrial applications are produced as medium voltage motors (above 1000 volts), the advantage being that they can be connected directly to a medium voltage electrical grid without a transformer, resulting in reduced costs and reduced electrical losses. For the time being, no international classification exists regarding the energy efficiency of such motors.

Therefore, as an outcome of the review study, the Commission proposed to the Consultation Forum to include a review clause in the new regulation to address possible minimum energy efficiency requirements for these motors during the next review of the regulation. However, many stakeholders insisted on an immediate inclusion of these motors in the scope of the regulation, while CEMEP strongly argued that there was no agreed method for setting requirements for these motors.

Further consideration was given to this issue during the Impact Assessment. It was found that other parameters than energy efficiency are critical and decisive in the design and selection of these motors. This concerns notably the starting capabilities (warm and cold motor) as well as the specification of short circuit capabilities of the mains connection point at the customer premises. In the meantime, a CEMEP-CENELEC task force developed an approach for the determination of the efficiency classes for these motors. However, this does not contain the values, levels and tolerances that are necessary for the definition of the classes; these should be determined in a standard.

In conclusion it seems premature to set energy efficiency requirements for these motors, and the option of a review clause should be maintained, in parallel with the elaboration of an appropriate standard by CENELEC. The impact of this decision is limited because this represents a limited market (a few thousand motors sold each year in the EU) and these motors are often custom-made with high energy efficiency requirements anyway.

5.1.2. Energy efficiency requirements for motors set to IE4 level

A limited number of stakeholders requested that by 2020, motors within the range 0.75 kW – 375 kW should reach the IE4 energy efficiency level. This option was considered in the review study (2012-2104), which showed that the LLCC option of most motors was IE3, except the larger ones (e.g. 110 kW). However, the report also specified that the cost effectiveness of this measure should be reviewed under a range of operating conditions and highlighted some technical challenges like increased motor size. It concluded that if the IE4 markets develops well over the next three years (up to 2017), the IE4 level could be requested for the year 2022. However, the latest industry data shows a 0.5% market share for IE4 motors for 2015 and for 2016 in the EU. According to market intelligence reports[43], although IE4 motors are expected to nearly double in terms of revenue share worldwide, they will account for only 2.0% of global motor shipments by 2021. Moreover most IE4 motors on the market concern permanent magnet, synchronous and switched reluctance motors. These motor types are currently out of scope because they are intrinsically very efficient.

This indicates that the market is not mature yet for requiring IE4 for the motors in scope. However this should be considered in the future, through a review clause in the regulation.

5.1.3. Setting requirements for VSD and drives when sold together

Recently, a new standard (IEC 61800-9-2:2017) was finalised that sets limit values for a motor system, i.e. a motor and a VSD together. It takes into consideration the motor losses, the VSD losses, plus the losses induced by the VSD in the motor when both are combined. It allows to optimise the combination of a VSD and a motor. The option to regulate, on the basis of this standard, a motor and a VSD when they are supplied together came late in the impact assessment process and its implementation requires additional work. For instance the standard is not complete, it covers only for 4-poles motors. There are other difficulties to solve, including market surveillance aspects. This option should be further investigated when revising the new regulation, possibly at an early stage.

5.1.4. Inclusion of submersible motors

Although it was not presented as an option to the Ecodesign Consultation Forum in September 2014, the inclusion of submersible motors has been considered in this impact assessment. It was not retained because of lack of technical standard for energy efficiency determination.

5.9. Options for Impact Analysis

The shortlist of options for further analysis includes:

- BAU: no further action
- ECO1: keeping the scope of the current motor regulation while updating the requirements
- ECO2: similar to ECO1 but including larger motors and some motors excluded in the current regulation
- ECO3: Similar to ECO2 but including smaller motors

6. ANALYSIS OF IMPACTS

6.1. Introduction

Reliable data for the very heterogeneous electric motor sector is scattered. As mentioned in Section 1, electric motors can be found in many energy-using products, either as a main or as an auxiliary component. There is a large variety and motors sold as component, in sub-

43 Preston Reine, *Industrial Motors and Drives: Global Market*, paper submitted at the EEMODS 2017 conference, IHS Markit

assemblies and in assembled end-products. This brings a considerable uncertainty to the statistical information on the subject.

Most studies use, directly or indirectly, an interpreted version of Eurostat data to estimate sales. Industry associations such as CEMEP complement this information with production data reported by their members or specifically collected for a preparatory study or review. Global market research companies like IHS are a valuable source to confirm trends, but difficult to use in the public domain to verify detailed sales figures, because they may not have the desired categorisations and boundaries as the products in scope. Energy consumption is assessed from estimated averages for power outputs, operating hours, load factors and effectiveness of VSDs per category. These estimates are provided by various sources (literature, experts, etc.) and checked for stakeholder consensus.

The review study has provided considerable input, and has been complemented by further analysis, including a re-assessment of some of the life cycle cost calculations, data collection and stakeholder contributions (notably CEMEP). Some hypotheses made in the review study have been revisited as part of the present IA.

Estimated prices and price increase of motors due to ecodesign measures are based on market research and stakeholder consultation. Employment impacts are derived from revenue per employee, again checked against reported revenue totals for the sector and information from annual reports of individual manufacturers.

In this Impact Assessment, in line with the MEErP[44], (industrial) energy prices were assessed from Eurostat data and for future projections an escalation rate of 4% was used. All prices and costs are expressed in Euro 2010, calculated with historical inflation. For investment-type considerations, a discount rate of 4% is used, in line with the Commission's recommended values (IA guidelines).

For primary energy conversion rates for electricity generation and distribution a Primary Energy Factor (PEF) of 2.5 is used, implying by convention a 40% efficiency over the full projection period. For GHG emissions, the emission rate (in kg CO2 eq./kWh) does vary over the projection period in line with overall EU projections as indicated in the MEErP.

This Impact Assessment has made a major effort to reduce the inherent uncertainty of quantitative data within above mentioned limitations. It has subdivided the market in many segments each with their specific commercial and technical characteristics. Segments relate to power sources, power outputs, purposes and whether or not the motor is fitted with a VSD. Considering that not every cross-section generates meaningful results, the base cases were identified as shown in Table 1 below.

[44] See Acronyms for a definition, as well as annex 7 for detailed explanations on the model used.

Table 1: Market segments ('base cases') in stock model.

Voltage	Phase	Output	General purpose		Special purpose		
LV or MV	*1 or 3*	*kW-range*	*without VSD*	*with VSD**	*explosion-proof*	*brake-motor*	*submersible*
LV	1	0.12-0.75	x	x			
		>0.75	x	x			
	3	0.12-0.75	x	x			
		0.75-7.5	**c**	**c**	x	x	
		7.5-75	**c**	**c**	x	x	
		75-375	**c**	**c**	x	x	
		375-1000	x	x			
MV[45]		375-1000					

Note: c = current scope; x = extended scope as proposed by ECO2 or ECO3 - LV= low voltage, MV= medium voltage

**=In current regulation VSDs were stimulated through VSD+IE2 option; new policy options address the own power use of the VSDs*

The scenario calculations relate to the period 1990-2050 with special focus on the period 2010-2030, where the impacts of policy measures become apparent. More details of the modelling can be found in Annex 7.

As a result of the detailed analysis carried out for this impact assessment, the figures diverge to a certain extent from those in the review study (generally reducing the estimate of potential savings). Where energy savings have been found lower than in the review study, the Life Cycle Cost calculations have been reassessed, to make sure that the requirements levels still match the Least Life Cycle Cost levels even with lower savings (see Annex 9).

Also note that all data in section 6 relate to impacts from the motor regulation itself. Unless mentioned otherwise, the question whether some of the impacts 'would have occurred anyway' due to other ecodesign regulations for end-products is addressed in Section 7 (comparison of options). Background information on this issue can be found in Annex 8.

6.2. Environmental Impact

6.1.1. Electricity savings

All ECO scenarios save energy compared to the BAU. Figure 9 presents the electricity consumption in the EU for the various scenarios. Not revising the current motor regulation results in an energy consumption of 1 495 TWh/yr in 2030. The ECO1 option saves 4 TWh/yr in 2030 compared to the BAU while ECO2 saves 12 TWh/yr compared to the BAU. ECO3 saves 14.3 TWh, which is 20% more than ECO2. For comparison, 14 TWh/yr is more than the electricity consumption of Latvia and Estonia together in 2015.

Table 2 below gives, for the years 2030 and 2040, an overview of the annual electricity consumption in those years and the accumulative consumption 2020-2030 and 2030-2040 compared to the BAU scenario.

45 Inclusion of Medium Voltage motors was considered in the Impact Assessment but not retained as a valid option, see section 5.8.1

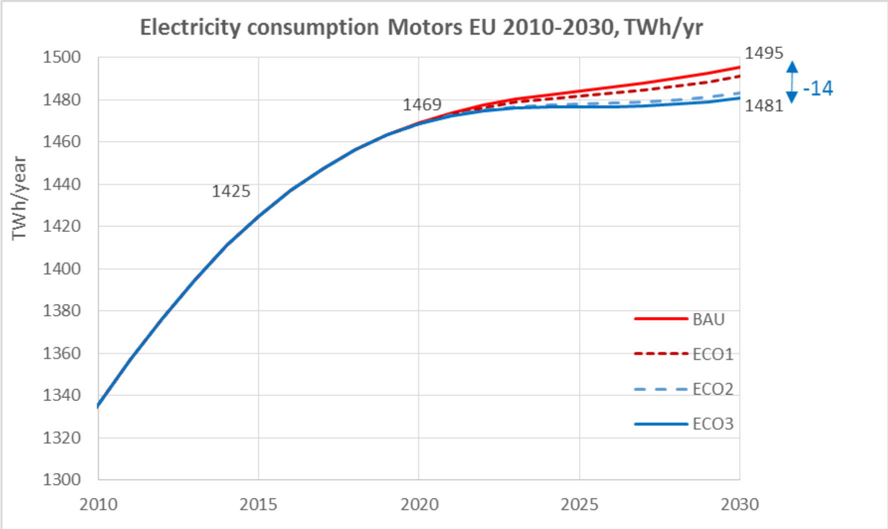

Figure 9: Electricity consumption of the different policy scenarios.

Table 2: Energy consumption of different policy options in TWh

Policy options	Annual			Accumulative	
	2020	**2030**	**2040**	**2020-2030**	**2020-2040**
BAU	1469	1495	1535	16317	31486
Difference vs. BAU					
ECO1		-4.3	-4.4	-26	-72
ECO2		-12.0	-14.1	-68	-209
ECO3		-14.3	-16.2	-82	-244

The table below shows the contribution of each motor type to the total energy savings in 2030 in the ECO3 scenario[46]. It can be seen from the table that about 60% of the impact stems from the scope extension.

Table 3 Contribution of each sub-category of motor to the total savings in the ECO3 scenario

Contribution of each sub-category of motor (TWh)	**2030**	**%**
3-phase 0.75-375 kW	5.8	41%
Small 1 phase motors 0.12-0.75 kW	0.9	7%
Small 3-phase motors 0.12-0.75 kW	1.4	10%
Single phase induction motors > 0.75 kW	2.5	17%
Large 3-phase induction motors 375-1000 kW	1.7	12%
Explosion proof motors 0.75-375 kW	1.2	8%
Brake motors 0.75-375 kW	0.7	5%
8-pole motors 0.75-375 kW	0.1	0.5%
Total	**14.3**	**100%**

6.1.2. Greenhouse Gas Emissions

Greenhouse gas (GHG) emissions, expressed in $MtCO_2eq$, follow the same trend as the electricity consumption. There is however a steeper downward trend in GHG emissions due to

[46] The savings associated with improved VSD efficiency is included in each motor type

a continuous decrease of specific GHG emissions per kWh electricity following increased use of renewable energy sources in EU electricity production and the shift to cleaner fossil fuels such as natural gas. Figure 10 gives an overview of the GHG emissions in the different scenarios. The policy option ECO1 saves 1.4 $MtCO_2eq$, and ECO2 a further 2.6 $MtCO_2eq$ compared to the BAU in 2030. ECO3 increases the savings by 20% up to 4.9 MtCO2eq.

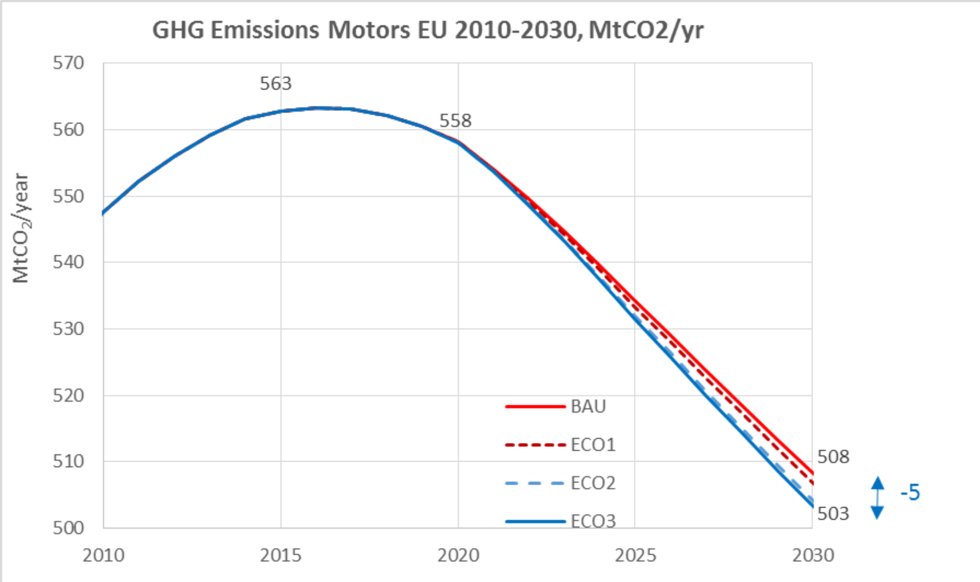

Figure 10: GHG emissions of the different policy scenarios.

Table 4 gives an overview of the gross GHG emissions and savings. For comparison, the savings are the equivalent of the annual emissions from 4 large (500 MW) fossil fuel fired power plants[47] or the equivalent of the annual GHG emissions avoided by over 2600 onshore windmills (2 MW each).[48]

Table 4: **GHG emission in MtCO2eq**

Policy options	**Annual**			**Accumulative**	
	2020	**2030**	**2040**	**2020-2030**	**2020-2040**
BAU	558	508	461	5873	10696
Difference vs. BAU					
ECO1		-1.4	-1.3	-9	-24
ECO2		-4.1	-4.2	-24	-69
ECO3		-4.9	-4.8	-29	-80

6.1.3. Other Environmental Impacts – Energy dependency

Reductions in the consumption of electricity in final energy demand are associated with multiple environmental benefits and are estimated to have an impact in reducing energy imports – especially oil and gas. The air pollution and health impacts are mainly achieved through the reduction of SO_2, NOx and PM emissions and corresponding pollution control costs. The 9.6 TWh net electricity savings in 2030 will induce 2.5 TWh savings of natural gas

[47] From Steen, M., Greenhouse gas emission from fossil-fuel fired power generation systems, DG-JRC/IAM and DG JRC, Analysis of energy saving potentials in energy generation-final results, DG-JRC Institute for Energy and Transport, 2012. Calculation: 500 MW * 8760 h/yr * 0.66 load factor * 400 kg/MWh = 1.156 $MtCO_2eq$/yr.

[48] 1.88 $ktCO_2eq$/windmill per year in the UK (size 2 MW, electricity produced 4.38 GWh/yr). See: http://www.pfr.co.uk/pfr/3/Renewable-Energy/15/Wind-Power/64/How-Much-Carbon-Dioxide/

(0.2 Mtoe), 0.1 TWh of oil (0.01 Mtoe), thereby reducing the energy dependency of the EU. It also saves 3.3 TWh of coal, for which dependency is less an issue.

6.1.4. Circular Economy perspective

The environmental life-cycle assessments in the technical preparatory studies, which are a part of the motor regulation's review, show that energy consumption and the related emissions, especially GHG emissions, are by far the most dominant environmental impact for this product category. The use of critical raw materials is minimal, because the products in scope are AC induction motors, meaning that they do not contain permanent magnets with neodymium (unlike Permanent Magnet motors). Metal content, especially copper content, of electric motors is high and achieving very high recycling rates is unproblematic. Further, the reparability of electric motors is good: bearings can be replaced and stators/rotors can be rewired. Therefore, it does not seem to be proportionate at this stage to consider additional measures in support of Circular Economy objectives or other environmental aspects for this product group, other than the exemption for spare parts mentioned below, and the provision of information relevant for disassembly, recycling or disposal at end-of-life, as already foreseen under the current measure. Comments were raised by some stakeholders[49] that accelerated phasing out of IE2 motors (envisaged under the ECO scenarios) would result in more waste as for certain motors repairs or replacements will no longer be possible. This possible effect on resource efficiency was taken into account (see in particular discussion on spare parts in section 6.5).

6.3. Economic Impacts

6.1.5. Product Costs

Changing production from IE2-level motors to IE3-level motors does not require new assembly lines or production plants. As stated by industry, it requires one-off redesign work and necessitates investment to replace some of the existing tools used in the production lines. More efficient motors tend to have higher labour costs and to require more copper, higher quality ferrite and to be heavier. Some of them are also larger (change of length or frame size in exceptional cases).

As a consequence, the selling price of the products in scope is expected to increase, typically by between 10 and 20% for the sector, representing additional production costs plus margin.

From Table 7, one can see that by 2030 the production costs for industry are expected to increase on average by 1.2%, 5.1% and 8.1% in 2030 for the ECO1, ECO2 and ECO3 scenarios respectively. The relative increases for trade and installers are assumed to be similar, as they are usually calculated as a margin on product costs. This cost increase applies to the transition from the current product mix of motors and VSDs of various efficiencies, to the energy-efficient mix described in the ECO scenarios.

Cost figures established under the review study carried out prior to the impact assessment[50] have been used, with updates where needed. Figure 11 gives an overview of the relationship between prices and energy efficiency of an exemplary motor type (M3 – 11 kW), with 2010 prices. For this motor type, the base case on the graph represents the IE0 level, the BAT (Best Available Technology) represents the IE4 level and the intermediate case is the IE2 level. In 2010, a typical 11 kW IE2 motor costs €680[51]. The price increase for an IE3 motor of this

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49 REFIT Stakeholder Platform meeting of February 2017.

50 De Almeida, A., Falkner, H., Fong, J. (2014). Lot 30: Electric Motors and Drives. *Ecodesign preparatory study for the European Commission*, Final Report

51 See Annex 7, Table 7.6, for price data.

size, which all the ECO scenarios would make mandatory, was calculated at 88€ (+13%) by interpolation between the intermediate case and the BAT. Actual price increases observed in 2017 for an IE3 motor of this size are about 10%, which indicates that the estimate was quite good. Due to further technological progress, and economies of scale, the price increase is estimated to become lower once new ECO requirements will come into force, making the switch to efficient motors economically even more beneficial for end-users. Annex 7, Table 7.6, shows market prices at three different efficiency levels (low, medium and best efficiency) for each of the 22 base cases.

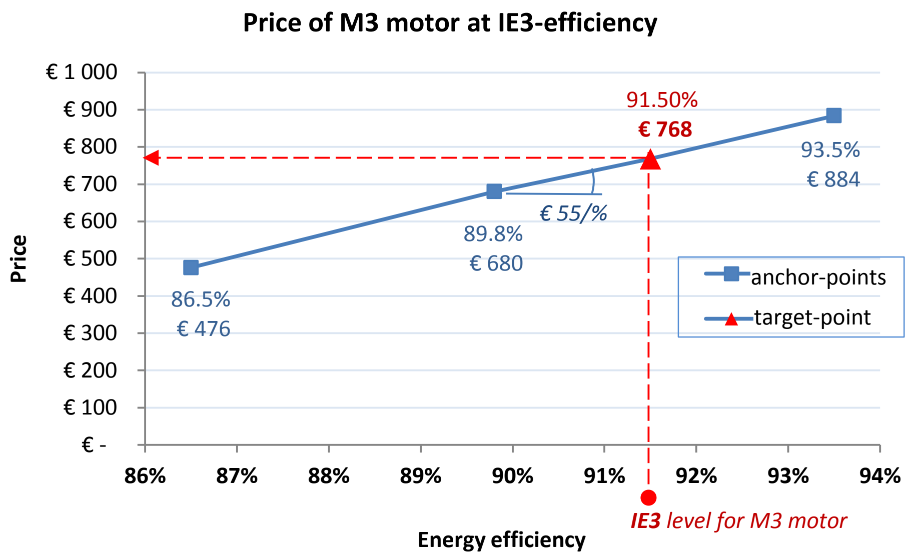

Figure 11: Prices and efficiencies are shown for Base Case, intermediate and BAT level motors. The price at other efficiency levels, e.g. at the IE3 level as shown as an illustration, is derived by interpolation.[52]

6.1.6. User Expenditure

End-users will face higher acquisition costs due to higher product costs, either as direct motor buyer (e.g. in some large industrial plants) or as buyers of goods in which motors are embedded (e.g. industry or households). However the overall expenditure over the lifetime of the motor is expected to go down due to energy savings. This is ensured through the selection of energy efficiency levels that match the least Life Cycle Costs over the product lifetime, as required by the Ecodesign directive. These cost optimum levels have been determined under the review study and where needed have been confirmed during the impact assessment (see Annex 9).

Table 5 gives the annual user expenditure, and Table 6 presents the accumulative expenditure since 2020 for the reference years 2030 and 2040. The first row of each table gives absolute expenditure for the baseline. The following rows relate to increase, due to acquisition and maintenance, and reductions, due to energy costs, in expenditure due to the proposed scenarios.

[52] From the three efficiency levels per base case the ratio of price/costs versus efficiency was assessed. With this ratio the initial price increase due to the efficiency improvement was calculated. A learning curve (and volume increase) effect of 1% per year was applied to calculate the price in a particular year. This price is split between industry, trade and installation at 54%, 26% and 20% respectively, i.e. fixed percentages that are customary in the sector.

Table 5: Annual user expenditure in billion Euros (Euro2010)

Policy options	Acquisition			Energy costs			Maintenance			Total		
	2020	2030	2040	2020	2030	2040	2020	2030	2040	2020	2030	2040
BAU	10.9	11.3	11.8	198	299	454	2.0	2.2	2.4	211	312	468
Difference vs. BAU												
ECO1		0.1	0.1		-0.8	-1.3		0.0	0.0		-0.7	-1.2
ECO2		0.5	0.5		-2.4	-4.2		0.0	0.0		-1.8	-3.7
ECO3		0.9	0.7		-2.9	-4.8		0.0	0.0		-2.0	-4.1

Table 5 shows an increase in annual acquisition costs in 2030 of up to €0.1 billion for option ECO1, €0.5 billion for ECO2 and €0.9 billion for ECO3. But overall, end-users will save €0.8 billion for option ECO1, €2.4 billion for ECO2 and 2.9 billion for ECO3 in 2030 due to energy savings[53].

Table 6 with accumulative expenditure shows that in the period 2020-2030 the users will invest around €1.5 billion more for option ECO1 but will save around €4.6 billion in lower energy bills. For option ECO2 the additional investments amount to €5.6 billion, while the energy savings reach €10.4 billion. For ECO3, the total additional investment is €9.2 billion and total energy savings amount to €14.6 for the period 2020-2030. For that option the benefits are more obvious when looking at the period 2020-2040, because the effects of the measure only take effect in 2022, as stipulated in section 5.6. Around that year the acquisition costs will rise in a significant manner due to new requirements in force, while the energy savings will take several years to materialise due to the progressive replacement of the motor stock. The cumulative effect in the period 2020-2030 is therefore mitigated. For the period 2020-2040, the picture is better as ECO3 induces an additional investment of €6.4 billion for the end-users, compensated by €8.0 billion energy savings over that period.

These figures provide an overall picture covering varied situations. More specifically, it is expected that industrial motor users will benefit substantially from the regulation through increased energy savings that are significantly larger than the incremental purchase cost of the motor. In the domestic and tertiary sector especially covered by the ECO3 scenario, users will experience various outcomes depending on the type of end-product and the usage they make of it. A user who rarely uses an appliance might experience an overall cost increase over the lifetime of the product, while an intensive user will experience substantial benefits. Overall, an 'average' domestic user will benefit from the regulation. Indeed, the energy efficiency requirements have been set in order to match the least life cycle cost for a typical application. Small motors for domestic appliances tend to be very cheap; therefore, should a financial loss occur for some end-users, it is likely to remain very limited. The cost-benefit analysis is described in Annex 9.

Table 6: Accumulative user expenditure in billion Euros (Euro2010)

Policy options	Acquisition		Energy costs		Maintenance		Total	
	2020-30	2020-40	2020-30	2020-40	2020-30	2020-40	2020-30	2020-40
BAU	122	238	2701	6488	23	46	2847	6772
Difference vs. BAU								
ECO1	1.5	2.6	-4.6	-16.0	0.0	0.0	-3.1	-13.3
ECO2	5.6	10.4	-12.1	-47.3	0.0	0.0	-6.5	-36.9
ECO3	9.2	16.8	-14.6	-55.2	0.0	0.0	-5.4	-38.4

[53] This does not represent a Life Cycle Cost calculation; it is the sum of all end-user costs in a given year.

6.1.7. Business Revenues

The increased motor acquisition costs discussed in Section 6.3.1 translate into a revenue increase for the economic actors: it is estimated that 54% of the increase will benefit the motor producing industry, 26% the traders and dealers, and 20% the installers (installation, assembly and maintenance).

Table 7: Business revenue for industry, trade and installers in billion Euros (Euro2010)

Policy options	Industry			Trade			Installers			Total		
	2020	2030	2040	2020	2030	2040	2020	2030	2040	2020	2030	2040
BAU	5.6	5.8	6.0	2.8	2.8	3.0	2.5	2.6	2.8	10.9	11.3	11.8
Difference vs. BAU												
ECO1		0.07	0.05		0.03	0.03		0.03	0.02		0.13	0.11
ECO2		0.29	0.25		0.14	0.12		0.11	0.09		0.55	0.46
ECO3		0.47	0.38		0.23	0.19		0.18	0.15		0.88	0.72

As can be deduced from Table 7, total business revenue increase by 1.2%, 4.8% and 7.8%in 2030 for the ECO1, ECO2 and ECO3 scenarios respectively.

Note that the modelling of revenues takes into account not only extra production costs based on today's pricing, but also a learning effect that reduces production costs by 1% annually.

However it has to be noted that in the current economic context the motors industry may not be able to materialise the full benefits of the regulation. Indeed since 2014 the oil and gas industry crisis has resulted in an unprecedented decline in investment in this sector, negatively affecting the global sales of motors and VSDs. This results in oversupplies, lower market prices and revenues for the motor systems industry. This means that suppliers may not be able to pass to their customers the full cost of more energy efficient motors. Sales are expected to recover in the period 2018-2021[54].

The product's value at end-of-life is assumed zero, i.e. costs for disassembly and disposal are assumed to be covered by revenue from recycling. Products in the scope are AC induction motors, meaning that they do not contain permanent magnets with neodymium. Hence there is no additional rest-value from recovery of this relatively rare material. Nonetheless, cost-neutrality is a conservative assumption, because the value of the metal content, especially of copper, is usually much higher than any recycling and disposal costs.

It has also to be understood that figures represent a global picture, as some manufacturers may get greater benefits than others. The specific case of SMEs is considered in the next section. Specific segments of the motor and VSD markets deserve a separate discussion:

a) *Very large motors (375-1000 kW)*

EU manufacturers have a very strong position in the manufacture (and export) of very large motors in the range of 375-1000 kW, covered in the ECO2 and ECO3 scenarios. The 'IE3' level is already in line with current trends. It does raise the EU ambition level to what is already, or soon expected to be, customary in the rest of the world and supports EU manufacturers in keeping their competitive edge.

b) *VSDs*

In the ECO2 and ECO3 scenarios, it is proposed to regulate the efficiency of VSDs in line with the international standard adopted early 2017. The energy efficiency IE2 level is proposed, i.e. the highest level in defined in the standard. Unfortunately there is not an

54 Preston Reine, IHS Markit, *Industrial Motors and Drives: Global Market*, paper submitted at the EEMODS 2017 conference

internationally agreed definition of higher levels (IE3 or IE4 levels): while many of 97 products analysed in a recent study largely exceed the minimal threshold for IE2 and potentially qualify for hypothetical IE3 or even IE4 levels, CEMEP's position is that defining and requiring levels above IE2 for VSDs is premature. Setting requirements for VSDs at the IE2 level will raise attention on VSDs and on VSD efficiency, will make sure all VSD manufacturers measure and declare VSD efficiency, will eliminate the mots inefficient drives that probably still exist on the market, and it will pave the way for tighter requirements in a future review of the regulation, based on a revised international standard. However in order to encourage the placing on the market of more efficient drives, it is proposed to define IE3 and IE4 classes in the regulation as part of the information requirements.

c) 8-pole motors

Based on life cycle cost calculation, the ECO2 and ECO3 scenarios include 8-pole motors that were previously excluded. These motors represent a very small market and are commercially available in IE2 and IE3 versions. According to CEMEP, manufacturers that have not already adjusted their production lines may face difficulties to make the necessary investments. This is why it could make sense to allow 3 years for this industry segment to adapt (i.e. 01/07/2022).

d) small motors (below 0.75 kW also called 'fractional horsepower' motors)

In ECO3, it is considered to extend the scope to the 'fractional horsepower' motors. The share of imports of these motors in the EU market is progressively increasing (from 13% in 2009 to 29 % in 2016). Imports are dominated by Asian companies in the form of separate motors or, above all, motors integrated in components or end-products. Third country producers that integrate the motors in products that then – as a component or end product – cross the EU border will have to declare compliance with the Ecodesign motor regulation on their document of conformity. The importers may be subject to document inspection and possibly also verification and testing by the EU market surveillance authorities.

The proposed ambition level of ECO3 for these motors is the ‘IE2’ level. This market can be categorised as follows:

i. Industrial 3-phase motors, for which IE2 is already commercially available but not widespread.

ii. Industrial single-phase motors, for which IE2 represents an ambitious level, that is not currently widespread. It is however economically justified due to the intensive use of these motors in the industry.

iii. Single-phase motors used in domestic appliances that are produced in very large quantities, are usually less robust and tend to be very cheap. Here the IE2 level also represents an ambitious level, not widespread on EU market. It has an economic justification because the extra cost of these motors will be compensated by energy savings also when assuming only 400 running hours per year (see annex 9). It as to be noted that for smaller motors, energy savings are proportionally higher than for large motors (see figure 1.2 in Annex 1): for example a 0.37 kW 4-poles IE2 motor consumes 9.2% less than its IE1 counterpart.

Smaller motors being also produced by smaller companies, it is believed that sufficient time should be provided for industry to adapt to this market transformation. This is why requirements in the ECO3 scenario could be proposed to enter into force as of 1st July 2022.

See also discussion in section 6.6 for further discussion of the specific case of motors integrated into products.

e) Single phase motors

For single-phase motors over 0.75 kW covered in the ECO2 and ECO3 scenarios, it is also believed that sufficient time should be provided for industry to adapt, for similar reason as described above for small motors.

f) Special purpose motors (brake motors and explosion-proof motors)

Regarding brake motors, which are usually a standard motor with a brake to abruptly slow or stop the shaft rotation, there is a general consensus among stakeholders in favour of removing the exclusion. One exception would remain for integrated brake motors[55] as the motor cannot be tested independently. CEMEP has pointed out technical difficulties related to the intermittent nature of brake motors operation and has argued for setting requirements at IE2 level. This would reopen a risk of loophole and is not seen as a major issue: the regulation proposal is limited to motors rated for continuous duty; brake motors working and rated for intermittent duty would in fact be excluded.

Similarly the exemption provided for explosion-proof (ATEX) motors could be defined more specifically, and the distinction should be made between motors operating in explosive atmospheres generally, for which there is no reason to foresee an exemption, and Increased Safety (Exe) motors, as defined in IEC EN 60079-7, which have certain technical specificities such as larger clearances, that may not enable them to reach high efficiency levels such as IE3 and for which IE2 is therefore proposed. This is in line with the provision of the international standard on motors energy efficiency (IEC 60034-30-1). For both categories, sufficient time adaptation is needed in order to adapt the products if needed, and allow the notified bodies to perform the conformity assessment pursuant to the ATEX directive[56] where applicable.

6.1.8. SMEs

The impact on SMEs needs to be considered along the whole value chain, taking into account the benefits for the segments of trading, customizing, installing and servicing motors, as well as fan users, balancing the possible difficulties for some specific market segments.

SMEs producing electric motors in the current scope are rare. Market data suggest that to be competitive in the production of standard motors a company size of more than 500 employees is needed. And even then, these 'smaller companies' like Marelli Motors[57] or Gruppo Lafert[58] tend to specialise on those market segments where the competitive edge stems from their customer service and tailor-made solutions to very specific needs.

The scope extension towards smaller motors considered in ECO3 would involve a greater number of SMEs directly active in motors production. CEMEP highlighted that for this specific market segment smaller companies could face difficulties in making the investments needed to produce high efficiency motors, with the risk that their production would cease. Similar difficulties were mentioned for single phase motors and 8-pole motors, for which they believe the narrow EU market does not justify the necessary investments.

The investments required to transform the production lines are proportionally more significant for SMEs than for larger companies, hence the potential difficulties. SMEs whose product range includes mainly motors in the new scope will be more affected. However in practice the

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55 Motors with an integrated brake where the brake is an integral part of the inner motor construction and can not be removed or supplied by a separate power source during the testing of motor efficiency.

56 Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast).

57 More information on Marelli Motors can be found online: www.marellimotors.com

58 More information on Gruppo Lafert can be found online: http://www.lafert.com/ita/corporate-mission.php

product range of SMEs tend to be quite diverse, including for example motors already in scope for which the investment has already been made, motors in the new scope requiring additional investments, and motors not in scope for which no investment is needed. It sometimes includes other types of equipment as well.

In total probably about 120-150 competitors are active on the EU market of small industrial motors. About 80 companies are based in the EU, and imports come mainly from countries such as China (Wolong, Blue Ocean, Klee, Able, Techtop, etc.), Thailand (Fasco), US (Weg, Franklin, etc…) or Turkey. A series of large players (not SMEs) dominate the market: it is believed that about 20 companies such as Siemens, EBM, Nidec, ABB, Wolong ATB, SEW, Danaher, Lenze, Hanning, Lafert, Baumüller, Nord, Stöber, EME-Unilectric, Motovario, AEG, Amer, Came, … dominate the market of small industrial motors with a share of about 70%-80%[59].

However the main presence of SMEs in the motors business resides in importing, reselling, customising, installing and maintaining, although exact numbers are not available as these small companies supply a broad range of industrial services, of which motor related activities are only a part. These SMEs will benefit from the new regulation through increased business revenue, as explained in the previous section. The greatest benefits are expected in the ECO3 scenario (largest revenues).

SMEs using motors in the course of their activities will benefit from the new regulation through reduced costs over the lifetime of the motors, as any increase of motor prices will be compensated by greater savings in energy bills. Considering the widespread use of motors, this will provide benefits to many enterprises. The benefits are proportionate to the energy savings, which means that ECO3 will provide the greatest benefits.

As mentioned above, the impact on SMES needs to be considered along the whole value chain, taking into account the benefits for the segments of trading, customizing, installing and servicing motors, as well as motor users, balancing the difficulties for some specific market segments. We consider that the overall benefits of the measure on SMEs, taking into account the whole value chain as highlighted above, will outweigh the difficulties that may be encountered by the SMEs specifically active in motors manufacturing, leading to the conclusion that ECO3 may be an advantageous option for SMEs.

6.1.9. Innovation, Research and Development, Competitiveness and Trade

In 2014 ABB employed around 8 500 researchers and developers in more than 30 countries. ABB's research and development (R&D) investments in 2014 totalled $1.5 billion, representing 3.8% of revenues. In 2013, Siemens invested €4.29 billion in its total R&D. This represents 5.7% of revenue. Also Schneider Electric devotes 5% of its revenue to R&D (€1.2-1.3 billion). Assuming proportionality with sales, these three companies globally spend more than €1 billion annually on R&D for new products and new production facilities of motors and VSDs. For the sector as a whole, the R&D expense in motor systems may be as high as €1.5 billion.

Overall, the revision of the motor regulation is expected to support innovation and drive market transformation, similarly to what could be observed in the past (see Annex 5). It is in line with ongoing market trends towards higher energy efficiency, and will act as a catalyst towards more energy efficient motors and VSDs. However it is not expected that the

[59] According to a personal communication by a motor manufacturer representative.

regulation will lead to any significant structural increase of R&D budgets because products meeting the requirements are already commercially available on the market. Impact will be most limited in the ECO1 scenario, as IE3 motors are largely available today. Under ECO2 additional process innovation may be required, mainly for single-phase or 8-pole motors and for companies not producing energy-efficient VSDs. For ECO3, process innovation may also be required, especially for single-phase motors – thus bringing in a category that so far has not yet been subject to minimum requirements in the EU. As the techniques to improve energy efficiency of induction motors are known already, innovation is likely to focus on cost-reduction, except for companies willing to offer products going beyond requirements.

This development of innovative energy-efficient technologies at competitive prices will enhance competitiveness of European manufacturers in home and foreign markets. On the contrary, no action (the BAU scenario) could lead to lower R&D spending or declining revenues, because the demand for innovative motor systems would be lower and hence reduce pay-back on R&D investments.

It has to be noted that new requirements assessed in this Impact Assessment would be introduced within a timeframe that is in line with the market's investment and innovation cycle, as established through consultation with industry stakeholders. The new requirements would be technology-neutral, as manufacturers are free to choose the options in order to improve the efficiency of their motors. A review clause is foreseen in order to keep pace with technological developments.

6.1.10. Administrative costs

a) Industry

The existing motor regulation defines that the assessment of conformity to the requirements is based on self-declaration by manufacturers, which is still seen as most appropriate option for any potential revision of the regulation. No stakeholder or Member State expressed doubt about the appropriateness of this system, or requested a different basis for the conformity assessment. This system of conformity assessment, in conjunction with compliance verification by MSAs (Market Surveillance Authorities), is considered capable of ensuring an effective and efficient implementation of all policy options. In line with the established practice for legislation on the EU's single market for goods, the proposed policy options would make use of the CE marking with a declaration of conformity. In practice, when placing products regulated by ecodesign on the market, companies are therefore required to:

i. assess the product’s conformity with the relevant requirements (typically requires physical testing of product energy efficiency)

ii. issue an EC declaration of conformity

iii. affix the CE mark on the products

iv. keep the documents relating to conformity assessments and declarations of conformity available for inspection by Member States for a period of 10 years after the last product has been manufactured

(i) (ii) and (iv) are performed once for each product type and do not need to be repeated for each individual product of this type that goes out of the factory. Therefore there are no additional administrative or reporting requirements for companies already producing IE3 motors in scope. Companies placing products on the market in the proposed new scope (ECO2 or ECO3 scenarios), or that are newly producing IE3 motors in the existing scope (ECO1 scenario) will of course have to go through the self-declaration procedure described above.

The current motors regulation also contains information requirements (Annex I.2: product information requirements on motors) : motor manufacturers and manufacturers of products in which motors are incorporated have to provide information listed in points 1 to 12 of the annex on their free access websites and technical documentation[60]. However following assessment of stakeholder comments, it appears that these information requirements could be revised, removing unnecessary administrative burden, in particular for manufacturers of products containing motors.

b) Authorities

The form of the legislation would be a Commission Regulation, which is directly applicable in all Member States. This means there are no costs for transposition of the legislation into national legislation.

The Impact Assessment on the recast of the Energy Labelling Directive[61] calculated the administrative burden of introducing a new implementing directive, similar to the proposed ecodesign implementing measure, in accordance with the EU Standard Cost Model. It estimates the administrative cost of implementing measures in the form of a Directive at €4.7 million of which €720 000 for administrative work on the amendment and development of the new directive and €4 million for transposition by Member States. It follows that the administrative cost of a Commission Regulation would be not more than €720 000. Further, most of these costs also arise in the BAU case, because the review leading to a revision, with all the involved costs, is a legal obligation on the Commission through the existing motor regulation.

MSAs are currently enforcing the motor regulation through compliance checks. An extension in scope increases the extent of surveillance activities as for any ecodesign regulation but does not create specific technical challenges. To the contrary, the current regulation addresses several loopholes and problems encountered by MSAs in the context of the current regulation. Enforcement involves random spot-checks by MSAs, but from experience with other regulations of this type most spot-checks are not random but follow a risk-based approach e.g. based on indications of competitors or third parties (e.g. industry or specific complaints of buyers). In those cases, MSAs maybe in a position to recuperate testing and legal costs, and to collect fines.

Based on (incomplete) data collected from Member States it was estimated in the IA for the revision of the energy labelling Directive (2015) that total market surveillance spending by Member States was likely to be around € 10 million annually for ecodesign and energy labelling. If one assumes equal spending for the +/- 45 ecodesign / energy labelling measures, the spending is about 200.000 € per measure. Increasing the scope of the motors regulation is likely to result in a shift of resources rather than an increase of resources: MS budgets for market surveillance do not increase in proportion to the scope of products to be covered; each Market Surveillance Authority establishes its own priorities, often on a risk-based approach.

Surveillance also encompasses activities such as outreach to actors (through webinars, brochures…) whose cost does not depend on the size of the scope of individual measures.

The EU is taking several measures to improve effectiveness of market surveillance such as support to the ADCOs (Administrative Cooperation Groups), the setting up of an energy

60 The information does not need to be published on motor manufacturer's free access website for tailor-made motors with special mechanical and electrical design manufactured on the basis of client request.

61 Commission staff working document - Accompanying document to the Proposal for a directive of the European Parliament and of the Council on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products - Impact assessment, COM(2008) 778 final, SEC(2008) 2863

labelling products database, the preparation of guidelines, and the review of the enforcement legislation on products. It also provides financial support to joint surveillance actions in the field of ecodesign and energy labelling.

Regarding motors integrated as components into end-products, a first compliance check can be done based on the technical documentation at no additional cost, for instance to ensure that the motor bears the CE-mark and that it is accompanied with the necessary technical documentation proving compliance. If the MSA wants to test the motor this may lead to higher costs if the motor has to be dismantled from the product in which it is integrated. However MSAs have other ways to have access to such motors, e.g. they may order them from the motor supplier or ask to the appliance manufacturer to provide them.

6.1.11. Intellectual Property Rights

Motors of efficiency class IE3 are commonly available from all major manufacturers. No stakeholder such as industry associations or individual companies raised concerns that more stringent ecodesign requirements would impose proprietary technology on manufacturers.

6.1.12. Stranded investments

When a regulation is reviewed and tighter requirements are proposed, the question of stranded investments arises. In the case of motors, the risk of stranded investments might exist for the production of IE2 motors. As of 16 June 2011, the IE2 efficiency level was required for all motors under scope of 640/2009. IE3 level have been introduced on 1 January 2015 and 1 January 2017 depending on the power, but IE2 motors are still allowed if equipped with a VSD. According to the three assessed ECO policy options, the IE3 efficiency level will be mandatory for these motors, as of 15 of January 2020. This means that investments in the production of IE2 motors (supposedly made before the IE2 requirement entered into force i.e. 16 June 2011) will last for 9 years at least. Considering the high depreciation rates practiced by the industry, 9 years is an appreciable duration and therefore the proposed phase-in time should not result in significant stranded assets. The industry association CEMEP did not raise this issue and was supportive to moving to the higher IE3 efficiency level for the motors currently in scope. In conclusion, stranded investments do not seem to be a concern for the proposed ECO measures.

6.4. Social Impact

6.1.13. Affordability

Electric motors are generally not directly purchased by private consumers. The motors in scope are sold to industry, the energy sector and to some extend also the tertiary sector, with many used as components in end-products. The scope extension under ECO 3 will also increase the efficiency of motors in many household appliances. The end-users will experience some increase in purchase price for their motorised products. There will be an overall change in the balance between upfront acquisition costs (which increase) and running costs (which will be lowered) but, as indicated in Section 6.3.2, the large savings in energy costs make this investment attractive (see also annex 9).

6.1.14. Health, Safety and Functionality Aspects

There are no specific health and safety aspects related to the measures analysed. Explosion-proof and other motors will still have to comply, and can comply, with EU safety requirements. There are no known negative impacts from using more efficient motors as prescribed by the policy options.

6.1.15. Employment

Impact on EU employment was estimated from average revenue per job. For industrial jobs (manufacturing, OEMs and business services) this is set at €50,000 per job. For trade (logistics, retailers, agents, importers and whole sellers) €60,000 per job is assumed and for installation work the revenue is set at €100,000 per employee. A share of these jobs, especially the OEMs, will be created outside the EU[62].

The new policy options will add around 6,500 (ECO1 scenario) to 20,000 jobs (ECO2 scenario) by 2030. The methodology, which is in line with latest publications on the issue[63, 64], takes into account only jobs in the supply chain. Induced employment from spending of e.g. employee's earnings or tax revenues is not taken into account here, but would only increase the total number of jobs created.

6.5. Exemptions

During stakeholder consultation, a number of technical difficulties related to the existing or new regulation were raised by stakeholders. These were taken into consideration during the impact assessment, and the following exemptions are considered in order to ensure smooth implementation of the regulation:

a) Spare parts

Under the current regulation, a motor supplied as spare part, to replace a motor that was not regulated when it was placed on the market, has to comply with the latest requirements applicable at the time it is supplied. This supports a fast replacement of the inefficient motor stock. However in some situations this can create difficulties. Indeed, energy efficient motors have different characteristics than standard motors. The extent to which these specific characteristics diverge depends on the strategies used by manufacturers to increase the efficiency for a specific model. In general however, energy efficient motors tend to be heavier, sometimes larger, and to have higher inertia (heavier rotor). Such differences may cause practical problems when replacing an existing motor by a more energy–efficient one, for example in an industrial installation or a complex product in which the motor is integrated. Sometimes this may be resolved by simple adaptations, by re-engineering, but in some cases this might be uneconomical and the product in which the original motor was integrated has to be replaced by a new product. This is not necessarily an optimal outcome in terms of circular economy. To resolve these issues industry players have advocated for an exemption for motors supplied as spare parts. Such exemption would favour the reparability of products in which the motors are integrated, but it slows down the replacement of inefficient motors and it creates a potential loophole, as it is quite difficult for market surveillance authorities to trace motors sold as spare parts and make sure they are effectively used as such. Therefore the exemption should not be allowed for an indefinite period of time. In the circulators regulation[65] a 5-years exemption has been allowed for circulators integrated in products, which face a similar issue. This is considered insufficient by industry. As an outcome of the reflexion, a spare parts availability of 7 years is proposed for motors integrated in products, as a pragmatic solution allowing to balance the justified need of spare parts availability and the necessity to limit the existence of the loophole in time.

[62] Ecodesign measures are not assumed to have a significant impact on outsourcing and factory location strategy of companies.

[63] Cambridge Econometrics, E3M-Lab, Warwick Institute for Employment Research & ICF International (2015). Assessing the Employment and Social Impact of Energy Efficiency. *Final Report.*

[64] Europe Economics (2015). The Economic Impact of the Domestic Appliances Industry in Europe. *Report for the European Committee of Domestic Equipment Manufacturers (CECED).*

[65] Commission Regulation (EC) No 641/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for glandless standalone circulators and glandless circulators integrated in products

b) Nuclear installations

Motors specifically designed and qualified to ensure safety of nuclear installations, as defined in article 3 of Directive 2009/71/EURATOM should be excluded because the high cost associated with requalification in the nuclear domain.

c) Totally Enclosed Non-Ventilated (TENV) Motors and TEAO (Totally Enclosed Air Over)

TENV motors are designed to operate without a fan and they predominantly dissipate heat by radiation. Their nominal output power is therefore typically only 30% compared to a standard IEC “air cooled” motor and are designed in larger frame size (size of the motor body). They are provided without their own fan and cannot therefore be tested separately.

TEAO motors are designed to be cooled by the specific air stream of the driven equipment (e.g. a fan). Therefore testing requires a dedicated cooling device. There is currently no internationally recognised test method for such motors.

d) Integrated brake motors

Motors with an integrated brake where the brake is an integral part of the inner motor construction and can neither be removed nor supplied by a separate power source during the testing of motor efficiency should be excluded because they cannot be tested independently (replaces the general exemption for brake motors in regulation 640/2009).

e) Increased safety motors

Increased safety motors (Exeb) as defined in standard IEC EN 60079-7:2015 should be assigned the IE2 level as discussed in section 2.2.3 (replaces the general exemption for motors designed to operate in potentially explosive atmospheres in regulation 640/2009).

f) Motors with mechanical commutators.

Mechanically commutated motors (e.g. Universal motors and some DC motors) have a very low operating time limited by the lifetime of the commutators. The preparatory study has shown that they have a low environmental impact. This exemption was not in regulation 640/2009 because its scope was limited to squirrel cage motors that by definition did not have commutators.

g) Motors in cordless or battery operated equipment, in hand-held equipment whose weight is supported by hand during operation, and motors in hand-guided mobile equipment moved while in operation;

This exemption is justified by the fact that it concerns equipment usually devised for occasional/intermittent use with low energy saving potential, and that possible weight increase of the motor could impede the functionalty of the end-product.

h) Motors specifically designed for electric vehicles;

The forthcoming revision of the CO2 emission standards for light duty vehicles is expected to include measures to incentivise electric car use, and it does not seem appropriate at this time to interfere.

i) Other exemptions already foreseen in regulation 640/2009 (as amended by regulation 4/2014)

(1) motors completely integrated into a product (for example gear, pump, fan or compressor) of which the energy performance cannot be tested independently from the product;

(2) motors specified to operate exclusively:

(i) at altitudes exceeding 4 000 metres above sea-level;

(ii) where ambient air temperatures exceed 60 °C;

(iii) in maximum operating temperature above 400 °C;

(iv) where ambient air temperatures are less than – 30 °C

(v) where the water coolant temperature at the inlet to a product is less than 0 °C or exceeding 32 °C;

(3) motors designed and specified to operate wholly immersed in a liquid[66];

j) VSDs

For VSDs, exemptions for spare parts and nuclear installations should be considered for the same reasons as explained above for motors, as well as for VSDS integrated into a product and whose energy performance cannot be tested independently from the product;

6.6. Inclusion of Motors used in End-Products

Integrated motors of which the energy performance can be tested independently are included in the scope of all proposals (BAU, ECO1, ECO2, and ECO3). This also includes motors in end-products that are themselves regulated through ecodesign implementing measures. This concerns for example motors used in industrial fans and pumps, and, in the case of the ECO3 option, small motors that may be included in household appliances such as washing machines (see Annex 8 for a detailed overview of such situations).

During the consultation process, the various segments of the industry have expressed diverging views on the issue of motors used in end-products.

On the one hand, EU producers of end-products where motor efficiency is important in meeting performance requirements of the end-product (fans, pumps, compressors, ventilation units, etc.) consider that requirements on motors are essential as they help them in meeting their own requirements by ensuring the availability of energy efficient motors and by reducing the price of efficient motors through larger production volumes. The envisaged approach is one of "cascading regulations": one energy efficient component (e.g. a motor) enables the energy efficiency of another component (e.g. a fan) to be improved which in turn can improve the efficiency of a final product (e.g. an air handling unit).

On the other hand, manufacturers of end-products for which efficient components are not critical in reaching a minimum efficiency tend to have a different view. They object that they will have to pay a higher purchase price for the motor and consider there are cheaper ways than an efficient motor to meet ecodesign requirements for their end-products, e.g. in the case of washing machine manufacturers. They request that motors used in end-products, which are already subject to their own ecodesign requirements, should be exempted from the motor regulation. They describe this as 'double regulation'[67]. Some stakeholders have suggested that the exemption should be more specific and target specifically 'bespoke 'motors, i.e. those tailor-made for a specific end-product manufacturer based on his specifications.

[66] There are currently no standards for these motors; their inclusion should be considered at a later stage (revision).

[67] The term 'double regulation' used by industry can be misleading because all motors are subject to a multitude of regulations and standards, not only in the EU but around the world. Following this logic, all motors are subject to 'multiple regulation'.

Besides the diverging industry positions, the first vision is supported by environmental NGOs and a few Member States, while a larger number of Member States support the second vision.

However such an exemption would create a number of problems. First of all, if motors used in regulated end-products are exempted it creates significant market surveillance difficulties and potential loopholes. An exemption for motors used in regulated end-products would no longer be based on tangible, physical characteristics of the product but on its trade route. Surveillance would thus mean that MSAs would have to trace a product to its final destination and if found non-compliant, i.e. the motor ends up in an end-products not covered by a separate ecodesign measure, the MSAs would have to go back to the producer/importer to prove that he or she placed the product on the market with a false declaration as regards the final destination. This would create a considerable burden for surveillance authorities, rendering market surveillance complex and inefficient. Limiting the exemption to ‘bespoke’ products does not reduce the risk of loophole.

Furthermore, the potential misuse of these motors would create legal uncertainty, because the entity placing the product on the market needs to guarantee with the CE-marking the product’s conformity, and therefore its later use. This entity can, however, not guarantee the usage of the motor once sold on the market. Effectively, a manufacturer or importer can only prevent this legal uncertainty by not placing such product on the market at all, which would effectively translate into a ban of these products.

Moreover, it could create an uneven playing field for competition between motors manufacturers and ultimately create ineffective regulation. EU motor manufacturers are assumed to upgrade their product range to meet the new efficiency requirements, while some extra-EU motor manufacturers could deliver low-cost, inefficient motors as long as they are incorporated in ecodesign-regulated products. This forces the EU motor manufacturers to split their efforts in two: a low-cost, inefficient segment to compete with extra-EU counterparts and an efficient, compliant segment where they deliver the quality required. Importers into the EU do not have that problem as they would be able to just focus on the low-cost segment.

An industry association presented a case-study aiming at demonstrating that the so-called ‘double regulation’ would be detrimental to the end-user. However this example has been analysed and is not considered realistic with regard to several assumptions made. As a matter of fact, Life Cycle Cost calculations carried out in the context of the Impact Assessment lead to a much shorter and acceptable pay-back, as discussed in Annex 9.

It is also necessary to consider the expected positive effects of the scope extension in other segments of the value chain, i.e. increased revenues and jobs in trading, customizing and servicing motors, as well as energy savings for the motor users. Considering all of the above and the outcome of the preceding impact assessment chapter, one can conclude that motors used in end-products should be covered.

6.7. Conclusion on Economic, Social and Environmental Impacts

There are no individual impact categories that are problematic, either for the current regulation or for any of the considered changes to it.

The current regulation is on track to save about 100 TWh/yr in energy, 35 MtCO_2eq in GHG emissions and almost €19 billion in user expenditure in 2030 with respect to the baseline without measures. Business revenue for industry is expected to increase by €1.6 billion euros in 2030, resulting in additional 26 000 jobs (see table 5.1 in Annex 5) compared to a situation without the current regulation.

The proposed ECO policy options all provide additional benefits, as shown in the table below.

Table 8 Overview of the main impacts of the policy options

Impacts	unit	2020 absolute BAU	Impacts 2030 absolute BAU	Impacts 2030 increments ECO1	Impacts 2030 increments ECO2	Impacts 2030 increments ECO3	Impacts 2040 absolute BAU	Impacts 2040 increments ECO1	Impacts 2040 increments ECO2	Impacts 2040 increments ECO3
Electricity use	TWh/yr	1469	1495	-4.3	-12.0	-14.3	1535	-4.4	-14.1	-16.2
GHG emissions	$MtCO_2eq$	558	508	-1.4	-4.1	-4.9	461	-1.3	-4.2	-4.8
Acquisition costs	billion €	10.9	11.3	0.13	0.55	0.88	11.8	0.11	0.46	0.72
Energy costs	billion €	198	299	-0.8	-2.4	-2.9	454	-1.3	-4.2	-4.8
User expenditure	billion €	211	312	-0.7	-1.8	-2.0	468	-1.2	-3.7	-4.1
Industry revenue	billion €	5.62	5.78	0.07	0.29	0.47	6.03	0.05	0.25	0.38
Trade revenue	billion €	2.77	2.85	0.03	0.14	0.23	2.97	0.03	0.12	0.19
Installer revenue	billion €	2.51	2.64	0.03	0.11	0.18	2.82	0.02	0.09	0.15
Employment (max)	000 jobs	184	190	2.2	9.4	15.0	198	1.8	7.9	12.3

The policy option ECO1 would add to that an extra saving of 4.3 TWh/yr, 1.4 $MtCO_2eq$ in GHG emissions and €0.7 billion in user expenditure in 2030. Business revenue is expected to increase further by €0.13 billion in 2030, resulting in 2 200 jobs.

Policy option ECO2 has higher savings and would add an extra saving of 7.7 TWh/yr, 2.6 $MtCO_2eq$ in GHG emissions and €1.1 billion in user expenditure in 2030. Business revenue is expected to increase by €0.42 billion in 2030, resulting in up to 7 200 additional jobs compared to the ECO1 scenario.

ECO3 scenario adds further savings on top of the ECO2 scenario: 2.4 TWh/yr, 0.8 MtCO2eq in GHG emissions and €0.14 billion in user expenditure in 2030. Business revenue is expected to increase further by €0.33 billion in 2030, resulting in extra 5 600 jobs.

The 2030 figures provide only a partial view of the effect of the regulation, because by 2030 the effect on the whole motor stock will be limited (due to enforcement dates being 2021 and 2022). As shown in the tables above, the effects by 2040 are generally more significant.

There is also a distributional element in the ECO3 scenario due to the extension of scope brings in new beneficiaries to motor energy efficiency requirements such as the private households which so far were not directly benefitting from it.

Note that these are gross savings. The net savings, i.e. subtracting impacts that would result from other ecodesign regulations, are one-third lower and will be presented in Section 7.

7. COMPARISON OF POLICY OPTIONS

Data in Section 6 relate to impacts from the motor regulation and proposed policy options themselves. Some of these impacts would happen anyway due to requirements on end-products in other ecodesign regulations in which motors are included. This section concentrates solely on net impacts, i.e. the share of impacts that would definitely not occur without the motor regulation.[68] This part is therefore especially relevant for policy making. Table 9 provides an overview of the net impacts of the options for the years 2030 and 2040.

68 Annex 8 presents a much more detailed discussion of the issue with the outcome that approximately two-thirds of the impacts can be attributed exclusively to the motor regulation and the here proposed policy options.

Table 9: Comparison of net impacts in 2030 and 2040

		2020	Impacts 2030				Impacts 2040			
Impacts		absolute	absolute	increments			absolute	increments		
	unit	BAU	BAU	ECO1	ECO2	ECO3	BAU	ECO1	ECO2	ECO3
Electricity use	TWh/yr	979	997	-2.8	-8.0	-9.6	1023	-2.9	-9.4	-10.8
GHG emissions	$MtCO_2eq$	372	339	-1.0	-2.7	-3.2	307	-0.9	-2.8	-3.2
Acquisition costs	billion €	7.3	7.5	0.09	0.36	0.59	7.9	0.07	0.31	0.48
Energy costs	billion €	132	199	-0.6	-1.6	-1.9	303	-0.9	-2.8	-3.2
User expenditure	billion €	141	208	-0.5	-1.2	-1.3	312	-0.8	-2.5	-2.7
Industry revenue	billion €	3.75	3.86	0.05	0.20	0.31	4.02	0.04	0.17	0.26
Trade revenue	billion €	1.85	1.90	0.02	0.10	0.15	1.98	0.02	0.08	0.13
Installer revenue	billion €	1.68	1.76	0.02	0.07	0.12	1.88	0.02	0.06	0.10
Employment (max)	000 jobs	122	126	1.5	6.2	10.0	132	1.2	5.3	8.2

According to Article 15 of the Ecodesign Directive, each policy option should not have a significant negative impact. For qualitative aspects, this assessment, which is discussed in various parts of Section 6, is summarised in Table 10.

Table 10: Evaluation of policy options in terms of their impacts compared to the baseline.

Significant impacts as stipulated in Article 15 of the Ecodesign Directive	BAU	ECO1	ECO2	ECO3
No significant negative impacts on the functionality of the product from the perspective of the user (Section 6.4.2)	✓	✓	✓	✓
Health, safety and the environment shall not be adversely affected (Section 6.4.2)	✓	✓	✓	✓
No significant negative impact on consumers in particular as regards affordability and life-cycle costs (Section 6.4.1)	✓	✓	✓	✓
No significant negative impacts on industry's competitiveness (Sections 6.3.3 to 6.3.5)	✓	✓	✓	✓
Setting of an ecodesign requirement shall not have the consequence of imposing proprietary technology on manufacturers (Section 6.3.8)	✓	✓	✓	✓
Impose no excessive administrative burden on manufacturers (Section 6.3.6)	✓	✓	✓	✓

The qualitative evaluation according to the objectives presented in Section 4 is shown in Table 11.Table **11: Score of impacts against objectives (see section 4).**

Symbols are used as representation of the quality of the option (0 = no change; + = limited improvement; ++ = significant improvement).

Table 11: Score of impacts against objectives (see section 4).

General Objectives	BAU	ECO1	ECO2	ECO3
1. Ensure free circulation of efficient motor systems within the internal market;	0	0	+	++
2. Promote competitiveness of the motor and VSD industry through the creation or expansion of the EU internal market for sustainable products;	0	+	+	++
3. Promote the energy efficiency of motor systems as contribution to the EU's objective to reduce energy consumption by 32.5 % and domestic GHG emissions by 40 % by 2030; and	0	+	++	++
4. Increase the security of energy supply in the Union through a reduction in energy consumption of motor systems.	0	+	++	++
Specific Objectives				
1. Achieve additional cost-efficient energy savings for the motors in scope by adjusting the ambition level in line with international and technical developments;	0	++	++	++
2. Achieve new cost-efficient energy savings for motors currently out of the scope, by ensuring where possible that no more inefficient motors and VSDs are traded on the market;	0	0	+	++
3. Address the issue of loopholes and exemptions in mid-sized motors;	0	+	++	++

The following table indicates the contribution of the three ECO scenarios to the main impacts, with respect to the total effect expected in ECO3.

Table 12 Contribution of the three ECO scenarios, with respect to the total effect expected in ECO3

Impacts		Total effect in 2030		
	unit	ECO1	ECO2	ECO3
Electricity use	TWh/yr	30%	54%	16%
GHG emissions	$MtCO_2eq$	30%	54%	16%
Acquisition costs	billion €	15%	47%	38%
Energy costs	billion €	30%	54%	16%
User expenditure	billion €	36%	57%	7%
Industry revenue	billion €	15%	48%	37%
Trade revenue	billion €	15%	48%	37%
Installer revenue	billion €	16%	43%	41%
Employment (max)	000 jobs	15%	48%	37%

All ECO options constitute valuable extensions to the current motor regulation (BAU). The motor scope extensions considered in ECO2 and ECO3 are in line with regulatory requirements in other jurisdictions. ECO2 is largely superior to ECO1: it delivers about half of the total effect in 2030 for all categories of impacts and effectively addresses some potential loopholes. ECO3 increases the savings further: it generates 16% of the total effect in terms of energy and GHG savings, 7% of the user expenditure reduction, and about a third of the increased industry revenue and associated job creation. It brings innovative potential to a full new segment of motor production.

The ECO2 and ECO3 options both provide a balanced outcome of the sometimes diverging views of the various industry segments, the NGOs and the Member States, in particular when phase-in periods and spare part provisions are designed in tune with the industry investment cycle. Regarding small, single phase and 8-pole motors, industrial stakeholders expressed concerns about potential economic difficulties. Consideration of the greater energy savings and associated environmental gains, and the larger benefits for the end-users and the rest of the value chain, including households, SMEs and industry, leads to the conclusion that ECO3, which delivers the highest impact in all categories, is the most attractive scenario, provided that sufficient time is provided for the industry to adapt, as discussed in more detail in section 6.3.3. As a consequence, a staged implementation is proposed: January 2021 for requirements for which the market is already in transition (e.g. motors in scope and large motors), and July 2022 where the requirements imply a more demanding market transformation (small, single phase and 8-pole motors).

This means that for the latter between 2.5 and 3 years would be provided for industry to adapt (assuming adoption first half of 2019). This is in line with the general discussions with industry, including a written statement by CEMEP requesting *'appropriate transition times for the manufacturers (at least two years) for affected products*'. A 2-years transition period is also considered necessary in other industry branches (e.g. water pumps).

Requirements under the current regulation were staged between June 2011 (IE2), and January 2015 or January 2017 (IE2 / IE3 + VSD, for motors below and above 7.5 kW respectively). Industry investments have broadly followed a similar pattern. The staged implementation proposed here (January 2021 – July 2022) means that investments in IE2 motors production would have covered 9 years at least. For example we can consider the case of a SME active in smaller motors, also producing motors already in scope, in the 0.75-7.5 kW range. It would have invested before June 2011 in the production of IE2 motors in scope. It probably would have invested before 2017 for IE3 motors in scope, and would have to invest again by 2022 for the smaller motors in the new scope (IE2). This means 5 years since the last investment round, which does not seem excessive and compatible with acceptable depreciation practices.

The ECO3 proposal results in the following overall net savings and impacts versus the BAU option in 2030:

- Electricity savings of 10 TWh/yr and GHG emission abatement of 3 MtCO_2eq/yr, of which 60% is due to the scope extension;
- Savings on annual end-user expenditure of €1.3 billion and extra business revenue of € 0.6 billion per year, which translates into ca. 10 000 jobs;
- Scope and ambition level aligned with technological progress and global minimum energy efficiency requirements in other economies;
- Contributing to EU industry's competitiveness and leading role as high-quality manufacturers;
- Higher revenues and profits for SMEs, which are usually active in maintenance and installations with possible exception for some small motor manufacturers (see section (6.3.4);
- Promoting innovation and medium term cost reduction for more efficient motors.

Contribution to the EU 2030 energy and climate targets and to the overall Ecodesign potential

Based on the analysis in the Impact Assessment for the revision of the Energy Efficiency Directive, it can be calculated based on the EUCO30 scenario that to reach the 32.5% goal for energy efficiency in 2030, the EU needs to keep its final energy consumption (FEC) below 954 Mtoe. To achieve this, FEC should be reduced by 125 Mtoe per year by 2030 at EU28 level as compared to the Reference scenario. For industry, it can be calculated based on the EUCO30 scenario that the final energy consumption is to be reduced by 2.7 Mtoe per year as compared to the Reference scenario. The scenario in fact does not attribute high reductions to the industrial sector, as the highest savings are to be achieved in the residential sector (buildings in particular). The expected impact of the preferred Ecodesign ECO3 measure would thus achieve about 30% of what is necessary for industry in terms of energy savings reduction needed.

In 1990, the EU-28 GHG emissions amounted to 5716 MtCO2eq[69]. In the EU Reference Scenario 2016 a 35% reduction compared to 1990 is estimated to be reached by 2030 with existing policies[70]. This means that an additional effort of 5% is still needed to reach the 40% GHG reduction objective, representing an additional reduction of 286 MtCO2eq. The expected savings of 3.2 MtCO2eq per year in 2030 to be delivered through the preferred option represent thus more than 1% of the effort to be made at EU level.

The measures from new products in the Ecodesign Working Plan 2016-2019, in addition to reviews of existing measures, have a potential to achieve 600 TWh of energy savings per year in 2030[71]. This means that the preferred option (9.6 TWh) can deliver 1.6% of this potential.

8. MARKET SURVEILLANCE AND EVALUATION

8.1. Market Surveillance

All proposed policy options are in line with Article 15(8) of the Ecodesign Directive, which requires that MSAs can verify the conformity of a product with all regulatory requirements.

The industry association CEMEP has pointed out the importance of securing a sufficient level of market surveillance for motors and VSDs in scope to ensure that all companies only place compliant products on the market. CEMEP is of the opinion that there is a need for increased enforcement by MSAs.

A specific topic is market surveillance of large electric motors. Should the regulation's scope be extended, motors up to 1 MW are included and it should therefore also be possible to test motors of this size. A similar issue has previously been discussed in connection with ecodesign requirements for other products groups, e.g. power transformers[72]. The result was that the following paragraph was added to the compliance verification procedure for MSAs:

"Given the weight and size limitations in the transportation of medium and large power transformers, Member States authorities may decide to undertake the verification procedure at the premises of manufacturers, before they are put into service in their final destination"

A similar clause may apply to motors above a certain size covered by the proposed measure, which would ensure that MSAs can verify compliance also for motors up to 1 MW in size.

8.2. Evaluation and monitoring

The motor regulation includes a legal review obligation for the Commission. This review was the starting point for the evaluation of the policy currently in place, as well as the development of policy options to ensure a continued alignment of energy efficiency requirements with technological innovation and international policy developments. A legally

[69] http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics_-_emission_inventories

[70] European Commission, *EU Reference Scenario 2016, Energy, transport and GHG emissions Trends to 2050*, Section 3.4.3

[71] Brussels, 30.11.2016, COM(2016) 773 final, COMMUNICATION FROM THE COMMISSION Ecodesign Working Plan 2016-2019

[72] Commission Regulation (EU) No 548/2014 of 21 May 2014 on implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to small, medium and large power transformers, OJ L 152, 22.5.2014, p. 1–15

binding evaluation of the policy's future implementation is also considered beneficial and strongly recommended. It is proposed to evaluate the motor regulation by 2024 to cover the regulation's impacts, for which the last requirements would come into force in 2022. The results of this evaluation should be presented to stakeholders and Member States in the Ecodesign Consultation Forum.

The appropriateness of the scope, definitions, concept and possible trade-offs should be assessed through a dialogue with stakeholders and Member States within this evaluation. This should include in particular an assessment of:

- resource efficiency, re-use and recycling and the level of measurement uncertainty;
- the possibility of setting stricter requirements for electric motors and variable speed drives, in particular IE3 for small motors, IE4 for mid-sized motors, and IE3or IE4 for VSDs[73];
- the possibility of setting minimum energy efficiency requirements to motors with a rated voltage above 1000V;
- the possibility to set requirements for motor and VSD together, as per IEC 61800-9-2 (this particular aspect could be reviewed at an earlier stage, within 2 years after adoption of the regulation);
- the inclusion of motors designed to operate wholly immersed in a liquid;
- relevance of the other exemptions;

The main indicator for evaluating the regulation's impact is the achievement of a market transition. As done in this Impact Assessment, an analysis of sales data will determine if the shift towards more energy efficient products motors and VSDs on the Union's market has happened as anticipated. The market overview will allow the Commission to verify the policy's impact based on these sub-indicators for motors and VSDs, which are reflecting the objectives:

- Reduction of the electricity consumption and related GHG emissions of motor systems;
- Increasing the economic savings for European users of motor systems;
- Safeguarding the competitiveness of the European motor system industry and the full value chain; and
- Improving the regulatory effectiveness and efficiency of the motor regulation.

The evaluation should assess these sub-indicators in line with the originally anticipated impacts of the policy option.

[73] IE3 and IE4 are not yet defined for VSDs in the current standard, but it should be revised to include these additional energy efficiency classes

Annex 1. GLOSSARY

Electric Motor

An electric motor consists of a piece of metal (rotor) that rotates within a fixed body (stator). The rotor is set in motion through the magnetic fields generated by (electro)magnets[74]. These (electro)magnets are present both in the rotor and in the stator[75]. The rotor-magnets are attracted or repulsed by the stator-magnets, depending on the direction of the electric current running through the magnet's coil. A rotor-magnet is always chasing the attracting stator-magnet, but when it comes near, the magnetic field in the stator magnet changes direction and the rotor-magnet gets attracted by the next attracting stator-magnet. This is the core principle behind every electric motor and the most common way to transform electric energy into movement.

AC motors

As indicated above, the operation of an electric motor requires a current that is periodically changing direction. The current in the European electric public grid is changing direction 50 times per second, this is why it is called alternating current (abbreviated AC) with a frequency of 50 Hertz (Hz). An AC motor is a motor designed to be fed by AC current. Direct Current (DC) can also be used in motors if the motor has an internal mechanism to change DC into AC.

Asynchronous induction motors

Most AC motors are induction motors. This refers to the fact that the rotor is equipped with electromagnets that are not directly connected to the electricity of the grid, but the current in the rotor-magnets is 'induced' by the magnetic fields generated in the stator electromagnets that are connected directly to the electricity input. The ideal shape of a rotor to facilitate an efficient induction resembles a cage, usually called a squirrel cage because it looks like a familiar toy for pet-rodents. Figure 1.1 gives a graphic representation of a motor with a squirrel cage.

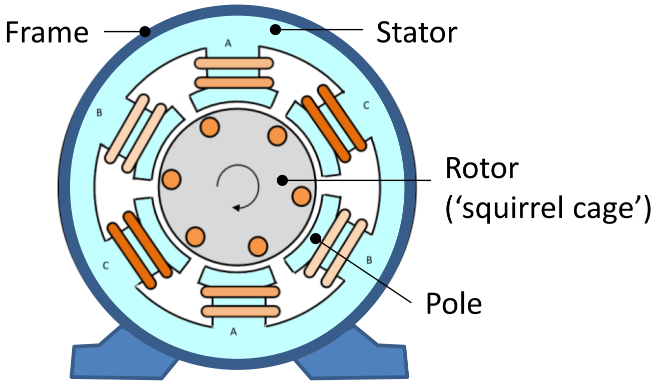

Figure 1.1 : Simplified diagram of a 6-pole AC induction motor.

All induction motors are asynchronous motors. The asynchronous nature of induction-motor operation comes from the slip between the rotational speed of the stator field and the somewhat slower speed of the rotor.

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74 An electromagnet is a type of magnet made of windings in which the magnetic field is produced by an electric current.

75 Permanent magnets can be used in the stator or in the rotor, but one of the motor components (stator or rotor) needs to be equipped with electromagnets, in order to enable a change of the current's direction, which is needed to put the rotor in motion.

Single phase and three phase motors

Electric power is normally distributed in two possible forms:

- Single phase power, in which the voltage and current flow changes in magnitude and direction in a cyclical fashion, typically 50 times per second in the EU (50 Hz). It is used in most homes and small businesses.
- Three phase power, combining three alternating currents (50 Hz) that vary in phase by 120 degrees. As a result, the power never drops to zero, making it possible to carry more load. It is used in large businesses and industry.

Motors need to be suited to the available power, this is why they are produced in single-phase or three-phase versions. Single phase motors draw significantly more current than the equivalent three-phase motors, making three-phase power a more efficient choice for industrial applications. This is why single-phase motors are normally not available above a few kW.

Motor speed – number of poles

The rotation speed of the motor speed is determined by two elements: the frequency at which the alternating current is changing direction and the number of magnets. The electric current in the European public electricity grid is changing direction 50 times per second. The electromagnets, also called poles, are always in pairs. A motor has at least 2 poles and motors with 4, 6 or more poles are common. In a 2-pole motor, the number of rotor turns per second equals the frequency of the electricity grid, i.e. 50 rotations per second or 3000 rotations per minute (3000 rpm). Increasing the number of poles reduce the speed but increases the force the rotor generates. For example, a 4-pole motor has twice the number of magnets and is twice as slow (1500 rpm), but it is also twice as strong.

Low and medium voltage motors

Electric motors are classified according to the electric voltage (V) with which they operate. Motors are considered low voltage if they run with 50-1000 V of AC or 120-1500 V of DC. Above these limits the motors are called medium voltage. The advantage of higher voltages is that for the same motor output power a lower electric current is required, which can be beneficial in some situations.

Special motors

In the current regulation 640/2009 there are some exceptions for special motors and considerations whether they should be included in the new scope. A short description is given here.

- 'Submersibles' are motors with special seals and cooling arrangements that allow them to be operated submersed in a liquid, e.g. submersible water pumps.
- ‘Explosion-proof’, 'ATEX' (ATmosphere EXplosive) are synonyms for motors that can be safely operated in an environment with explosive gases, i.e. without the risk of sparks and subsequent explosions or fires, while ‘increased safety’ motors meet the stringent quality and performance norms laid down in International standard IEC 60079-0
- 'Brake motor' is a motor equipped with an electro-mechanical brake unit to stop the rotor movement. The released brake-energy is either dissipated as heat or it can be recaptured and stored. The latter is commonly used in electric or hybrid cars.

Motor output

The twisting force that makes the motor rotating is called the torque. The torque is expressed in Newton-meter[76]. The motor output power is expressed in Watt (W), kiloWatt (kW) or Newton-meter per second (Nm/s) and it represents the amount of Nm a motor can transmit to a rotating load in one second. In our metric system 1 Nm/s equals 1 W. In the imperial system, like in the US, the more common power unit is 'brake horsepower' (hp) with a conversion of roughly 1 hp = 750 Nm/s = 0.75 kW.

Motor efficiency

The motor efficiency is the ratio of the motor mechanic output power, in W, to the motor input electric power, also in W, at nominal speed. It is usually expressed as a percentage. For instance, a motor that converts 100 W of electric power into a mechanic output power of 60W has an efficiency of 60 W / 100 W= 0.6 = 60%. The percentage values are usually sorted into energy efficiency classes depending on the motor power, which are defined in the international standard IEC 60034-30-1 as 'EI1' (Standard), 'EI2' (High), 'EI3' (Premium) and 'EI4' (Super Premium)[77]. Figure 1.2 gives an overview of these classes for a specific motor.

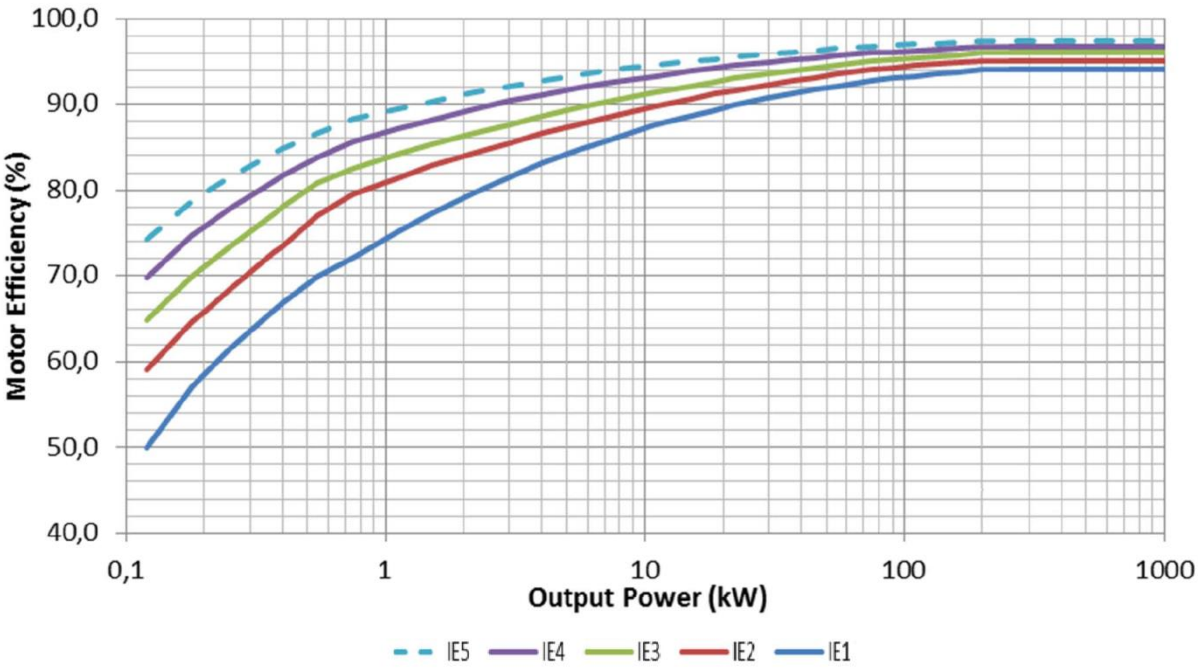

Figure 1.2: Electric motor efficiency classes according to IEC600034-30: 2014.

Drive and 'variable speed drive' (VSD)

A simple motor runs at a fixed speed that is determined by the number of poles and the frequency of the electric current. A **'**drive' must be added to the motor to achieve different speed(s). This can be in the form of an indirect drive that works on the motor shaft, such as a gearbox, or it can be a direct one, i.e. a piece of power electronics that controls the frequency of the current and hence the rotation speed of the motor. This Impact Assessment deals with

76 What is a Newton-Meter? Imagine you have a stick of 1 meter that you can fix perpendicular to a rotating motor axis and then measure how much force (in Newton) you need to stop the motor. The product of the length of the stick and the stopping force is the output power in Nm.

77 The designations were present in the 2008 version of the standard but have been removed from the 2014 version.

direct drives, also known as ‘variable speed drives’ (VSD). In operating conditions where the desired speed varies, VSDs can generate energy savings of 40% or more.

Drive efficiency

Every drive uses energy, and some are more efficient than others. Furthermore, VSDs may reduce the motor efficiency due to the high frequency current delivered by the VSD. That is why a VSD should only be used when it is needed and improves the overall efficiency of a motor. The international standard IEC EN 61800-9-1 defines energy efficiency classes for drives, similar to the ones for motors. Note that the efficiency of VSDs only incorporates the efficiency of the VSD itself; it does not include the modified motor efficiency through the use of a VSD.

Important notice: This glossary aims to deliver a basic, simplified understanding of technical issues in this Impact Assessment.

Annex 2. PROCEDURAL INFORMATION

DG GROW and DG ENER are Co-Chef de File for ecodesign. DG ENER, Unit C.3. is the lead DG for this product group.

Electric motors were mentioned as one of the priority products directly in the first Ecodesign Directive from 2005. On this basis, the Commission drafted the motor regulation currently in place (Commission Regulation No (EC) 640/2009), which was discussed and voted on by Member States in the Regulatory Committee. Following scrutiny by the European Parliament and Council, the Commission adopted the measure with a publication in the Official Journal of the European Union in 2009. An amendment has been adopted[78] and entered into force of amendment on 26 January 2014. The legal basis for the implementing measure is Article 114 TFEU.

Article 7 of the motor regulation requires the Commission to review the regulation no later than seven years after its entry in force, i.e. on 11 August 2016 at the latest:

"*The Commission shall review this Regulation in the light of technological progress on both motors and drives no later than seven years after its entry into force and present the result of this review to the Ecodesign Consultation Forum. The review will include resource efficiency, re-use and recycling and the level of measurement uncertainty.*"

The Commission fulfilled this legal obligation. As input for the review the preparatory study on special motors and VSDs was carried out in the period 2012-2014 and the results were presented to the Ecodesign Consultation Forum on 29 September 2014, leading to the policy options presented in this impact assessment. The latest Ecodesign Working Plan, adopted in November 2016 for the period 2016-2019, confirms that electric motors continue to be a priority product group.

Article 19 of the Ecodesign Directive foresees a regulatory procedure with scrutiny for the adoption of implementing measures. Subject to qualified majority support in the Regulatory Committee and after scrutiny of the European Parliament and of the Council, the adoption of the measure by the Commission is planned for the end of 2018.

All relevant Commission services (ENER, SG, GROW, ENV, CNECT, JUST, ECFIN, REGIO, RTD, CLIMA, COMP, TAXUD, EMPL, MOVE, TRADE and the JRC) were consulted on a first draft Impact Assessment on 23 June 2015. An additional consultation was performed on 29 September 2017 with a request for comments by 13 October.

This first draft was presented to the Regulatory Scrutiny Board, who issued a ‘negative opinion’ on 2 October 2015. A second submission also received a negative opinion on 5 February 2016. After the third submission, the Regulatory Scrutiny Board (RSB) delivered its positive opinion (27 October 2017).

This Impact Assessment takes into account all comments of the Regulatory Scrutiny Board. Stakeholder input received at the Refit Platform Stakeholder Group in February 2017 has also been taken into consideration, notably by refining life-cycle cost calculations which confirm that there is an economic advantage for end-users to include small motors in the regulation, at the IE2 level (see discussion in section 6.7 and annex 9).

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78 Commission Regulation (EU) No 4/2014 of 6 January 2014 amending Regulation (EC) No 640/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for electric motors

Tables 2.1 and 2.2 below summarise the Board's recommendations of 5 February 2016 and 27 October 2017 respectively, and how they are addressed in this Impact Assessment report.

Table 2.1.

Resubmission of 22 December 2015 **(B) Overall opinion (5 February 2016): NEGATIVE**	**Where and how these have been addressed in the Impact Assessment report submitted on 26/09/2017**
While the report has been improved to some extent along the lines of the Board's recommendations it still does not adequately inform decision making.	This version of the report takes into account all the comments and opinions of the Regulatory Scrutiny Board and additionally has been restructured to fit the stipulations (p. 45-53) of the Better Regulation Toolbox. All elements of the previous draft have been revisited and revised. The Section on policy options has been completely rewritten to present the policy options in a clear and concise manner, followed by a detailed and well-structured assessment.
The presentation of the information has to be substantially improved to make the report more coherent and accessible for non-experts. Moreover, the report should still further clarify the following key aspects:	A glossary has been added in Annex 1, to give non-experts a basic understanding of technical motor issues. A general introduction into ecodesign is provided. The whole draft Impact Assessment has been redrafted for more clarity, especially with non-experts in mind. Furthermore, words and abbreviations have been explained in the text.
1) What lessons can be drawn from the implementation of the current Regulation? What evidence is there to explain the causes of the problem?	Following the overall redrafting, an evaluation of current regulation and its expected impacts is presented in Annex 5. The main causes of the problem are further described in section 2, which provides detailed insights into the identified problems and presents evidence for the causes of the problems.
2) What is the added value of this initiative and how is coherence with existing ecodesign and labelling legislation ensured?	Section 3 presents the EU-added value of an action at an EU-level and the coherence with other Union law. Section 2.3 shows how market actors are affected, section 6.6 covers the specific case of motors being used in other products. Section 6 describes the (positive) overall impacts of the initiative. Section 2.4 presents what would happen in the absence of the regulation.
3) How are the market actors going to be affected? What are the foreseen costs to re-design the motors and how have these costs been estimated?	The market actors affected are presented in Section 2.3 and in Annex 6. A paragraph on compliance costs has been added (section 2.5).
(C) Main recommendations for improvements	
(1) Description of the market and causes of the problem: The report needs to better describe the market (further clarifying who the market actors are) and more clearly showing for each sub-category of products the potential for energy saving and greenhouse gases reduction. While it explains that China and the US have regulations in place, the report should still show more clearly who the main trade partners are, presenting data on imports and exports. Moreover, the report should refer to experience gained from implementing the current regulation and to any changes in the evolution of the market and in the behaviour of the market players. Further evidence should be included, if available, to explain the causes of the problem, for instance why purchasers in a professional market do not take into account potential electric motors from the outset.	The problem and its underlying drivers are described in detail in section 2. Actors affected are presented in Section 2.3. This includes data on imports and exports with trade partners. The analysis of impacts in Section 6 gives an overview of the potential of energy saving and GHG emission reductions, and shows the effect of extending the scope. Annex 5 presents the experience gained from implementing the current motor regulation, and its impact on the market. Section 2.2 specifically addresses the economic rationale behind the problem that market actors do not take the full benefit of energy efficient motors into account.

(2) Added value and coherence with existing initiatives: The report should still clarify potential consequences arising from the double regulation of motors and the appliances in which they are installed. More robust argumentation and concrete evidence should be presented on the reasons for including motors that possibly may be integrated in end- products which are also regulated under ecodesign. For instance, the report should better explain (a) if there are problems relating to market surveillance, why is a solution on reinforced enforcement not put forward rather than regulating through new ecodesign measures; (b) what are the drawbacks of allowing manufacturers to implement the cheapest solution to comply with energy savings imposed by other ecodesign regulations instead of focusing on improving motor efficiency?	Section 6.6 covers the specific case of motors being used in other products. Further, Section 6 accounts for any double counting of impacts.
(3) Assessment of the options: The report should still better assess the compliance costs involved, elaborating on how market actors are going to be affected and more thoroughly substantiating the statements describing the expected impacts on SMEs. Important information is missing, such as the magnitude of redesign costs or impact on overall economy (e.g. GDP and jobs in other sectors). The report should still provide a more in-depth comparison of the options, explaining the criteria chosen and the underlying analysis. It should explain whether there is a risk of stranded investments (including on downstream markets) and if not, provide a thorough explanation for that. Finally, the report should explain what operational monitoring and evaluation arrangements are going to be put in place and how likely it is that existing market surveillance arrangements are going to ensure compliance with the requirements.	Compliance costs are addressed in section 2.5 and affected market actors in section 2.3 and Annex 6. Issues that are specific to some market segments are also analysed in section 6.2. The policy options are presented and compared in Section 5. The economic impacts are described in detail in Section 6.3, including product costs and necessary investments (Section 6.3.1), user expenditures (Section 6.3.2), business revenues (Section 6.3.3), the impact on SMEs (Section 6.3.4 impact on R&D (Section 6.3.5), and administrative costs (Section 6.3.6). Section 6.4 gives an overview of the social impacts, including employment (Section 6.4.3). Section 8.1 presents how Market Surveillance can verify compliance, and Section 8.2 presents of the impact of the policy options can be evaluated. Stranded investments are discussed in section 6.3.8.
(D) Presentation	
The presentation of the report should be significantly improved in order to provide a clear basis for decision makers. Information should be presented in a less technical manner (to this end a glossary would be useful) and more coherence between the different sections should be ensured (e.g. presenting the preferred option after the comparison of the options). The main assumptions used in the cost/benefit analysis should be summarized in the main report. Different categories of stakeholders' Views should be better presented throughout the report, in particular on the options.	The report has been re-written to take into account the comments from the Regulatory Scrutiny Board. Both content and language has been improved for providing a clear basis for the Board. A glossary has been added and explanations and footnotes provided. Where relevant, stakeholders' views have been added. Assumptions for calculations are provided in the text or in footnotes.

Table 2.2.

RSB Positive Opinion 27.10.2017	Where and how the comments have been taken into account in this version of the Impact Assessment report.
(B) Main considerations The Board acknowledges the improvements made with respect to the readability and evidence base of the report. The Board gives a positive opinion, with a recommendation to further improve the report with respect to the following key aspects:	
(1) The added-value of the initiative in the wider context is not clearly presented (e.g. contribution to the Europe 2030 energy and climate targets; contribution to the overall Ecodesign potential).	Paragraphs have been added at the end of Section 7 quantifying the contribution of the proposal to the 32.5% goal for energy efficiency in 2030, to the objectives of the Ecodesign Working Plan 2016-2019, and to the additional effort needed to reach the 40% GHG reduction objective in 2030.
(2) The analysis of impacts on SMEs is insufficient. The report does not specify in how far the extension of the scope of the Ecodesign Regulation to small motors could negatively affect	See question C (3) below

SMEs that produce motors.	
It does not analyse to what extent the proposed transition and exemption periods would be appropriate for these SMEs.	See question C (5) below
(3) The impact on national Market Surveillance Authorities is unclear. Even though the report acknowledges that the wider scope of the Regulation will entail more burdens for Market Surveillance Authorities, there is no specific analysis on how the proposal will affect them.	In section 6.3.6 a paragraph has been added that explains better the possible impact of the proposal on Market Surveillance Authorities (MSAs), also highlighting some actions undertaken by the EC to support the work of MSAs.
(4) The rationale behind the proposed transition and exemption periods is vague. The report does not clearly justify the selection of multiple transition and exemption periods for different categories of products. It does not explain them in the context of competitiveness and circular economy aspects.	See question C (5) below
(C) Further considerations and recommendations for improvement	
The evaluation is not a sufficient basis to support the problem description. The report could usefully estimate the energy savings and greenhouse gas reductions realised thanks to the 2009 Regulation, but also the gap resulting from regulatory failures and loopholes. Moreover, it could present upfront the remaining ecodesign potential which the extension of the scope of the Regulation could reap.	The energy savings and greenhouse gas reductions realised thanks to the 2009 Regulation are described in section 1 of annex 5. In that annex a sentence has been added, quantifying the energy and GHG savings in the year 2017. This is also indicated in the introduction to the IA. A sentence has been added in section 3 of annex 5 providing our best estimate of *the lost savings resulting from regulatory failures and loopholes mentioned in this report.* The estimate is also mentioned in section 2.1 (problem definition). A sentence has been added in section 6.2.1 indicating which part of the impact stems from the scope extension.
(2) The report could add other cost savings that are generated by the initiative. Apart from the direct cost savings for the consumers, ecodesign measures may reduce indirect costs, like the need to invest in the replacement of high-polluting energy supply, health costs of emissions, or damages to the environment.	A new section '6.2.3 Other Environmental Impacts' has been added, that addresses this issue.
(3) The report includes a new section on SMEs (6.3.4) and acknowledges that option ECO3 (the preferred one) would involve a greater number of SMEs directly engaged in motor production. While the industry organisation (CEMEP) issued warnings about the capability of SMEs to adjust to new requirements, the report concludes that, overall, the preferred option 'may be advantageous' for SMEs. The report should more thoroughly assess the impacts of the measures on those SMEs that produce motors.	A paragraph has been added in section 6.3.4 with qualitative information on the impact on SMEs that produce motors.
(4) The report should assess the capabilities of national Market Surveillance Authorities to cope with the extended scope of the Regulation (or the possible increase in administrative cost linked to that). In particular, it should assess to what extent the implementation of ecodesign requirements to both components (motors in this case) and end-products will increase the costs of inspections and/or affect their quality.	See point B (3) above. A paragraph has been added in section 6.3.6.
(5) The report should clarify the rationale behind the choice of	The proposed staged requirements are is in line with

transitional periods for different categories of products. It should demonstrate that the length of the transition period measure will allow industry – and in particular SMEs – to adapt to the new regulation. Similarly, it should assess the duration of the period for spare parts availability for embedded motors in the context of consumer needs, life-cycle assessment and circular economy requirements.	discussions with industry, who recommended a two years adaptation period. In section 7 we have added two paragraphs that better explain the rationale behind our choices and in section 6.2.4 a paragraph has been added on the SMEs perspective on this. As stated in the IA report, "*As an outcome of the reflection, a spare parts availability of 7 years is proposed for motors integrated in products, as a pragmatic solution allowing to balance the justified need of spare parts availability and the necessity to address enforcement difficulties*."

Annex 3. STAKEHOLDER CONSULTATION

This Annex gives a brief summary of the consultation process. Details are given of how, who and on what stakeholders were consulted and how it was ensured that all relevant stakeholders had an opportunity to provide an opinion on key elements relevant for the IA.

Stakeholder opinions could be voiced through a multitude of targeted consultations with an opportunity to provide an opinion on any key elements relevant for the IA.

Consultation and expertise

There has been extensive consultation of stakeholders and other experts during the preparatory study carried out by external consultants on behalf of the Commission's Directorate General for Energy (DG ENER). External expertise on electric motors and VSDs was collected and analysed during this process. The results of the stakeholder consultation during and after the Consultation Forum are further described in this section.

Preparatory study and stakeholder consultations

The preparatory study for the review of Regulation 640/2009 started in March 2012 and was completed in June 2014. It followed the structure of the MEErP 2011, the dedicated Methodology for Ecodesign of Energy related Products[79].

The preparatory study covered motor systems outside the scope of Regulation 640/2009 as well as variable speed drives (VSDs). A technical, environmental and economic analysis was performed to assess the pertinence of introducing regulatory measures for these products and to assess policy options, as per the review clause of Regulation 640/2009, and within the framework of the Ecodesign Directive.

The preparatory study was developed in an open process, taking into account input from relevant stakeholders including manufacturers and their associations, environmental NGOs, consumer organisations and Member State representatives. The study provided a dedicated website where interim results and further relevant materials were published regularly for timely stakeholder consultation and input. The study website was promoted on the Ecodesign-specific websites of DG ENER and DG ENTR.

As part of the preparatory study, four open consultation meetings for directly affected stakeholders and other stakeholders were organised to discus and validate the preliminary study results. The meetings were held at the following dates and places:

- First Stakeholder Meeting, 26 June 2012, Frankfurt
- Second Stakeholder Meeting, 4 February 2013, Brussels
- Intermediate Stakeholder Meeting, 20 June 2013, Frankfurt
- Final Stakeholder Meeting, 10 February 2014, Brussels

Working Document and Consultation Forum

Building on the results of the preparatory study, the Commission services presented a Working Document suggesting ecodesign requirements based on scenarios developed under the preparatory study. The Working Document was discussed on 29 September 2014 in the Ecodesign Consultation Forum, consisting of a balanced representation of Member States' representatives and all relevant interested and affected parties (manufacturer associations,

[79] Kemna, R.B.J., Methodology for the Ecodesign of Energy-related Products (MEErP) – Part 2, VHK for the European Commission, 2011.

NGOs, etc.) concerned with the product group of electric motors, in line with Article 18 of the Ecodesign Directive.

The Working Document was circulated before the meeting to the members of the Ecodesign Consultation Forum and to the secretariat of the ENVI (Environment, Public Health and Food Safety) Committee of the European Parliament for information. The working document was included in the Commission's CIRCA system alongside the stakeholder comments received in writing before and after the Consultation Forum meeting. Minutes of the Consultation Forum meetings can be found in Annex 4. About 50 position papers were received and analysed by the Commission services in the frame of the Consultation Forum.

Results of stakeholder consultation during and after the Consultation Forum

The positions of main stakeholders on key features of the Commission services' Working Document received during and after the Consultation Forum can be summarized as follows:

- In general, the revision and extension of current Ecodesign regulation 2009/640/EC on electric motors is welcomed. As a result, a wider range of motors would be covered by the revised regulation, including smaller and larger motors, special purpose motors and variable speed drives (VSDs).

- Minimum efficiency requirements for motors in scope of 640/2009 should be set at IE3 level and the option of having a minimum requirement at IE2 level if the motor is equipped with a VSD should be removed. Member States and other stakeholders stated that IE2 motors equipped with VSD are not equivalent to IE3 motors and considered it an option difficult to enforce by Market Surveillance Authorities. Most stakeholders agreed, while a minority was even proposing switching to IE4 level (see discussion in section 5.8.2).

- Many stakeholders support extending the scope to include medium voltage motors (i.e. between 1 kV and 6 kV). China has implemented mandatory energy efficiency requirements[80] and a voluntary scheme is in place in the US for such motors. Some stakeholders stated that without this scope extension, there is a risk that Europe would become a "dumping ground" for inefficient medium voltage motors. An international test method is available (IEC 60034-2-1). See section 5.8.1 for further discussion and explanation why this scope extension is not considered in the preferred policy option.

- Several stakeholders, including a lead motor manufacturer, supported the inclusion of 8-pole motors, indicating that there is no technical barrier, and that many countries, including the USA, Brazil and Australia, are covering 8-pole motors under their regulations. Industry association CEMEP argued that there is a very small market for 8-pole motors (less than 1 % of total sales), that setting a minimum IE3 class for these motors could risk European manufacturers losing competitiveness vis-a-vis 8-pole motor manufacturers from lower cost countries and moving their production outside Europe with negative social impacts for Europe (see conclusions in section 7).

- A similar discussion arose about small (0.12-0.75 kW) and single phase motors (0.12-7.5kW) that are currently not regulated for which it is proposed to require IE2 levels. This was supported by several Member States, while NGOs required IE3 level as of 2020. However CEMEP highlighted that smaller companies could face difficulties in making the investments needed to produce the IE2 versions of these motors, with the risk that their production would cease (see conclusions in section 7).

[80] GB 30254-2013. Minimum allowable values of energy efficiency and the energy efficiency grades for cage three-phase high voltage induction motor.

- Regarding information requirements for products in which motors are incorporated, industry stakeholders point out the risk of excessive administrative burden for end-product manufacturers and confusing users of the end-product (see discussion in section 6.3.6).
- Several Member States and NGOs support the shift of minimum efficiency requirement for VSDs to IE2 or even higher (instead of IE1 as proposed to the Consultation Forum in September 2014), arguing that many VSDs on the market can already achieve IE2 levels, VSD industry is not supportive, emphasising the increasing production costs (estimated at 10-20 %) to achieve IE2 level instead of IE1, and technical difficulties, especially for higher voltage VSDs (above 220 kW) and lower voltage (under 5 kW). After the Consultation Forum, one Member State submitted results of laboratory efficiency tests of 20 VSDs in the range between 0.12 kW and 30 kW, all of which were in the IE2 class. A recent study showed similar results[81]. It is proposed to set the requirements at the IE2 level, except above 220 kW.
- While some industry stakeholders and Member States oppose the inclusion of motors integrated into other energy-related products in the scope, other Member States and all NGOs support their inclusion to avoid loopholes and secure energy savings (see discussion in section 6.6).
- Regarding the date of application of minimum requirements there are different opinions. Member states and NGOs have called for an early effective date while industry has pointed to necessary adaptation time. (See conclusions in section 7).
- Regarding introduction of information requirements on rare earth materials and permanent magnets, NGOs and some Member States would like to introduce information requirements on the presence, the localisation and extraction process of rare earth materials in magnets allowing safe and cost-effective recycling. However this is not relevant as motors in scope are asynchronous motors and are not made with magnets.

Impact Assessment

An Impact Assessment is required when the expected economic, environmental or social impacts of EU action are likely to be significant. The Impact Assessment for the review of regulation 640/2009 was carried out between November 2014 and September 2017, with further adjustments later in 2017 in order to take the comments issued by the Regulatory Scrutiny Board in its Positive Opinion dated 27.10.2017. The present report represents a significant overhaul after two negative options issued by the Regulatory Scrutiny Board in October 2015 and February 2016.

The data collected in the Lot 30 preparatory study served as a basis for the impact assessment. Additional data and information was collected and discussed by the Impact Assessment study team with industry and experts representing other stakeholders and Member States. During this process, several meetings were held with industry and other experts. The additional data and information collection focused on:

- Market data on motors and drives
- Average sales for motors and VSDs
- Price information, in particular on special motors not comprised by the preparatory study (brake motors, explosion motors and 8-pole motors);

[81] Conrad U. Brunner, Rita Werle, *New technology needs - new policy - From component to systems*, presentation at the 2017 EEMODS conference (Rome, Italy)

- Price information on more efficient motors based on average increases from one to the next efficiency class for motors and VSDs;
- Distribution of current and future VSD sales on efficiency classes, which was an area with most diverse information received;
- Average VSD efficiencies;
- Average load factors;
- Assumptions on economic and employment assumptions: Manufacturer selling price as fraction of product price; margin wholesaler; manufacturer turnover per employee; OEM personnel as fraction of manufacturer personnel; wholesaler turnover per employee; installer turnover per employee and fraction of OEM personnel outside EU.

Annex 4. MINUTES OF THE CONSULTATION FORUM MEETING

Meeting of the Consultation Forum under Article 18 of Directive 2009/125/EC on energy-related products: Electric motors (Lot 30)

Brussels, 29 September 2014 (10.00 – 16:00)

Participants: See "Attendance List" in Annexes

EC Participants: Robert NUIJ (ENER, Chairman), Marcos GONZALEZ ALVAREZ (ENER)

Welcome and Presentation

The **Chair** welcomed the participants and indicated that the purpose of the meeting was to discuss the proposed draft Ecodesign Regulation on electric motors. The agenda was adopted without changes.

Working documents on electric motors

After a presentation by the **Commission services** the documents were discussed by Member States and stakeholders.

DE and **DK** asked for discussing the draft Regulation following the proposed legislative text. As no opposition was expressed the **Commission services** agreed to the proposal.

Article 1. Subject matter and scope

DE asked why small motors were included and asked for justification from a life cycle cost point of view for such inclusion.

DE requested a better definition and differentiation between "explosion proof motors" and "increased safety motors". This comment was supported by **BE** and **NL**. **BADEN-WÜRTTEMBERG**, that participated in the meeting on a one off basis to provide input as a market surveillance authority, also asked for better definitions of "hand-held equipment" and "cordless or battery operation".

DE indicated that not only motors in hand-held equipment but also motors used in appliances moved by hand should be excluded from the scope. This comment was supported by **BE** and **VDMA**.

EURELECTRIC indicated that the proposed Regulation will have a major impact on motors used in hydro, wind and nuclear plants that need to be certified for use in such environments, and that the application of the Regulation to these motors would have disproportionate costs. **FORATOM** added that in many cases it would be impossible to use the new motors due to space occupancy problems and earthquake resistance requirements.

EPEE mentioned that motors integrated into other products should be excluded from the scope as this would lead to double regulation without increasing the energy efficiency of the final product. This comment was supported by **CECED**, which added that the different timings for the coming into force of the requirements would have negative effects on the redesign cycle of the product. **IT** also agreed with excluding motors integrated into other products from the scope.

NL indicated that they support the inclusion of motors integrated into other products in the scope of the Regulation, **BE**, **DK** and **ECOS** also supported this inclusion.

ECOS indicated that small motors are included in the IEC standard and that only motors rated on continuous duty are covered.

BE asked the Commission to evaluate if a special provision is needed for replacement motors used as spare parts.

NL, **DE**, **IT, BADEN-WÜRTTEMBERG**, **EPEE** and **CECED** asked the **Commission services** to clarify who is responsible for compliance in the case of motors integrated into other products.

The **Commission services** indicated that a binding interpretation of the European legislation can only be provided by the European Court of Justice. The **Commission services** interpretation, as discussed with legal experts and other relevant **Commission services**, is based on the Ecodesign Directive and the "Blue Guide on the implementation of EU product rules". The **Commission services** indicated that according to the "Blue Guide" the manufacturer of the final product is responsible for compliance with any relevant Regulation.

IT indicated that the date of placing on the market of the component has also to be evaluated and added that the date of placing on the market of the final product shouldn't be the date of placing on the market of the component, they asked the **Commission services** to clarify the issue.

Article 2. Definitions

DK asked the Commission to remove the reference to 3-phases in the definition of variable speed drive. **CEMEP** considered that the definition of variable speed drive should be taken from the relevant European standard.

NL indicated that certain definitions were missing from the text and that they should be added to Article 2. This comment was supported by **UK**.

DE pointed out that the definitions should be revisited as there are special shape motors that, based on the current definitions, would be in the scope of the Regulation, although they should be excluded.

CEMEP said that 8-pole motors should not be covered by the Regulation, as they represent less than 1 % of the market. They added that the energy efficiency requirement for brake motors should be IE2 as they usually work on intermittent duty and have increased rotor inertia. **ECOS** disagreed with **CEMEP** and indicated that 8-pole motors should be covered. **DE** considered that 8-pole motors are seldom used in Europe.

NL indicated that according to the current draft, medium voltage motors will only be addressed in a review in 2018. China already has minimum requirements for these motors. **NL** asked the Commission to speed up the process of developing requirements for medium voltage motors in order to avoid low efficiency medium voltage motors being brought to the European market. **SE** indicated that the test methods for medium voltage motors are already available and only a definition of efficiency levels is missing. Hence, the discussion on their inclusion should not be postponed until 2018. **FI** strongly supported the inclusion of medium voltage motors in the scope of the Regulation, indicating that minimum values could be set now and reassessed before they come into application. **ECOS** also indicated that more ambition was needed regarding medium voltage motors.

The **Commission services** concluded that, based on these views, the inclusion of medium voltage motors before 2018 would be analysed.

Article 3. Ecodesign requirements

DE asked the **Commission services** to further evaluate how to articulate the transitional period when the proposed Regulation comes into force repealing Regulation 640/2009, to avoid creating additional burdens for manufacturers that would need to create new documentation for the motors.

DK indicated that the number of tiers should be reduced and added that the current tier coming into force in 2017 under Regulation 640/2009 could be skipped. **NL** said that from a legal certainty point of view it would be better to make any change to the current Regulation from 2018 onwards. **SE** said that they are in favour of removing the IE2 + VSD option and that 2018 would be an acceptable date for doing so. **CEMEP** said that IE2 + VSD and IE3 are not equivalent and supported the current proposal to remove this option from 2020 onwards. **EUROPUMP** said that applying the Regulation when the product is being "put into service" should help with its enforcement.

AT indicated that IE3 for electric motors could be implemented in a shorter period of time.

DK said that the requirements for variable speed drives (IE1) are not stringent enough as such drives are already widely used on the market. **ECOS** supported the **AT** and **DK** proposals. **NL** and **SE** agreed on the need to further analyse the possibility of setting more stringent requirements for variable speed drives. **CEMEP** and **CEN/CENELEC** supported the current proposal.

EUROPUMP asked for more clarity about how variable speed drives need to be tested when the manufacturer is not providing the motor as well.

ECOS mentioned that the current option IE2 + VSD or IE3 was a compromise solution but experience shows that it is problematic. **ECOS** added that Switzerland found it very difficult to enforce the IE2 + VSD option and has decided to go for IE3 only. This comment was supported by **FI**. **IT** did not support the deletion of option IE2 + VSD or IE3 and asked for a further analysis of the topic.

The **Commission services** indicated that the impact of more stringent requirements on variable speed drives and the IE2 + VSD allowance would be analysed further during the Impact Assessment.

Article 4. Conformity assessment

NL indicated that larger motors could be subject to a conformity assessment procedure different to the one currently proposed.

UK said that the references to the Ecodesign Directive should be updated.

IT invited the **Commission services** to carefully assess any conformity assessment procedure different from manufacturer self-declaration from a complexity point of view.

The **Commission services** agreed to investigate the different conformity assessment methodologies to be used and to update the references to the Ecodesign Directive.

Article 5. Verification procedure for market surveillance purposes

NL asked for clarification as to why the proposed text on the horizontal amendment on tolerances currently under discussion had not been used.

The **Commission services** clarified that the discussion on tolerances is conducted separately from the discussion on electric motors and this is why the draft text has not been implemented in this proposal.

Article 6. Indicative benchmarks

ECOS pointed out that the benchmark for variable speed drives should be modified as IE3 products are already available.

The **Commission services** indicated that data used come from the preparatory study, but if additional data are provided, the benchmark could be modified.

Article 8. Revisions

NL requested a modification of the order of the text, as 2020 is currently mentioned before 2018. If minimum requirements on medium voltage motors were not to be set now, **NL** argued that the 2018 review should be limited to this point and asked for a stronger text to reflect this. This comment was supported by **SE**, **DK** and **ECOS**. **IT** considered that the legal text should not prejudice the result of the review.

DK and **ECOS** added that if no stricter requirements were not to be set for variable speed drives, this should also be included in the review clause.

BADEN-WÜRTTEMBERG said that if mechanically commutated motors increased their penetration on the market they should be included in the review clause.

The **Commission services** noted the comments and indicated that the final wording of the review clause would depend on the final text of the Regulation itself.

Annex I. Ecodesign requirements

SE indicated that setting the same level of requirements for single-phase and three-phase motors means that in reality the relative level of stringency is higher for single-phase motors and asked for a clarification.

BADEN-WÜRTTEMBERG pointed out some errors in the tables and formulas used and asked for them to be corrected. This was supported by **DE**.

The **Commission services** replied that the result of the preparatory study shows that the same level of requirements (i.e. IE2) is optimal for small single-phase and three-phase motors, even if the relative stringency is higher for single-phase motors. The mistakes that were pointed out would be corrected.

ECOS stated that variable speed drives should be tested at 100 % speed and 100 % load. **CEN/CENELEC** replied that in order to provide comparable information 90 % speed has to be used. **ECOS** stated that an international standard providing a test method for variable speed drives should be ready by 2018. **CEN/CENELEC** said that the European standard should be used.

The **Commission services** replied that the current proposals are based on the European standard because it is the only one mature enough. If appropriate international standards exist in the future, we will be able to use them.

ORGALIME considered that requirements on having information on the website of the motor integrator would lead to an excessive administrative burden and has no added value. **EUROTRANS** and **CETOP** supported this position. **IT** indicated that having information on the technical documentation provides no added value. **DK** said that having information on free access websites facilitates the tasks of market surveillance authorities. **BE** added that information requirements also provide added value for consumers; this statement was supported by **FI**. **EPTA** considered the information requirements for motors to be excessive. They indicated that information requirements were useful for market surveillance authorities but some of the requirements in the current proposals were not needed. They recommended removing information requirements for motors not covered by the Regulation. **CECED** pointed out that in some cases there might be confidentiality issues regarding the information requirements. **IT** indicated that information requirements should be kept to a minimum and including only information with an actual added value. **AT** considered that information requirements are important for product selection by consumers. **NL** pointed out that information requirements were not only used by market surveillance authorities but also by consumers, and added that the product information requirements should be practically applicable. NL suggested that the **Commission services** re-examine the information requirements, especially for integrated products.

The **Commission services** said that the current proposal was largely based on the current motor Regulation but that the requirements would be re-examined, especially taking into account that the scope of the Regulation would be broadened.

Annex III. Verification procedure

FI said that the definition of tolerances should be updated.

BE asked whether the tolerance was to be applied to the efficiency or to the losses.

The **Commission services** indicated that it should be applied to the losses and asked for a proposal on the definitions.

IT invited the **Commission services** to re-examine the proposal as it would be difficult to implement in practice.

Annex IV. Benchmarks

DK stated that the current benchmark for variable speed drives is below IE2 level.

The **Commission services** replied that the benchmarks could be updated if available data support this.

AOB

The **Chair** indicated that minutes of three previous Consultation Forum meetings had been circulated for comments and no comments had been received so far.

No comments were raised by participants. The **Chair** concluded that the minutes of the three previous meetings were formally approved.

The **Chair** informed the consultation forum of the ongoing work on a number of product groups and outlined the planning for upcoming meetings until the end of 2014.

The **Chair** ended the discussion, thanked participants and requested any further feedback and data from stakeholders by 31 October 2014 at the latest.

Attendance List

Commission Services	Robert NUIJ Marcos GONZÁLEZ ÁLVAREZ
Austria	Bernd SCHAEPPI
Belgium	Bram SOENEN Bram VERCKENS
Czech Republic	Simon PILAT
Germany	Floris AKKERMAN Albert REINHARD
Denmark	Peter NIELSEN Sandie BRAENGAARD NIELSEN
Finland	Kaisa-Reeta KOSKINEN Hannu VAANANEN
France	Evelyne BISSON
Spain	David VILLA CRIADO
Ireland	Mark SWEENEY
Italy	Milena PRESUTTO
The Netherlands	Hans-Paul SIDERIUS
Sweden	Carlos LOPES
Slovakia	Marcela RUKOVANSKA
The United Kingdom	Edward Michael RIMMER Alka PATEL
Baden-Württemberg	Robert RAPP
ATKINS	Hugh FALKNER
CECED	Bruno VERMOESEN Matteo RAMBALDI Astrid NEVE Luise CHRISTMANN Frank HORSTMANN Pierre CHALANÇON Dennis HUELSMANN Hakan GEDIK
CEMEP	Jurgen SANDER Andrea SOLZI Bruno Lund PEDERSEN Steve BRAMBLEY Jani KORKEAKOSKI Gregor DIETZ
CEN/CENELEC	Martial PATRA Bernard GINDROZ Gerhard BERGE Benoit LEPRETTRE Andreas KRAETZSCHMAR
CETOP	Joern DUERER
ECOS	Chloé FAYOLE Conrad BRUNNER
EGMF	Christina WEDEL
EPEE	Veerle BEELAERTS Franck REPENTIN Neil McDOWELL JONES Denis BONVILLAIN
EPTA	Charles TOLLIT
EURELECTRIC	Henning HAEDER François GONCZI

EUROPUMP	Markus HOLMBERG Karl HULTQVIST Frank ENNENBACH Markus TEEPE
EUROTRANS	Oliver FROELICH
FEM	Anne Claire RASSELET René POTTERS Heiko SIPPEL
FORATOM	Guy PARKER Oliver HUBERT
INFORSE	Gunnar Boye OLESEN
ISC-UC	Anibal DE ALMEIDA
ORGALIME	Lars KOCH
VDMA	Heiko BOEKHOFF Charalambos FREED Hanna BLANKEMEYER
VHK	René KEMNA

Annex 5. EVALUATION OF REGULATION 640/2009 ON ECODESIGN REQUIREMENTS FOR ELECTRIC MOTORS

In the context of the Regulatory Fitness and Performance programme (REFIT)[82] and its Better Regulation policy[83], the Commission is committed to evaluate in a proportionate way all EU activities intended to have an impact on society or the economy. This should be done on the basis of the life cycle of the intervention. Many evaluations are triggered by individual clauses in legislation formulated as requiring a review. For the review of an existing Ecodesign measure, three out of the five standard evaluation criteria foreseen by Better Regulation need to be addressed, i.e. whether the measure has been effective, efficient and relevant. Indeed, the coherence and EU added-value criteria have already been addressed at the framework level, i.e. in 2012, when the Ecodesign Directive has been reviewed[84]

This annex presents the information collected during the review study and the impact assessment that allows evaluating the existing motors regulation (640/2009).

1. Effectiveness

This section focuses on two key objectives of the regulation: ensuring a transition towards more energy-efficient motors, and achieve significant energy savings. Other impacts are quantified but are not analysed in depth.

1.1 Market transformation and innovation

Figure 5.1 below gives an overview of the market share of motors according to their international energy efficiency class, as provided by industry association CEMEP.

82 https://ec.europa.eu/info/law/law-making-process/overview-law-making-process/evaluating-and-improving-existing-laws/reducing-burdens-and-simplifying-law/refit-making-eu-law-simpler-and-less-costly_en

83 https://ec.europa.eu/info/law/law-making-process/better-regulation-why-and-how_en

84 COM(2012) 765 final, REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL, Review of Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products (recast)

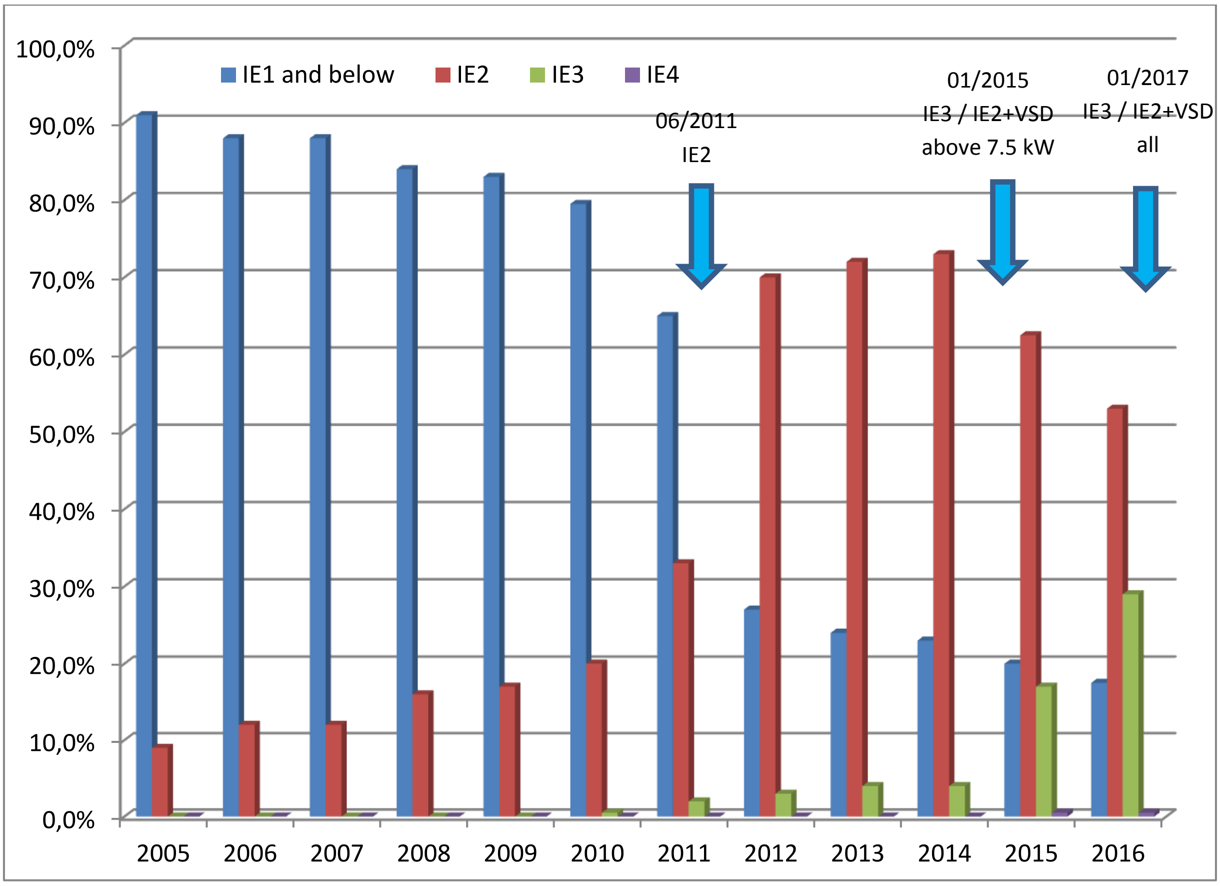

***Figure5.1: EU market share of motor in scope according to IE efficiency class 2005- 2016. Arrows shows the entering into force of requirements under 640/2009*[85]**

The figure shows that in 2009, when the regulation was adopted, 83% of the motors sold were still of the energy efficiency class IE1. Three years later (2012), just after the IE2 requirement came into force, the share of IE1 motors went down to 27% while the share of IE2 rose to 70%. The introduction of IE3 / EI2 + VSD requirement in January 2015 provided a significant push to IE3 motors: their share was only 4% in 2014 and rose to 29% in 2016. The remaining portion of IE1 motors in 2016 reflects sales of motors that are exempted of the regulation (e.g. brake motors, etc.), and may also indicate imperfect enforcement.

The overall picture shows a drastic transformation of the motors market in the period 2009-2015. Stakeholders from the motor industry, specifically the industry association CEMEP, confirm the notion that the regulation had the intended effect of transforming the market towards more efficient motors. On some motor manufacturers' websites only IE3 motors with prices are readily accessible; IE2 motors are on request only.

Regarding VSDs, available data from CEMEP or Eurostat (Prodcom) do not show a significant increase of the sales in the period 2013-2015, which tends to confirm enforcement difficulties highlighted by Market Surveillance Authorities, which deem this measure impractical and not delivering results 'on the ground'.

The pro-innovative effects of Ecodesign standards for electrical motors were assessed in Fraunhofer IDI Discussion Paper Innovation Systems and Policy Analysis No 51, 2016[86] and

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85 CEMEP, July 2017. This data displays a different picture of the motors market than the figures supplied earlier and used in the review study (2014). CEMEP justifies the change by the use of a better accounting methodology. In the recent figures, the uptake of IE3 motors occurs later, but at a faster pace.

found that no effect of the policy measure can be found when using patent application for efficient motors as a proxy, but a case study analysis with 6 semi-structured expert interviews carried out by Fraunhofer[87]showed that all stakeholders acknowledge that Eco Design rules have an influence on companies innovation behaviour and increases market opportunities for efficient products. The innovation effects are however mainly process-related (meaning existing production lines are restructured or upscaled), whereas the Eco Design requirements do not push radical product innovation as they mostly ban the worst performing products from entering the market.

1.2 Energy savings

Is the ongoing market transformation sufficient to achieve the energy savings that were anticipated in 2009?

In the original 2009 Impact Assessment (IA1), about 140 TWh of savings were expected in 2020, and 208 TWh in 2030, compared to a Business-As-Usual situation (BAU - no regulation), representing saving of about 11% and 16% respectively.

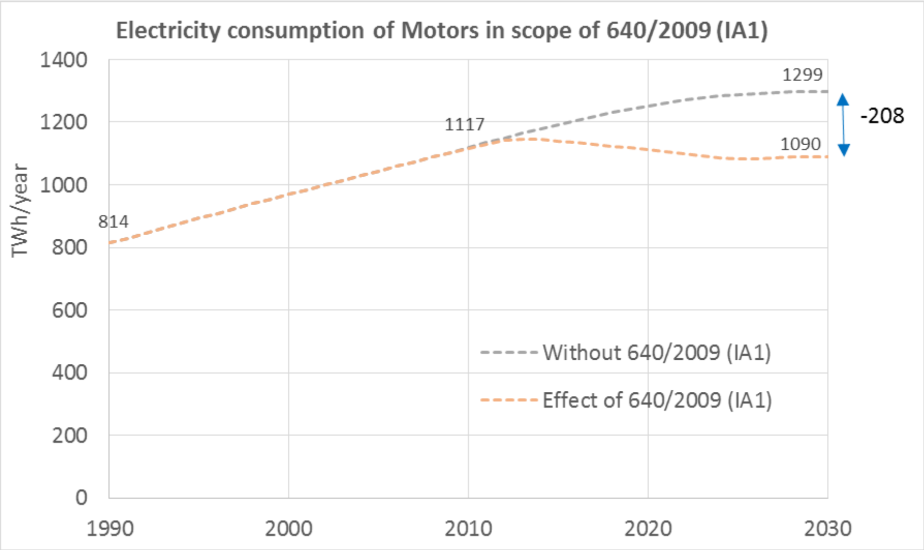

Figure 5.2: Energy consumption of electric motors in scope of the motor regulation as per IA1 (2009)

However, in the current Impact Assessment (IA2), different hypothesis have been used than in IA1. The BAU scenario without regulation 640/2009 has been recalculated accordingly, leading to lower energy consumption, as well as lower savings, as shown in the figure below:

86 http://www.isi.fraunhofer.de/isi-wAssets/docs/p/de/diskpap_innosysteme_policyanalyse/discussionpaper_51_2016.pdf

87 The 6 interviewees for the Fraunhofer study were 4 different companies as well as 2 experts from non-governmental organizations and member state institutions. The company representatives included R&D management positions, product managers and leaders of the policy departments. The aim of the case selection was not to generate a statistical representative sample but include a broad range of companies taking into account the diversity and heterogeneity of firm-level innovation responses. To increase the validity of the results, whenever possible Fraunhofer included firms with similar characteristics as well as firms with contrasting characteristics in order to allow for literal and theoretical replication (Yin 2002).

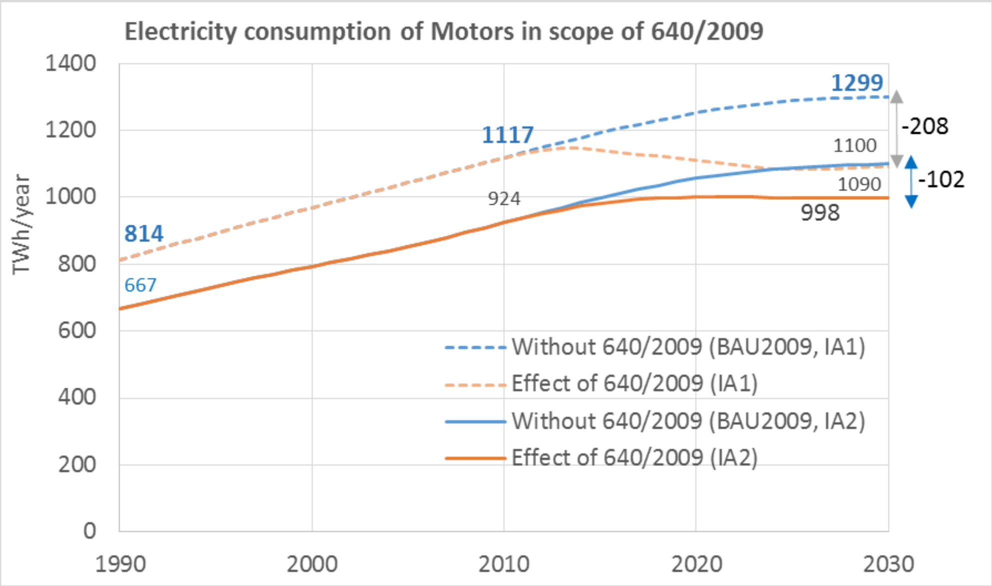

Figure 5.3: Energy consumption of electric motors in scope of the motor regulation, comparison IA1 (2009) and IA2 (2017)

The recalculated energy savings by 2030 in IA2 amount only to 9% of the energy consumption in the baseline case (BAU), compared to 16% in IA1. The main reasons for this difference are the more sophisticated modelling and updated hypotheses used in this IA as well as updated data, including those presented in figure 5.1. Nevertheless, it is fair to say that with an estimated 57 TWh savings in 2020 and 102 TWh in 2030, regulation 640/2009 has clearly transformed the motors market and delivered substantial savings.

The energy savings realised in the year 2017 are estimated as 31 TWh and the corresponding GHG emissions reduction as 12 MteqCO2.

1.3 Other impacts

Table 5.1 provides an overview of the effect of Regulation 640/2009 in a comparison to a BAU scenario without the regulation.

Table 5.1: Overview of the motor regulation's expected impacts versus a BAU scenario without the regulation at different points in time

	Year	2015		2020		2030	
Impact	**unit**	**BAU absolute**	**difference vs. BAU**	**BAU absolute**	**difference vs. BAU**	**BAU absolute**	**difference vs. BAU**
Electricity use	TWh/yr	998	-16	1057	-57	1100	-102
GHG emissions	MtCO2eq	394	-6	402	-22	374	-35
Acquisition costs	billion €	4.0	1.0	4.3	1.9	4.8	1.6
Energy costs	billion €	119	-1.9	143	-7.7	220	-20.3
User Expenditure	billion €	125	-0.9	148	-5.7	226	-18.7
Industry revenue	billion €	2.1	0.5	2.2	0.9	2.5	0.8
Trade revenue	billion €	1.0	0.2	1.1	0.4	1.2	0.4
Installer revenue	billion €	0.9	0.3	0.9	0.5	1.1	0.4
Employment	000 jobs	68	16	72	31	80	26

2. Efficiency

How efficient has the regulation been in delivering the above mentioned benefits?

The energy efficiency requirements came along with increased industry revenue and reduced expenditure for the end-user, as can be seen in the table above: user acquisition costs were projected to rise by €1.0 billion Euros for the year 2015, but are more than compensated by the reduction of energy use costs (€1.9 billon reduction). It has to be said that this is an aggregate figure but for individual users the situation may look differently. As a rule of thumb the buyers of larger motors will experience the higher net savings. The overall trade balance is expected to improve due to the EUs dominance in high value motors. It was not possible to obtain information on actual compliance cost and accrued benefits and costs by businesses, as explained in section 2.5.

IA1 assumed no costs for national administrations for transposition of the regulation into national legislation as it is of directly applicable nature. This is still a valid assumption. There have been more difficulties than expected for market surveillance by Member States, and the new regulation intends to address these issues. However there is no evidence that these difficulties did induce significant extra surveillance costs, as the consequence of these difficulties was an imperfect surveillance rather than a more expensive one.

As a conclusion, there is no doubt that the chosen policy instrument has been efficient in delivering the desired results.

3. Relevance

Is the current regulation (still) relevant?

The review study and the Impact Assessment have shown that the regulation is effectively supporting a transition towards more energy-efficient motors, and that it is on track to deliver substantial savings. The results also indicate that higher savings could be achieved by revising the requirements, extending the scope, and correcting imperfections in the regulation (see sections 6 and 7 of this report). This forms the basis of the proposal for an updated regulation. It is made possible and necessary by technical progress and international developments: development of more efficient motors, availability of technical standards and tightened energy efficiency requirements around the globe.

Moreover, the motor regulation only regulates the most significant environmental impacts to ensure an optimal efficiency. The environmental life cycle analysis during the review showed that the electricity consumption during motor use, and the related carbon, acidifying and other emissions at the level of power plants, is by far the most important environmental impact. Proportionality thus indicates that the setting of minimum energy efficiency requirements should remain the key focus for this product group.

As indicated in section 7 of this report, the preferred Ecodesign measure ECO3 is estimated to achieve 9.6 TWh net energy savings per year in 2030. This is the best estimate of the lost savings resulting from regulatory failures and loopholes mentioned in this report.

Annex 6. WHO IS AFFECTED BY THE INITIATIVE AND HOW

This annex sets out the practical implications of the initiative for the main and directly affected stakeholders based on the preferred policy option.

Motor manufacturers

In the preferred policy option ECO3, the scope of the regulation is enlarged from products with an output range 0.75-375 kW to a range of 0.12 kW-1000 kW. Also single-phase AC motors and 8-pole motors are included. The impact on motor manufacturers is discussed in section 6.3.3.

SMEs

See discussion in section 6.3.4.

Motor buyers

Buyers of fractional horsepower motors will be mainly producers of end-products for the tertiary or domestic sector. In this segment, the fraction of industrial motors is relatively small. Buyers that have not already switched to IE2 motors will have to pay a higher price. At the moment (see also stock model) the switch from a low-quality 'No category' (< 'IE1') to a high-quality 'IE2' level is expected to give a price increase of 35% for a 370 W motor. This is the worst case; on average the motor industry estimates that the OEM motor price increase will be in the order of 10-15%, also taking the learning effect into consideration. Depending on the share of the motor in total production costs, the price effect on the end-product in which the motor is integrated will be a fraction of that. This may result in an increased sales price of the end-product, potentially affecting the end-users (see below).

Motor users

This is discussed further in section 6.3.2.

Market Surveillance Authorities

The elimination of loopholes will simplify the work of market surveillance authorities. The work of the Member States' Market Surveillance Authorities would naturally increase due to the scope extension. However, this follows the normal pattern, when including more products under regulatory measures.

Further information on administrative burden for Member States is given in the main report paragraph 6.3.6.

Annex 7. ANALYTICAL MODEL USED

General introduction

Availability of reliable data for the very heterogeneous electric motor sector is poor. Electric motors can be found, with a few exceptions like lighting and some heating, in almost all energy-using products, either as a main or as an auxiliary component. There is a large variety and motors are sold as components, in sub-assemblies and in assembled end-products. This brings a considerable uncertainty to any statistical information on the subject.

Most studies use, directly or indirectly, an interpreted version of Eurostat (Europroms) data to estimate sales. Industry associations like CEMEP complement this information with production data reported by their members or specifically collected for a preparatory study or review. Global market research companies like IHS are a valuable source to confirm trends, but difficult to use in the public domain to verify detailed sales figures, because they may not have the desired categorisations and boundaries as the products in scope of the study. Energy consumption is assessed from estimated averages for power outputs, operating hours, load factors and effectiveness of variable speed drives (VSDs) per category. These estimates are provided by various sources (literature, experts etc.) and checked for stakeholder consensus. Prices and price increase of motors due to Ecodesign measures are based on stakeholder consultation and checked against revenue totals of the sector. Employment impacts are derived from revenue per employee, again checked against reported revenue totals for the sector and anecdotal information from annual reports of individual manufacturers.

As regards the various monetary rates, the impact assessment study conforms to the MEErP. This means e.g. that (industrial) energy prices were assessed from Eurostat data and for future projections an escalation rate of 4% was used. All prices and costs are expressed in Euro 2010, calculated with historical inflation rates and a 2% inflation for future projections. For investment-type considerations, a discount rate of 4% is used.

For greenhouse gas emissions, the emission rate (in kg CO2 eq./kWh) does vary over the projection period in line with overall EU projections as indicated in MEErP.

This impact assessment study has made a major effort to reduce the inherent uncertainty of quantitative data. It has subdivided the market in many segments with each their specific commercial and technical characteristics. Segments relate to power source (AC, 1 phase or 3 phase), power output (typically 5 classes), purpose (general or special purpose, the latter subdivided in brake, explosion-proof and 8-pole) and whether or not the motor is fitted with a VSD. Considering that not every cross-section generates meaningful results, a total of 22 market segments ('base cases') was found, as shown in the ‘legend’ table (Table 7.1 in this Annex).

Main characteristics of the model

The impact assessment uses a stock model developed by VHK first in the context of the MEErP 2005 methodology and then further developed in the MEErP 2011 and the VHK EIA-studies for the Commission. It has been used successfully, i.e. to the satisfaction of stakeholders and Commission, in over 20 impact assessment studies for Ecodesign and Energy Labelling studies, where VHK assisted the Commission.

The stock model has been specifically developed and paid for by the Commission (DG GROW and DG ENER) and is thus subject to the same intellectual property provisions as other contract work for the Commission.

Over the years, as it was part of various Commission contracts it has been scrutinised by many Commission officials of various DGs as well as experts from various stakeholder groups (industry, Member States and NGOs).

The input data for the electric motor stock model have been retrieved from preparatory studies and additional stakeholder consultation. For throughput data the model follows the MEErP and latest official (e.g. Eurostat) publications.

As mentioned, the main uncertainties in the electric motor stock model stem from uncertainties in the motor-specific input data for this very heterogeneous product sector and technical assistants for this impact assessment have sought to diminish uncertainties by extending market segmentation and consultation for these segments.

A particular effort has been made to eliminate the effect of double counting of savings in end-products regulated by both motor regulation and end-product regulation, addressed in a separate Annex 8.

Model structure

The general structure of the model follows the format and conventions as laid down in the VHK EIA-study.[88]

The figure on the next page gives an illustration of the parameters used. The parameters with extension …BAU are used for the baseline scenario. The parameters with extension …ECO are used for one or more policy options (ECO1, ECO2, etc.).

The model is built in MS Excel, using a 1 year time step. Every parameter name corresponds to an Excel sheet. Auxiliary sheets are added for the calculations.

In the case of electric motors, 5 scenarios are calculated (BAU2009, BAU2017, ECO1, ECO2 and ECO3). BAU2009 is only used in section 1 of the main report and in Annex 5, where the impact of regulation 640/2009 is assessed. In the scenario analysis BAU2017, called 'BAU' in section 5, is used. In total the stock model file contains approximately 110 sheets. File size is 18 Mb. To facilitate access and avoid safety warnings, the files do not contain any macros, references to other files, or other proprietary software procedures.

[88] VHK, Ecodesign Impact Accounting – status May 2015, for EC, DG ENER, November 2015. Download: https://ec.europa.eu/energy/sites/ener/files/documents/Ecodesign%20Impacts%20Accounting%20%20-%20final%2020151217.pdf

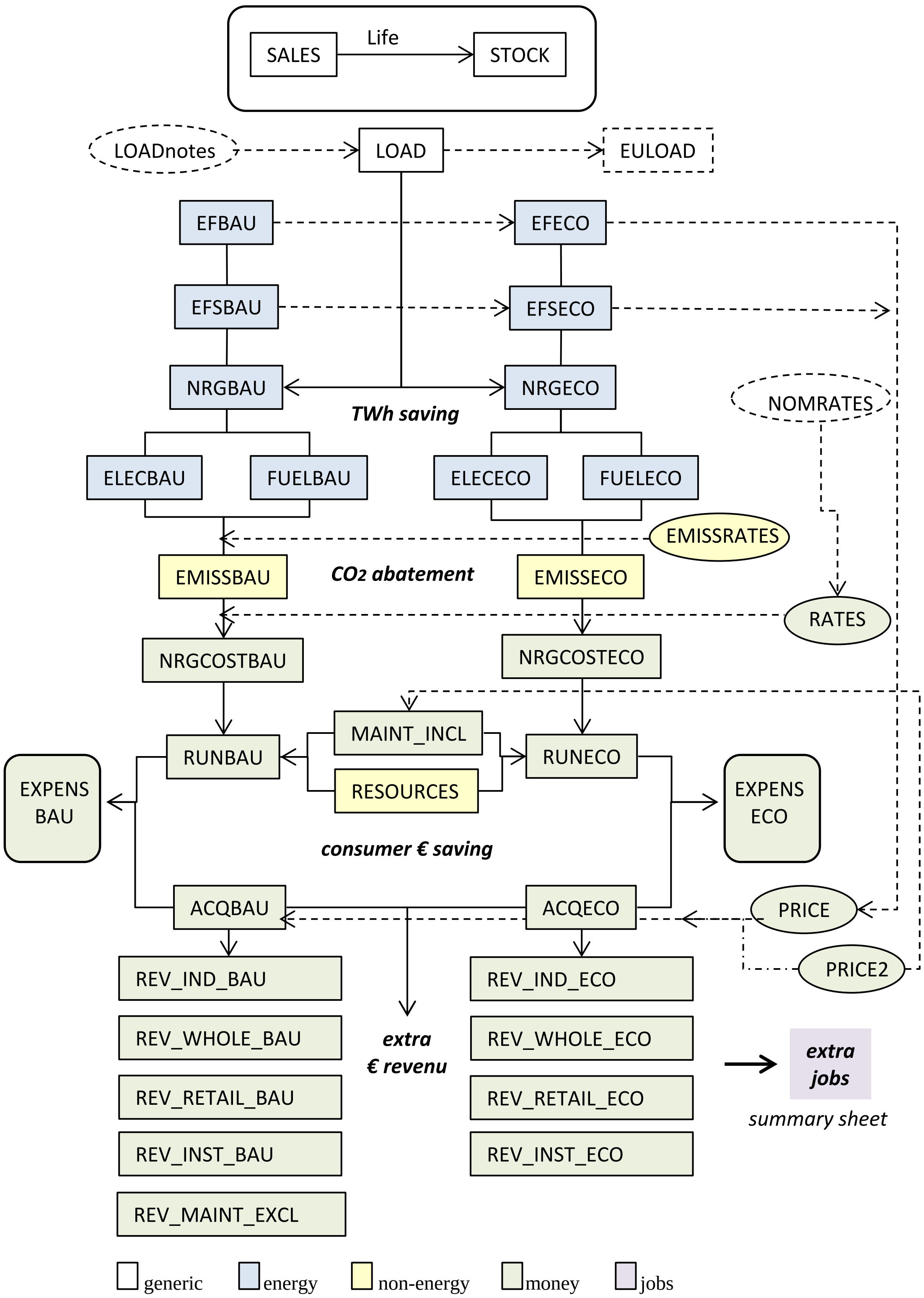

Figure 7.1. Structure of core calculation.

The tables hereafter give the details of main inputs and outputs of the model. They provide data for the 4 scenarios BAU2009, BAU2017, ECO1 and ECO3. ECO2 figures can be deduced by using figures of ECO3 except for small motors (XS1, XS1v, XS3 and XS3) where ECO1 figures should be used.

Inputs

Table 7.1. Use of acronyms for market segments ('base cases') in the stock model

Voltage	Phase	Output	General purpose		special purpose		
LV or MV	*1 or 3*	*kW-range*	*no vsd*	*with vsd*	*explosion-proof*	*brake-motor*	*8-pole motor*
LV	1	0.12-0.75	*XS1*	*XS1v*			
		>0.75	*S1*				
	3	0.12-0.75	*XS3*	*XS3v*			
		0.75-7.5	***S3***	***S3v***	*ExS*	*BrakeS*	*8poleS*
		7.5-75	***M3***	***M3v***	*ExM*	*BrakeM*	*8poleM*
		75-375	***L3***	***L3v***	*ExL*	*BrakeL*	*8poleL*
		375-1000	*XL3*	*XLv3*			

Aggregates use combinations of letters, e.g.
SML3±v comprises S3/M3/L3 and S3v/M3v/L3v;
XS13±v comprises XS1/XS1v/XS3/XS3v. S13±v comprises S1/S1v/S3/S3v;
XL3±v comprises XL3 and XL3v;
ExSML, BrakeSML, 8poleSML comprise the whole special purpose subcategory (all sizes).

Table 7.2. Basic functional parameters and efficiency classes

Motor	**Output**	**Hours**	**Load**	**Life**	**Motor efficiency class, values at given output****						**VSD efficiency Class (losses in W)**				
Type	**kW**	**h/y**	**factor**	**years**	**No cat**	**IE1**	**IE2**	**IE3**	**IE4**	**IE5**	**IE0**	**IE1**	**IE2**	**IE3**	**Δmotor ***
S3	1.1	2800	0.57	9	70.0%	75.0%	81.4%	84.1%	87.2%	89.8%					
M3	11	3500	0.52	11	85.1%	87.6%	89.8%	91.4%	93.3%	94.6%					
L3	110	7000	0.52	16	92.0%	93.3%	94.5%	95.4%	96.3%	97.0%					
S3v	1.1	2800	0.34	9	70.0%	75.0%	81.4%	84.1%	87.2%	89.8%	204	163	122	82	1.15
M3v	11	3500	0.31	11	85.1%	87.6%	89.8%	91.4%	93.3%	94.6%	980	784	588	392	1.15
L3v	110	7000	0.31	16	92.0%	93.3%	94.5%	95.4%	96.3%	97.0%	6978	5582	4187	2791	1.25
XS1	0.37	400	0.40	8	59.2%	66.0%	72.7%	77.3%	81.1%	84.9%					
XS1v	0.37	400	0.24	8	59.2%	66.0%	72.7%	77.3%	81.1%	84.9%	148	118	89	59	1.15
XS3	0.37	2000	0.40	8	59.2%	66.0%	72.7%	77.3%	81.1%	84.9%					
XS3v	0.37	2000	0.24	8	59.2%	66.0%	72.7%	77.3%	81.1%	84.9%	148	118	89	59	1.15
XL3	550	6000	0.52	18	92.8%	94.0%	95.1%	96.0%	96.7%	97.4%					
XL3v	550	6000	0.36	18	92.8%	94.0%	95.1%	96.0%	96.7%	97.4%	34714	27771	20828	13886	1.25
ExS	1.1	2250	0.57	9	70.0%	75.0%	81.4%	84.1%	87.2%	89.8%					
ExM	11	3000	0.52	11	85.1%	87.6%	89.8%	91.4%	93.3%	94.6%					
ExL	110	6000	0.52	16	92.0%	93.3%	94.5%	95.4%	96.3%	97.0%					
BrakeS	1.1	1250	0.57	9	70.0%	75.0%	81.4%	84.1%	87.2%	89.8%					
BrakeM	11	1600	0.52	11	85.1%	87.6%	89.8%	91.4%	93.3%	94.6%					
BrakeL	110	2400	0.52	16	92.0%	93.3%	94.5%	95.4%	96.3%	97.0%					
8poleS	1.1	2250	0.57	9	59.8%	66.5%	70.8%	77.7%	80.8%	84.6%					
8poleM	11	3000	0.52	11	82.0%	85.0%	86.9%	88.6%	90.4%	92.3%					
8poleL	110	6000	0.52	16	89.3%	91.1%	92.3%	93.7%	94.7%	95.8%					
S1	1.1	800	0.5	12	70.0%	75.0%	81.4%	84.1%	87.2%	89.8%					

*= Degradation of motor efficiency when VSD is applied. Losses induced by VSD in motor are 1.15 times motor losses for output powers < 90 kW; 1.25 times for higher powers. Based on EN 50598-2.
Formula for annual energy use (in kWh/yr):
Energy use=Output Power * Hours * Load factor / (motor efficiency). In case of VSD application, overall (motor+VSD) efficiency = motor output power / (motor output power + motor losses*Δmotor + VSD losses)

**= Except for 8-pole motors, reference is 4-pole 50 Hz. Data from EN 60034-30-1. IE0: 20% more losses than IE1. IE5: 20% less losses than IE4. The distribution of sales over the motor efficiency classes gives the average efficiency used in the model.
For VSD, class IE0 has 25% higher losses than IE1

The stock model uses a 1 year time-step. Stock (= number of installed products) is calculated from sales over the current and X-1 preceding years, where X=product life.

Table 7.3. SALES-BAU (in 000 units)
(this is for BAU2009, without effect of CR 640/2009)

Motor	1990	2010	2015	2020	2025	2030
S3	5169	7034	7301	7372	7254	7078
M3	691	915	940	936	906	865
L3	54	67	67	65	60	54
S3v	551	1398	1711	2048	2405	2824
M3v	98	248	303	363	427	501
L3v	12	30	37	44	51	60
sum SML3±v	**6575**	**9692**	**10358**	**10828**	**11102**	**11382**
% with VSD	10%	17%	20%	23%	26%	30%
XS1	11631	15746	16115	16212	16295	16372
XS1v	237	1750	2156	2335	2485	2644
XS3	3262	4350	4518	4634	4686	4734
XS3v	78	574	721	812	896	990
sum XS13±v	**15209**	**22420**	**23511**	**23992**	**24363**	**24740**
% with VSD	2%	10%	12%	13%	14%	15%
XL3	5.9	6.1	5.3	5.1	5.1	5.1
XL3v	0.7	3.6	5.0	5.6	5.9	6.2
sum XL3±v	**6.6**	**9.7**	**10.3**	**10.7**	**11.0**	**11.3**
% with VSD	10%	37%	49%	52%	53%	55%
ExS	217	320	342	357	366	375
ExM	44	64	69	72	74	76
ExL	3	5	5	5	5	6
sum ExSML	**264**	**389**	**416**	**434**	**445**	**457**
BrakeS	271	400	427	447	458	469
BrakeM	55	80	86	90	92	94
BrakeL	4	6	6	7	7	7
sum Brake	**330**	**486**	**519**	**543**	**557**	**571**
8poleS	10.8	16.0	17.1	17.9	18.3	18.8
8poleM	2.2	3.2	3.4	3.6	3.7	3.8
8poleL	0.2	0.2	0.3	0.3	0.3	0.3
sum 8pole	**13**	**19**	**21**	**22**	**22**	**23**
S1	**6633**	**9778**	**10450**	**10925**	**11200**	**11483**
TOTAL	**29031**	**42794**	**45285**	**46755**	**47701**	**48667**

SALES-BAU2 & -ECO (in 000 units),
(this is for BAU2017, with effect of CR 640/2009)
Sales are the same as in BAU2009, except for VSD-shift for motors in scope of CR 640/2009

Motor	1990	2010	2015	2020	2025	2030
S3	5169	7021	6850	5789	5749	5731
M3	691	912	780	669	658	647
L3	54	67	52	45	43	41
S3v	551	1411	2162	3632	3910	4171
M3v	98	251	463	630	674	719
L3v	12	30	52	63	68	73
sum SML3±v	**6575**	**9692**	**10358**	**10828**	**11102**	**11382**
% with VSD	10%	17%	26%	40%	42%	44%

For other motor categories sales are the same as in BAU2009

For ECO1 to ECO3 sales are the same as in BAU2017

Table 7.4. STOCK-BAU (in 000 units)
(this is for BAU2009, without effect of CR 640/2009)

Motor	1990	2010	2015	2020	2025	2030
S3	43397	59564	63607	65798	66058	64940
M3	6990	9386	9982	10284	10242	9940
L3	766	994	1038	1060	1042	986
S3v	4134	10483	13139	16031	19086	22428
M3v	857	2171	2732	3350	4004	4716
L3v	134	342	430	533	644	765
sum SML3±v	**56279**	**82940**	**90928**	**97057**	**101076**	**103775**
% with VSD	9%	16%	18%	21%	23%	27%
XS1	87882	119313	126855	129167	129898	130547
XS1v	694	11289	15016	17649	19037	20260
XS3	24701	33051	35166	36466	37195	37606
XS3v	228	3707	4957	5979	6696	7396
sum XS13±v	**113505**	**167360**	**181994**	**189261**	**192826**	**195808**
% with VSD	1%	9%	11%	12%	13%	14%
XL3	93.0	113.6	110.7	104.8	98.4	93.5
XL3v	6.3	34.4	51.8	71.4	88.4	100.8
sum XL3±v	**99.3**	**148.1**	**162.5**	**176.2**	**186.9**	**194.3**
% with VSD	6%	23%	32%	41%	47%	52%
ExS	1802	2656	2910	3103	3229	3313
ExM	434	639	703	754	788	811
ExL	45	66	73	79	84	87
sum ExSML	**2281**	**3362**	**3686**	**3936**	**4100**	**4210**
BrakeS	2253	3320	3638	3879	4036	4141
BrakeM	543	799	879	943	985	1013
BrakeL	56	83	91	99	104	108
sum Brake	**2851**	**4202**	**4608**	**4920**	**5125**	**5263**
8poleS	90.1	132.8	145.5	155.1	161.4	165.6
8poleM	21.7	32.0	35.2	37.7	39.4	40.5
8poleL	2.2	3.3	3.6	3.9	4.2	4.3
sum 8pole	**114**	**168**	**184**	**197**	**205**	**211**
S1	**71202**	**104945**	**115533**	**124226**	**130090**	**134089**
TOTAL	**246331**	**363124**	**397096**	**419773**	**433609**	**443551**

STOCK-BAU2 & -ECO (in 000 units),
(this is for BAU2017, with effect of CR 640/2009)
Stock is the same as in BAU2009, except for VSD-shift for motors in scope of CR 640/2009

Motor	1990	2010	2015	2020	2025	2030
S3	43397	59547	62631	58269	52436	51701
M3	6990	9382	9670	8723	7551	7239
L3	766	993	1004	928	819	710
S3v	4134	10499	14115	23561	32708	35667
M3v	857	2175	3044	4912	6695	7417
L3v	134	343	464	666	867	1041
sum SML3±v	**56279**	**82940**	**90928**	**97057**	**101076**	**103775**
% with VSD	9%	16%	19%	30%	40%	43%

For other motor categories stock is the same as in BAU2009

For ECO1 to ECO3 stock is the same as in BAU2017

Tables below give the efficiency of the sales for the 4 scenarios BAU2009, BAU2017, ECO1 and ECO3. Efficiencies are linked to sales and allow to calculate the efficiency of the stock. The latter is not reported here, see underlying Excel file.

Table 7.5. Efficiency of motors sold in a given year, in %.

	EFNBAU (without effect of CR 640/2009)						EFNBAU2 (with effect of CR 640/2009 on SML3±v)			
Lot	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	70.1%	75.9%	76.5%	77.2%	77.9%	78.6%	80.6%	83.1%	83.5%	83.9%
M3	85.2%	87.9%	88.1%	88.4%	88.7%	89.0%	89.6%	90.8%	91.1%	91.3%
L3	92.0%	93.5%	93.6%	93.7%	93.9%	94.0%	94.4%	95.1%	95.2%	95.3%
S3v	59.7%	66.6%	67.5%	68.3%	69.2%	70.0%	71.2%	73.7%	74.3%	74.8%
M3v	77.6%	81.7%	82.2%	82.6%	83.0%	83.5%	83.7%	85.1%	85.4%	85.8%
L3v	85.3%	88.2%	88.5%	88.8%	89.1%	89.4%	89.5%	90.3%	90.6%	90.8%
							for types below, EFNBAU2=EFNBAU			
XS1	62.4%	65.3%	66.0%	66.7%	67.5%	68.2%	*66.0%*	*66.7%*	*67.5%*	*68.2%*
XS1v	47.8%	51.1%	51.9%	52.8%	53.6%	54.5%	*51.9%*	*52.8%*	*53.6%*	*54.5%*
XS3	62.4%	65.3%	66.0%	66.7%	67.5%	68.2%	*66.0%*	*66.7%*	*67.5%*	*68.2%*
XS3v	47.8%	51.1%	51.9%	52.8%	53.6%	54.5%	*51.9%*	*52.8%*	*53.6%*	*54.5%*
XL3	93.5%	94.4%	94.7%	95.0%	95.2%	95.5%	*94.7%*	*95.0%*	*95.2%*	*95.5%*
XL3v	86.9%	88.4%	88.9%	89.2%	89.6%	90.0%	*88.9%*	*89.2%*	*89.6%*	*90.0%*
ExS	70.1%	75.9%	76.5%	77.2%	77.9%	78.6%	*76.5%*	*77.2%*	*77.9%*	*78.6%*
ExM	85.2%	87.9%	88.1%	88.4%	88.7%	89.0%	*88.1%*	*88.4%*	*88.7%*	*89.0%*
ExL	92.0%	93.5%	93.6%	93.7%	93.9%	94.0%	*93.6%*	*93.7%*	*93.9%*	*94.0%*
BrakeS	70.1%	75.9%	76.5%	77.2%	77.9%	78.6%	*76.5%*	*77.2%*	*77.9%*	*78.6%*
BrakeM	85.2%	87.9%	88.1%	88.4%	88.7%	89.0%	*88.1%*	*88.4%*	*88.7%*	*89.0%*
BrakeL	92.0%	93.5%	93.6%	93.7%	93.9%	94.0%	*93.6%*	*93.7%*	*93.9%*	*94.0%*
8poleS	62.1%	67.9%	68.5%	69.2%	69.9%	70.6%	*68.5%*	*69.2%*	*69.9%*	*70.6%*
8poleM	82.2%	84.9%	85.1%	85.4%	85.7%	86.0%	*85.1%*	*85.4%*	*85.7%*	*86.0%*
8poleL	90.0%	91.5%	91.6%	91.7%	91.9%	92.0%	*91.6%*	*91.7%*	*91.9%*	*92.0%*
S1	70.1%	75.9%	76.5%	77.2%	77.9%	78.6%	*76.5%*	*77.2%*	*77.9%*	*78.6%*

	EFNECO (with effect of CR 640/2009 and new measures on SML3)				EFNECO3 (with effect of new measures on all types)			
Lot	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	*80.6%*	83.4%	84.4%	84.6%	*80.6%*	*83.4%*	*84.4%*	*84.7%*
M3	*89.6%*	91.0%	91.6%	91.7%	*89.6%*	*91.0%*	*91.6%*	*91.8%*
L3	*94.4%*	95.2%	95.5%	95.5%	*94.4%*	*95.2%*	*95.5%*	*95.6%*
S3v	*71.2%*	74.0%	75.1%	75.5%	*71.2%*	74.1%	75.8%	*76.2%*
M3v	*83.7%*	85.2%	86.0%	86.2%	*83.7%*	85.3%	86.4%	*86.7%*
L3v	*89.5%*	90.4%	90.9%	91.1%	*89.5%*	90.5%	91.3%	*91.4%*
	for types below, EFNECO=EFNBAU2							
XS1	*66.0%*	*66.7%*	*67.5%*	*68.2%*	*66.0%*	67.5%	72.8%	*73.2%*
XS1v	*51.9%*	*52.8%*	*53.6%*	*54.5%*	*51.9%*	53.8%	60.1%	*60.5%*
XS3	*66.0%*	*66.7%*	*67.5%*	*68.2%*	*66.0%*	67.5%	72.8%	*73.2%*
XS3v	*51.9%*	*52.8%*	*53.6%*	*54.5%*	*51.9%*	53.8%	60.1%	*60.5%*
XL3	*94.7%*	*95.0%*	*95.2%*	*95.5%*	*94.7%*	95.3%	96.0%	*96.1%*
XL3v	*88.9%*	*89.2%*	*89.6%*	*90.0%*	*88.9%*	89.8%	90.8%	*90.9%*
ExS	*76.5%*	*77.2%*	*77.9%*	*78.6%*	*76.5%*	78.0%	84.2%	*84.6%*
ExM	*88.1%*	*88.4%*	*88.7%*	*89.0%*	*88.1%*	88.8%	91.5%	91.7%
ExL	*93.6%*	*93.7%*	*93.9%*	*94.0%*	*93.6%*	94.0%	95.4%	95.5%
BrakeS	*76.5%*	*77.2%*	*77.9%*	*78.6%*	*76.5%*	78.0%	84.2%	84.6%
BrakeM	*88.1%*	*88.4%*	*88.7%*	*89.0%*	*88.1%*	88.8%	91.5%	91.7%
BrakeL	*93.6%*	*93.7%*	*93.9%*	*94.0%*	*93.6%*	94.0%	95.4%	95.5%
8poleS	*68.5%*	*69.2%*	*69.9%*	*70.6%*	*68.5%*	70.0%	77.8%	78.2%
8poleM	*85.1%*	*85.4%*	*85.7%*	*86.0%*	*85.1%*	85.6%	88.6%	88.8%
8poleL	*91.6%*	*91.7%*	*91.9%*	*92.0%*	*91.6%*	91.8%	93.7%	93.8%
S1	*76.5%*	*77.2%*	*77.9%*	*78.6%*	*76.5%*	77.5%	81.5%	81.9%

Unit prices for motors and VSDs

Table 7.6. Anchor-points for motor price calculation (euros 2010, excl. VAT, incl. installation) depending on efficiency (EF), annual decrease for learning effect (price dec), share of price that is for installation, and annual maintenance costs

Motor	BC	BC	mid	mid	BAT	BAT	dec	inc	price	share	maint
	Price	EF	Price	EF	Price	EF	Price/EF	Price/EF	dec	install	
	€	%	€	%	€	%	€/%	€/%	%/a	%	€/a
S3	120	71.8%	170	81.4%	247	87.2%	5	13	1%	21%	0
M3	476	86.5%	680	89.8%	884	93.5%	62	55	1%	12%	64
L3	4375	92.7%	6250	94.5%	7500	96.3%	1042	694	1%	4%	353
S3v										30%	0
M3v										27%	82
L3v										20%	462
XS1	33	62.4%	50	66.0%	83	77.3%	5	3	1%	20%	0
XS1v										31%	0
XS3	68	62.4%	90	66.0%	135	77.3%	6	4	1%	22%	0
XS13v										31%	0
XL3	18550	93.5%	26500	95.1%	34450	96.8%	4969	4676	1%	6%	1176
XL3v										24%	1285
ExS	180	71.8%	255	81.4%	371	87.2%	8	20	1%	21%	0
ExM	714	86.5%	1020	89.8%	1326	93.5%	93	83	1%	12%	64
ExL	6563	92.7%	9375	94.5%	11250	96.3%	1563	1042	1%	4%	353
BrakeS	180	71.8%	255	81.4%	371	87.2%	8	20	1%	21%	0
BrakeM	714	86.5%	1020	89.8%	1326	93.5%	93	83	1%	12%	64
BrakeL	6563	92.7%	9375	94.5%	11250	96.3%	1563	1042	1%	4%	353
8poleS	192	63.8%	272	73.4%	395	79.2%	8	21	1%	13%	0
8poleM	762	83.5%	1088	86.8%	1414	90.5%	99	88	1%	7%	64
8poleL	7000	90.7%	10000	92.5%	12000	94.3%	1667	1111	1%	3%	353
S1	132	71.8%	187	81.4%	272	87.2%	5.7	14.6	1%	19%	0

Prices are sum of purchase and installation; no VAT included. BC uses 'No category' data. MID uses default class data (IE1 or IE2). BAT uses IE3 or IE4 data. All prices in Euro 2010. Prices for motor with VSD in a given year are determined as sum of motor price and VSD price in the same year (no anchor points defined for motors with VSD)

Source for most prices is the Lot30 prepratory study. For small motors (0.12-0.75 kW), smal medium motors (0.75-7.5 kW) and 8-pole motors, additional price research was performed in summer 2017 (online via internet; some quotations requested from wholesalers and manufacturers).

Table 7.7. Anchor-points for VSD price calculation (euros 2010, excl. VAT) depending on VSD losses (W), annual decrease for learning effect (price dec), share of price that is installation, and annual maintenance costs

VSD	BC	BC	mid	mid	BAT	BAT	BC-mid	mid-BAT	Price	share	maint
	Price	VSD loss	Price	VSD loss	Price	VSD loss	Price/W	Price/W	decrease	install	
	€	W	€	W	€	W	€ct/W	€ct/W	%/a	%	€/a
XS1	270	148	300	118	360	59	-1.02	-1.02	1%	33%	0
XS3	270	148	300	118	360	59	-1.02	-1.02	1%	33%	0
S3	378	204	420	163	504	82	-1.03	-1.03	1%	33%	0
M3	1526	980	1695	784	2034	392	-0.86	-0.86	1%	33%	18
L3	7182	6978	7980	5582	9576	2791	-0.57	-0.57	1%	33%	109
XL3	55611	34714	61790	27771	74148	13886	-0.89	-0.89	1%	32%	109

Prices are sum of purchase and installation; no VAT included. All prices in Euro 2010
BC uses 'No category' data. MID uses IE1. BAT uses IE3.
Price for a VSD in a given year is determined in function of the VSD efficiency in that year by interpolating between the three anchor points (efficiency-price pairs).

Energy rates

Table 7.8. Electricity rates in euros/kWh (source:*)

Year	1990	2000	2010	2015	2020	2025	2030
€/kWh	0.119	0.084	0.104	0.120	0.135	0.164	0.200

* Source for 2007-2016: Eurostat, extraction 18 July 2017, Industrial users Band IC: 500 MWh < Consumption < 2000 MWh, excluding VAT and other recoverable taxes and levies, EU-28 annual average.
Source for years preceding 2007: MEErP2011 and EIA2016.
For years following 2016 applied an escalation rate of 4%/a. No discount rate applied (modelling here is not on investment decisions).

CO2 emissions from power generation

Table 7.9. CO2 emission rates for EU power generation and distribution (sources: MEErP 2011, EIA 2016)

Year	1990	2000	2010	2015	2020	2025	2030
kg CO2/kWh electric	0.50	0.43	0.41	0.40	0.38	0.36	0.34

Energy efficiency of power generation

By convention, a primary energy factor of 2.5 (efficiency 40%) is applied. Note that no primary energy values are used in this report. All values are in kW, kWh and TWh electricity to avoid confusion.

Outputs

Electricity consumption

Table 7.10. Electricity consumption, in TWh/yr for the four scenarios examined

	ELECBAU (without effect of CR 640/2009)						ELECBAU2 (with effect of CR 640/2009 on SML3±v)			
Lot	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	109.4	138.6	146.8	150.7	149.9	146.1	141.0	126.1	111.0	108.6
M3	164.6	214.5	227.3	233.6	231.9	224.4	218.9	195.1	167.0	159.2
L3	334.2	427.8	445.1	453.8	445.2	420.7	429.8	395.1	346.8	299.0
S3v	7.4	16.8	20.7	24.9	29.3	34.1	21.6	34.4	46.8	50.5
M3v	13.3	32.2	40.1	48.9	58.2	68.2	44.3	70.3	94.8	104.3
L3v	38.0	94.2	117.6	144.9	174.4	206.5	126.2	179.2	231.6	276.8
sum SML3±v	**666.9**	**924.2**	**997.6**	**1056.8**	**1089.1**	**1099.9**	**981.9**	**1000.1**	**998.0**	**998.3**
share VSD	9%	16%	18%	21%	24%	28%	20%	28%	37%	43%
							for types below, ELECBAU2=ELECBAU			
XS1	8.3	10.9	11.5	11.5	11.5	11.4	*11.5*	*11.5*	*11.5*	*11.4*
XS1v	0.1	0.8	1.0	1.2	1.3	1.3	*1.0*	*1.2*	*1.3*	*1.3*
XS3	11.7	15.1	15.9	16.3	16.4	16.4	*15.9*	*16.3*	*16.4*	*16.4*
XS3v	0.1	1.3	1.7	2.0	2.2	2.4	*1.7*	*2.0*	*2.2*	*2.4*
sum XS	**20.2**	**28.1**	**30.1**	**31.1**	**31.4**	**31.6**	***30.1***	***31.1***	***31.4***	***31.6***
share VSD	1%	7%	9%	10%	11%	12%	*9%*	*10%*	*11%*	*12%*
XL3	170.8	207.6	201.8	190.5	178.3	168.8	*201.8*	*190.5*	*178.3*	*168.8*
XL3v	8.7	46.6	69.7	95.6	118.0	133.9	*69.7*	*95.6*	*118.0*	*133.9*
sum XL	**179.5**	**254.2**	**271.5**	**286.2**	**296.3**	**302.8**	***271.5***	***286.2***	***296.3***	***302.8***
share VSD	5%	18%	26%	33%	40%	44%	*26%*	*33%*	*40%*	*44%*
ExS	3.6	5.0	5.4	5.7	5.9	6.0	*5.4*	*5.7*	*5.9*	*6.0*
ExM	8.8	12.5	13.7	14.7	15.3	15.7	*13.7*	*14.7*	*15.3*	*15.7*
ExL	16.7	24.4	26.7	29.0	30.6	31.7	*26.7*	*29.0*	*30.6*	*31.7*
sum ExSML	**29.1**	**41.9**	**45.9**	**49.3**	**51.8**	**53.4**	***45.9***	***49.3***	***51.8***	***53.4***
BrakeS	2.5	3.4	3.7	4.0	4.1	4.2	*3.7*	*4.0*	*4.1*	*4.2*
BrakeM	5.8	8.3	9.1	9.8	10.2	10.5	*9.1*	*9.8*	*10.2*	*10.5*
BrakeL	8.3	12.2	13.4	14.5	15.3	15.9	*13.4*	*14.5*	*15.3*	*15.9*
sum Brake	**16.7**	**24.0**	**26.3**	**28.2**	**29.6**	**30.5**	***26.3***	***28.2***	***29.6***	***30.5***
8poleS	0.2	0.3	0.3	0.3	0.3	0.3	*0.3*	*0.3*	*0.3*	*0.3*
8poleM	0.5	0.6	0.7	0.8	0.8	0.8	*0.7*	*0.8*	*0.8*	*0.8*
8poleL	0.9	1.2	1.4	1.5	1.6	1.6	*1.4*	*1.5*	*1.6*	*1.6*
sum 8-pole	**1.5**	**2.2**	**2.4**	**2.6**	**2.7**	**2.8**	***2.4***	***2.6***	***2.7***	***2.8***
S1	**45.1**	**61.6**	**67.0**	**71.4**	**74.2**	**75.8**	***67.0***	***71.4***	***74.2***	***75.8***
Sum all	**959.0**	**1336.2**	**1440.6**	**1525.7**	**1575.0**	**1596.8**	**1424.9**	**1469.0**	**1484.0**	**1495.1**

Table 7.10. Electricity consumption, continued

	ELECECO (with effect of CR 640/2009 and new measures on SML3)				ELECECO3 (with effect of new measures on all types)			
Lot	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	*141.0*	126.0	110.4	107.6	*141.0*	*126.0*	*110.4*	*107.5*
M3	*218.9*	195.0	166.5	158.4	*218.9*	*195.0*	*166.5*	*158.3*
L3	*429.8*	395.1	346.5	298.5	*429.8*	*395.1*	*346.5*	*298.4*
S3v	*21.6*	34.4	46.5	50.0	*21.6*	34.4	46.3	*49.5*
M3v	*44.3*	70.2	94.5	103.7	*44.3*	70.2	94.3	*103.2*
L3v	*126.2*	179.1	231.2	276.1	*126.2*	179.1	230.9	*275.4*
sum SML3±v	***981.9***	**999.8**	**995.6**	**994.3**	***981.9***	**999.8**	**994.8**	**992.5**
share VSD	*20%*	28%	37%	43%	*20%*	28%	37%	43%
	for types below, ELECECO=ELECBAU2							
XS1	*11.5*	*11.5*	*11.5*	*11.4*	*11.5*	11.5	11.0	10.6
XS1v	*1.0*	*1.2*	*1.3*	*1.3*	*1.0*	1.2	1.2	1.2
XS3	*15.9*	*16.3*	*16.4*	*16.4*	*15.9*	16.3	15.8	15.3
XS3v	*1.7*	*2.0*	*2.2*	*2.4*	*1.7*	2.0	2.1	2.2
sum XS	***30.1***	***31.1***	***31.4***	***31.6***	***30.1***	**31.0**	**30.2**	**29.3**
share VSD	*9%*	*10%*	*11%*	*12%*	*9%*	10%	11%	12%
XL3	*201.8*	*190.5*	*178.3*	*168.8*	*201.8*	190.5	177.9	168.1
XL3v	*69.7*	*95.6*	*118.0*	*133.9*	*69.7*	95.6	117.5	132.9
sum XL	***271.5***	***286.2***	***296.3***	***302.8***	***271.5***	**286.1**	**295.4**	**301.1**
share VSD	*26%*	*33%*	*40%*	*44%*	*26%*	33%	40%	44%
ExS	*5.4*	*5.7*	*5.9*	*6.0*	*5.4*	5.7	5.7	5.5
ExM	*13.7*	*14.7*	*15.3*	*15.7*	*13.7*	14.7	15.1	15.3
ExL	*26.7*	*29.0*	*30.6*	*31.7*	*26.7*	29.0	30.4	31.4
sum ExSML	***45.9***	***49.3***	***51.8***	***53.4***	***45.9***	**49.3**	**51.2**	**52.2**
BrakeS	*3.7*	*4.0*	*4.1*	*4.2*	*3.7*	4.0	3.9	3.9
BrakeM	*9.1*	*9.8*	*10.2*	*10.5*	*9.1*	9.8	10.1	10.2
BrakeL	*13.4*	*14.5*	*15.3*	*15.9*	*13.4*	14.5	15.2	15.7
sum Brake	***26.3***	***28.2***	***29.6***	***30.5***	***26.3***	**28.2**	**29.2**	**29.7**
8poleS	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	0.3	0.3	0.3
8poleM	*0.7*	*0.8*	*0.8*	*0.8*	*0.7*	0.8	0.8	0.8
8poleL	*1.4*	*1.5*	*1.6*	*1.6*	*1.4*	1.5	1.6	1.6
sum 8-pole	***2.4***	***2.6***	***2.7***	***2.8***	***2.4***	**2.6**	**2.6**	**2.7**
S1	***67.0***	***71.4***	***74.2***	***75.8***	***67.0***	**71.4**	**73.0**	**73.3**
Sum all	**1424.9**	**1468.7**	**1481.6**	**1491.1**	**1424.9**	**1468.4**	**1476.4**	**1480.8**

Greenhouse gas emissions

GHG-emissions are calculated multiplying the electricity consumption of table 7.10 by the CO2 emission rates of table 7.9.

Table 7.11. GHG Emissions, in MtCO2eq./yr for the four scenarios examined

	EMISBAU (without effect of CR 640/2009)						EMISBAU2 (with effect of CR 640/2009 on SML3±v)			
Lot	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	54.7	56.8	58.0	57.3	54.0	49.7	55.7	47.9	40.0	36.9
M3	82.3	88.0	89.8	88.8	83.5	76.3	86.4	74.1	60.1	54.1
L3	167.1	175.4	175.8	172.5	160.3	143.1	169.8	150.1	124.9	101.7
S3v	3.7	6.9	8.2	9.5	10.6	11.6	8.5	13.1	16.9	17.2
M3v	6.7	13.2	15.9	18.6	20.9	23.2	17.5	26.7	34.1	35.5
L3v	19.0	38.6	46.4	55.1	62.8	70.2	49.9	68.1	83.4	94.1
sum SML3±v	**333.5**	**378.9**	**394.1**	**401.6**	**392.1**	**374.0**	**387.8**	**380.0**	**359.3**	**339.4**
share VSD	9%	16%	18%	21%	24%	28%	20%	28%	37%	43%
							for types below, EMISBAU2=EMISBAU			
XS1	4.2	4.5	4.5	4.4	4.1	3.9	*4.5*	*4.4*	*4.1*	*3.9*
XS1v	0.0	0.3	0.4	0.5	0.5	0.5	*0.4*	*0.5*	*0.5*	*0.5*
XS3	5.9	6.2	6.3	6.2	5.9	5.6	*6.3*	*6.2*	*5.9*	*5.6*
XS3v	0.0	0.5	0.7	0.8	0.8	0.8	*0.7*	*0.8*	*0.8*	*0.8*
sum XS	**10.1**	**11.5**	**11.9**	**11.8**	**11.3**	**10.8**	***11.9***	***11.8***	***11.3***	***10.8***
share VSD	1%	7%	9%	10%	11%	12%	*9%*	*10%*	*11%*	*12%*
XL3	85.4	85.1	79.7	72.4	64.2	57.4	*79.7*	*72.4*	*64.2*	*57.4*
XL3v	4.4	19.1	27.5	36.3	42.5	45.5	*27.5*	*36.3*	*42.5*	*45.5*
sum XL	**89.7**	**104.2**	**107.2**	**108.8**	**106.7**	**102.9**	***107.2***	***108.8***	***106.7***	***102.9***
share VSD	5%	18%	26%	33%	40%	44%	*26%*	*33%*	*40%*	*44%*
ExS	1.8	2.0	2.1	2.2	2.1	2.0	*2.1*	*2.2*	*2.1*	*2.0*
ExM	4.4	5.1	5.4	5.6	5.5	5.3	*5.4*	*5.6*	*5.5*	*5.3*
ExL	8.3	10.0	10.6	11.0	11.0	10.8	*10.6*	*11.0*	*11.0*	*10.8*
sum ExSML	**14.5**	**17.2**	**18.1**	**18.8**	**18.6**	**18.2**	***18.1***	***18.8***	***18.6***	***18.2***
BrakeS	1.3	1.4	1.5	1.5	1.5	1.4	*1.5*	*1.5*	*1.5*	*1.4*
BrakeM	2.9	3.4	3.6	3.7	3.7	3.6	*3.6*	*3.7*	*3.7*	*3.6*
BrakeL	4.2	5.0	5.3	5.5	5.5	5.4	*5.3*	*5.5*	*5.5*	*5.4*
sum Brake	**8.4**	**9.8**	**10.4**	**10.7**	**10.6**	**10.4**	***10.4***	***10.7***	***10.6***	***10.4***
8poleS	0.1	0.1	0.1	0.1	0.1	0.1	*0.1*	*0.1*	*0.1*	*0.1*
8poleM	0.2	0.3	0.3	0.3	0.3	0.3	*0.3*	*0.3*	*0.3*	*0.3*
8poleL	0.4	0.5	0.5	0.6	0.6	0.6	*0.5*	*0.6*	*0.6*	*0.6*
sum 8-pole	**0.8**	**0.9**	**0.9**	**1.0**	**1.0**	**0.9**	***0.9***	***1.0***	***1.0***	***0.9***
S1	**22.5**	**25.3**	**26.5**	**27.2**	**26.7**	**25.8**	***26.5***	***27.2***	***26.7***	***25.8***
Sum all	**479.5**	**547.8**	**569.1**	**579.8**	**567.0**	**542.9**	**562.8**	**558.2**	**534.2**	**508.4**

Table 7.11. GHG Emission, continued

	EMISECO (with effect of CR 640/2009 and new measures on SML3)				EMISECO3 (with effect of new measures on all types)			
Lot	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	*55.7*	47.9	39.7	36.6	*55.7*	*47.9*	*39.7*	*36.9*
M3	*86.4*	74.1	59.9	53.9	*86.4*	*74.1*	*59.9*	*54.1*
L3	*169.8*	150.1	124.8	101.5	*169.8*	*150.1*	*124.8*	*101.7*
S3v	*8.5*	13.1	16.7	17.0	*8.5*	13.1	16.7	*17.2*
M3v	*17.5*	26.7	34.0	35.3	*17.5*	26.7	33.9	*35.5*
L3v	*49.9*	68.1	83.2	93.9	*49.9*	68.1	83.1	*94.1*
sum SML3±v	***387.8***	**379.9**	**358.4**	**338.1**	***387.8***	**379.9**	**358.1**	**337.4**
share VSD	*20%*	28%	37%	43%	*20%*	28%	37%	43%
	for types below, EMISECO=EMISBAU2							
XS1	*4.5*	*4.4*	*4.1*	*3.9*	*4.5*	4.4	4.0	3.6
XS1v	*0.4*	*0.5*	*0.5*	*0.5*	*0.4*	0.5	0.4	0.4
XS3	*6.3*	*6.2*	*5.9*	*5.6*	*6.3*	6.2	5.7	5.2
XS3v	*0.7*	*0.8*	*0.8*	*0.8*	*0.7*	0.8	0.8	0.7
sum XS	***11.9***	***11.8***	***11.3***	***10.8***	***11.9***	**11.8**	**10.9**	**10.0**
share VSD	*9%*	*10%*	*11%*	*12%*	*9%*	10%	11%	12%
XL3	*79.7*	*72.4*	*64.2*	*57.4*	*79.7*	72.4	64.0	57.2
XL3v	*27.5*	*36.3*	*42.5*	*45.5*	*27.5*	36.3	42.3	45.2
sum XL	***107.2***	***108.8***	***106.7***	***102.9***	***107.2***	**108.7**	**106.3**	**102.4**
share VSD	*26%*	*33%*	*40%*	*44%*	*26%*	33%	40%	44%
ExS	*2.1*	*2.2*	*2.1*	*2.0*	*2.1*	2.2	2.0	1.9
ExM	*5.4*	*5.6*	*5.5*	*5.3*	*5.4*	5.6	5.4	5.2
ExL	*10.6*	*11.0*	*11.0*	*10.8*	*10.6*	11.0	11.0	10.7
sum ExSML	***18.1***	***18.8***	***18.6***	***18.2***	***18.1***	**18.7**	**18.4**	**17.8**
BrakeS	*1.5*	*1.5*	*1.5*	*1.4*	*1.5*	1.5	1.4	1.3
BrakeM	*3.6*	*3.7*	*3.7*	*3.6*	*3.6*	3.7	3.6	3.5
BrakeL	*5.3*	*5.5*	*5.5*	*5.4*	*5.3*	5.5	5.5	5.3
sum Brake	***10.4***	***10.7***	***10.6***	***10.4***	***10.4***	**10.7**	**10.5**	**10.1**
8poleS	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	0.1	0.1	0.1
8poleM	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	0.3	0.3	0.3
8poleL	*0.5*	*0.6*	*0.6*	*0.6*	*0.5*	0.6	0.6	0.5
sum 8-pole	***0.9***	***1.0***	***1.0***	***0.9***	***0.9***	**1.0**	**1.0**	**0.9**
S1	***26.5***	***27.2***	***26.7***	***25.8***	***26.5***	**27.1**	**26.3**	**24.9**
Sum all	**562.8**	**558.1**	**533.4**	**507.0**	**562.8**	**558.0**	**531.5**	**503.5**

<u>Acquisition costs</u> (purchase and installation, in Euro 2010)

EU total Acquisition costs are calculated multiplying the unit motor prices in a given year by the sales quantities in a given year (table 7.3). Unit prices are determined in function of efficiency as indicated in tables 7.6 and 7.7.

Table 7.12. Acquisition costs, in bn euros /yr (euros 2010, excl. VAT, incl. installation costs)

	ACQBAU (without effect of CR 640/2009)						ACQBAU2 (with effect of CR 640/2009 on SML3±v)			
Lot	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	0.6	1.0	1.0	1.0	0.9	0.9	1.1	1.0	1.0	1.0
M3	0.3	0.5	0.5	0.5	0.5	0.4	0.5	0.4	0.4	0.4
L3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2
S3v	0.3	0.8	1.0	1.1	1.3	1.4	1.3	2.1	2.2	2.3
M3v	0.2	0.6	0.7	0.8	0.9	1.0	1.1	1.5	1.5	1.5
L3v	0.1	0.4	0.5	0.6	0.6	0.7	0.7	0.9	0.9	0.9
sum SML3±	**1.8**	**3.6**	**4.0**	**4.3**	**4.5**	**4.8**	**4.9**	**6.2**	**6.2**	**6.3**
share VSD	34%	49%	53%	57%	62%	66%	62%	72%	73%	75%
							for types below, ACQBAU2=ACQBAU			
XS1	0.4	0.7	0.8	0.8	0.8	0.8	*0.8*	*0.8*	*0.8*	*0.8*
XS1v	0.1	0.6	0.7	0.7	0.8	0.8	*0.7*	*0.7*	*0.8*	*0.8*
XS3	0.2	0.4	0.4	0.4	0.4	0.4	*0.4*	*0.4*	*0.4*	*0.4*
XS3v	0.0	0.2	0.3	0.3	0.3	0.3	*0.3*	*0.3*	*0.3*	*0.3*
sum XS	**0.7**	**1.9**	**2.1**	**2.2**	**2.3**	**2.3**	***2.1***	***2.2***	***2.3***	***2.3***
share VSD	14%	42%	46%	47%	49%	51%	*46%*	*47%*	*49%*	*51%*
XL3	0.1	0.1	0.1	0.1	0.1	0.1	*0.1*	*0.1*	*0.1*	*0.1*
XL3v	0.0	0.3	0.4	0.4	0.5	0.5	*0.4*	*0.4*	*0.5*	*0.5*
sum XL	**0.2**	**0.4**	**0.5**	**0.6**	**0.6**	**0.6**	***0.5***	***0.6***	***0.6***	***0.6***
share VSD	31%	68%	77%	79%	79%	80%	*77%*	*79%*	*79%*	*80%*
ExS	0.0	0.1	0.1	0.1	0.1	0.1	*0.1*	*0.1*	*0.1*	*0.1*
ExM	0.0	0.1	0.1	0.1	0.1	0.1	*0.1*	*0.1*	*0.1*	*0.1*
ExL	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
sum ExSML	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	***0.2***	***0.2***	***0.2***	***0.2***
BrakeS	0.0	0.1	0.1	0.1	0.1	0.1	*0.1*	*0.1*	*0.1*	*0.1*
BrakeM	0.0	0.1	0.1	0.1	0.1	0.1	*0.1*	*0.1*	*0.1*	*0.1*
BrakeL	0.0	0.0	0.0	0.0	0.0	0.1	*0.0*	*0.0*	*0.0*	*0.1*
sum Brake	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	***0.2***	***0.2***	***0.2***	***0.2***
8poleS	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
8poleM	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
8poleL	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
sum 8-pole	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	***0.0***	***0.0***	***0.0***	***0.0***
S1	**0.9**	**1.5**	**1.6**	**1.6**	**1.6**	**1.6**	***1.6***	***1.6***	***1.6***	***1.6***
Sum all	**3.7**	**7.9**	**8.6**	**9.0**	**9.3**	**9.7**	**9.5**	**10.9**	**11.1**	**11.3**

Table 7.12. Acquisition cost, continued

Lot	ACQECO (with effect of CR 640/2009 and new measures on SML3) 2015	2020	2025	2030	ACQECO3 (with effect of new measures on all types) 2015	2020	2025	2030
S3	*1.1*	1.0	1.0	1.0	*1.1*	*1.0*	*1.0*	*1.0*
M3	*0.5*	0.5	0.4	0.4	*0.5*	*0.5*	*0.4*	*0.4*
L3	*0.3*	0.3	0.3	0.2	*0.3*	*0.3*	*0.3*	*0.2*
S3v	*1.3*	2.1	2.2	2.3	*1.3*	2.1	2.3	2.3
M3v	*1.1*	1.5	1.5	1.6	*1.1*	1.5	1.5	1.6
L3v	*0.7*	0.9	0.9	0.9	*0.7*	0.9	0.9	1.0
sum SML3±	***4.9***	**6.2**	**6.4**	**6.5**	***4.9***	**6.2**	**6.5**	**6.5**
share VSD	*62%*	72%	73%	74%	*62%*	72%	73%	75%
	for types below, ACQECO=ACQBAU2							
XS1	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	0.8	1.0	1.0
XS1v	*0.7*	*0.7*	*0.8*	*0.8*	*0.7*	0.8	0.9	0.9
XS3	*0.4*	*0.4*	*0.4*	*0.4*	*0.4*	0.4	0.5	0.5
XS3v	*0.3*	*0.3*	*0.3*	*0.3*	*0.3*	0.3	0.3	0.4
sum XS	***2.1***	***2.2***	***2.3***	***2.3***	***2.1***	**2.3**	**2.7**	**2.7**
share VSD	*46%*	*47%*	*49%*	*51%*	*46%*	47%	45%	47%
XL3	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	0.1	0.1	0.1
XL3v	*0.4*	*0.4*	*0.5*	*0.5*	*0.4*	0.5	0.5	0.5
sum XL	***0.5***	***0.6***	***0.6***	***0.6***	***0.5***	**0.6**	**0.6**	**0.6**
share VSD	*77%*	*79%*	*79%*	*80%*	*77%*	78%	78%	79%
ExS	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	0.1	0.1	0.1
ExM	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	0.1	0.1	0.1
ExL	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	0.0	0.0	0.0
sum ExSML	***0.2***	***0.2***	***0.2***	***0.2***	***0.2***	**0.2**	**0.2**	**0.2**
BrakeS	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	0.1	0.1	0.1
BrakeM	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	0.1	0.1	0.1
BrakeL	*0.0*	*0.0*	*0.0*	*0.1*	*0.0*	0.1	0.1	0.1
sum Brake	***0.2***	***0.2***	***0.2***	***0.2***	***0.2***	**0.2**	**0.3**	**0.3**
8poleS	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	0.0	0.0	0.0
8poleM	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	0.0	0.0	0.0
8poleL	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	0.0	0.0	0.0
sum 8-pole	***0.0***	***0.0***	***0.0***	***0.0***	***0.0***	**0.0**	**0.0**	**0.0**
S1	***1.6***	***1.6***	***1.6***	***1.6***	***1.6***	**1.6**	**1.8**	**1.8**
Sum all	**9.5**	**11.0**	**11.2**	**11.4**	**9.5**	**11.1**	**12.1**	**12.1**

Energy costs (in Euro 2010)

EU total Energy costs are calculated multiplying the electricity consumption of table 7.10 by the electricity rates of table 7.8.

Table 7.13. Energy costs, in bn euros /yr for the four scenarios examined (euros 2010)

	NRGCOSTBAU (without effect of CR 640/2009)						NRGCOSTBAU2 (with effect of CR 640/2009 on SML3±v)			
Lot	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	13.0	14.5	17.6	20.3	24.6	29.2	16.9	17.0	18.2	21.7
M3	19.6	22.4	27.2	31.5	38.1	44.8	26.2	26.3	27.4	31.8
L3	39.7	44.7	53.3	61.2	73.1	84.0	51.4	53.3	56.9	59.7
S3v	0.9	1.8	2.5	3.4	4.8	6.8	2.6	4.6	7.7	10.1
M3v	1.6	3.4	4.8	6.6	9.6	13.6	5.3	9.5	15.6	20.8
L3v	4.5	9.8	14.1	19.6	28.6	41.2	15.1	24.2	38.0	55.3
sum SML3±v	**79.3**	**96.5**	**119.4**	**142.6**	**178.8**	**219.7**	**117.5**	**135.0**	**163.8**	**199.4**
share VSD	9%	16%	18%	21%	24%	28%	20%	28%	37%	43%
							for types below, NRGCOSTBAU2=NRGCOSTBAU			
XS1	1.0	1.1	1.4	1.6	1.9	2.3	*1.4*	*1.6*	*1.9*	*2.3*
XS1v	0.0	0.1	0.1	0.2	0.2	0.3	*0.1*	*0.2*	*0.2*	*0.3*
XS3	1.4	1.6	1.9	2.2	2.7	3.3	*1.9*	*2.2*	*2.7*	*3.3*
XS3v	0.0	0.1	0.2	0.3	0.4	0.5	*0.2*	*0.3*	*0.4*	*0.5*
sum XS	**2.4**	**2.9**	**3.6**	**4.2**	**5.2**	**6.3**	***3.6***	***4.2***	***5.2***	***6.3***
share VSD	1%	7%	9%	10%	11%	12%	*9%*	*10%*	*11%*	*12%*
XL3	20.3	21.7	24.1	25.7	29.3	33.7	*24.1*	*25.7*	*29.3*	*33.7*
XL3v	1.0	4.9	8.3	12.9	19.4	26.8	*8.3*	*12.9*	*19.4*	*26.8*
sum XL	**21.3**	**26.6**	**32.5**	**38.6**	**48.6**	**60.5**	***32.5***	***38.6***	***48.6***	***60.5***
share VSD	5%	18%	26%	33%	40%	44%	*26%*	*33%*	*40%*	*44%*
ExS	0.4	0.5	0.6	0.8	1.0	1.2	*0.6*	*0.8*	*1.0*	*1.2*
ExM	1.0	1.3	1.6	2.0	2.5	3.1	*1.6*	*2.0*	*2.5*	*3.1*
ExL	2.0	2.5	3.2	3.9	5.0	6.3	*3.2*	*3.9*	*5.0*	*6.3*
sum ExSML	**3.5**	**4.4**	**5.5**	**6.7**	**8.5**	**10.7**	***5.5***	***6.7***	***8.5***	***10.7***
BrakeS	0.3	0.4	0.4	0.5	0.7	0.8	*0.4*	*0.5*	*0.7*	*0.8*
BrakeM	0.7	0.9	1.1	1.3	1.7	2.1	*1.1*	*1.3*	*1.7*	*2.1*
BrakeL	1.0	1.3	1.6	2.0	2.5	3.2	*1.6*	*2.0*	*2.5*	*3.2*
sum Brake	**2.0**	**2.5**	**3.1**	**3.8**	**4.9**	**6.1**	***3.1***	***3.8***	***4.9***	***6.1***
8poleS	0.0	0.0	0.0	0.0	0.1	0.1	*0.0*	*0.0*	*0.1*	*0.1*
8poleM	0.1	0.1	0.1	0.1	0.1	0.2	*0.1*	*0.1*	*0.1*	*0.2*
8poleL	0.1	0.1	0.2	0.2	0.3	0.3	*0.2*	*0.2*	*0.3*	*0.3*
sum 8-pole	**0.2**	**0.2**	**0.3**	**0.3**	**0.4**	**0.6**	***0.3***	***0.3***	***0.4***	***0.6***
S1	**5.4**	**6.4**	**8.0**	**9.6**	**12.2**	**15.1**	***8.0***	***9.6***	***12.2***	***15.1***
Sum all	**114.0**	**139.6**	**172.4**	**205.9**	**258.6**	**319.0**	**170.5**	**198.2**	**243.6**	**298.7**

Table 7.13. Energy cost, continued

Lot	NRGCOSTECO (with effect of CR 640/2009 and new measures on SML3) 2015	2020	2025	2030	NRGCOSTECO3 (with effect of new measures on all types) 2015	2020	2025	2030
S3	*16.9*	17.0	18.1	21.5	*16.9*	*17.0*	*18.1*	*21.5*
M3	*26.2*	26.3	27.3	31.6	*26.2*	*26.3*	*27.3*	*31.6*
L3	*51.4*	53.3	56.9	59.6	*51.4*	*53.3*	*56.9*	*59.6*
S3v	*2.6*	4.6	7.6	10.0	*2.6*	4.6	7.6	9.9
M3v	*5.3*	9.5	15.5	20.7	*5.3*	9.5	15.5	20.6
L3v	*15.1*	24.2	38.0	55.2	*15.1*	24.2	37.9	55.0
sum SML3±v	***117.5***	**134.9**	**163.5**	**198.6**	***117.5***	**134.9**	**163.3**	**198.2**
share VSD	*20%*	28%	37%	43%	*20%*	28%	37%	43%
	for types below, NRGCOSTECO=NRGCOSTBAU2							
XS1	*1.4*	*1.6*	*1.9*	*2.3*	*1.4*	1.6	1.8	2.1
XS1v	*0.1*	*0.2*	*0.2*	*0.3*	*0.1*	0.2	0.2	0.2
XS3	*1.9*	*2.2*	*2.7*	*3.3*	*1.9*	2.2	2.6	3.1
XS3v	*0.2*	*0.3*	*0.4*	*0.5*	*0.2*	0.3	0.3	0.4
sum XS	***3.6***	***4.2***	***5.2***	***6.3***	***3.6***	**4.2**	**5.0**	**5.8**
share VSD	*9%*	*10%*	*11%*	*12%*	*9%*	10%	11%	12%
XL3	*24.1*	*25.7*	*29.3*	*33.7*	*24.1*	25.7	29.2	33.6
XL3v	*8.3*	*12.9*	*19.4*	*26.8*	*8.3*	12.9	19.3	26.6
sum XL	***32.5***	***38.6***	***48.6***	***60.5***	***32.5***	**38.6**	**48.5**	**60.1**
share VSD	*26%*	*33%*	*40%*	*44%*	*26%*	33%	40%	44%
ExS	*0.6*	*0.8*	*1.0*	*1.2*	*0.6*	0.8	0.9	1.1
ExM	*1.6*	*2.0*	*2.5*	*3.1*	*1.6*	2.0	2.5	3.1
ExL	*3.2*	*3.9*	*5.0*	*6.3*	*3.2*	3.9	5.0	6.3
sum ExSML	***5.5***	***6.7***	***8.5***	***10.7***	***5.5***	**6.7**	**8.4**	**10.4**
BrakeS	*0.4*	*0.5*	*0.7*	*0.8*	*0.4*	0.5	0.6	0.8
BrakeM	*1.1*	*1.3*	*1.7*	*2.1*	*1.1*	1.3	1.7	2.0
BrakeL	*1.6*	*2.0*	*2.5*	*3.2*	*1.6*	2.0	2.5	3.1
sum Brake	***3.1***	***3.8***	***4.9***	***6.1***	***3.1***	**3.8**	**4.8**	**5.9**
8poleS	*0.0*	*0.0*	*0.1*	*0.1*	*0.0*	0.0	0.1	0.1
8poleM	*0.1*	*0.1*	*0.1*	*0.2*	*0.1*	0.1	0.1	0.2
8poleL	*0.2*	*0.2*	*0.3*	*0.3*	*0.2*	0.2	0.3	0.3
sum 8-pole	***0.3***	***0.3***	***0.4***	***0.6***	***0.3***	**0.3**	**0.4**	**0.5**
S1	***8.0***	***9.6***	***12.2***	***15.1***	***8.0***	**9.6**	**12.0**	**14.6**
Sum all	**170.5**	**198.2**	**243.2**	**297.8**	**170.5**	**198.2**	**242.4**	**295.8**

Maintenance costs

Maintenance costs are assumed not to change when motor or VSD efficiency increases, so there would be no differences in maintenance costs between the scenarios. However, a motor with VSD is assumed to have the combined maintenance costs of motor and VSD. For motors in scope of CR 640/2009, the use of VSDs has been promoted and consequently a shift in sales (and consequently stock) from motors without VSD to motors with VSD has been modelled. This shift increases the maintenance costs in the BAU2 scenario compared to the BAU scenario. In the ECO- scenarios, and in all scenarios for motors not in scope of 640/2009, there is no shift towards motors with VSD in the model, and consequently maintenance costs do not change there.

Table 7.14. Maintenance costs, in bn euros /yr for the four scenarios examined (euros 2010)

	MAINT_BAU (without effect of CR 640/2009)						MAINT_BAU2 (with effect of CR 640/2009 on SML3±v)			
Lot	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M3	0.4	0.6	0.6	0.7	0.7	0.6	0.6	0.6	0.5	0.5
L3	0.3	0.4	0.4	0.4	0.4	0.3	0.4	0.3	0.3	0.3
S3v	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M3v	0.1	0.2	0.2	0.3	0.3	0.4	0.2	0.4	0.5	0.6
L3v	0.1	0.2	0.2	0.2	0.3	0.4	0.2	0.3	0.4	0.5
sum SML3±v	**0.9**	**1.3**	**1.4**	**1.6**	**1.6**	**1.7**	**1.4**	**1.6**	**1.7**	**1.8**
share VSD	16%	26%	30%	34%	38%	43%	32%	45%	55%	60%
							for types below, MAINT_BAU2=MAINT_BAU			
XS1	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
XS1v	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
XS3	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
XS3v	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
sum XS	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	***0.0***	***0.0***	***0.0***	***0.0***
share VSD										
XL3	0.1	0.1	0.1	0.1	0.1	0.1	*0.1*	*0.1*	*0.1*	*0.1*
XL3v	0.0	0.0	0.1	0.1	0.1	0.1	*0.1*	*0.1*	*0.1*	*0.1*
sum XL	**0.1**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	***0.2***	***0.2***	***0.2***	***0.2***
share VSD	7%	25%	34%	43%	50%	54%	*34%*	*43%*	*50%*	*54%*
ExS	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
ExM	0.0	0.0	0.0	0.0	0.1	0.1	*0.0*	*0.0*	*0.0*	*0.0*
ExL	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
sum ExSML	**0.0**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	***0.1***	***0.1***	***0.1***	***0.1***
BrakeS	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
BrakeM	0.0	0.1	0.1	0.1	0.1	0.1	*0.1*	*0.1*	*0.1*	*0.1*
BrakeL	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
sum Brake	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	***0.1***	***0.1***	***0.1***	***0.1***
8poleS	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
8poleM	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
8poleL	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.0*	*0.0*	*0.0*
sum 8-pole	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	***0.0***	***0.0***	***0.0***	***0.0***
S1	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	***0.0***	***0.0***	***0.0***	***0.0***
Sum all	**1.1**	**1.6**	**1.8**	**1.9**	**2.1**	**2.2**	**1.8**	**2.0**	**2.1**	**2.2**

User expenditure (acquisition + maintenance + energy costs, in Euro 2010)

Table 7.15. Total user Expense, in bn euros /yr for the four scenarios examined (euros 2010)

	EXPENSBAU (without effect of CR 640/2009)						EXPENSBAU2 (with effect of CR 640/2009 on SML3±v)			
Lot	**1990**	**2010**	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	13.6	15.5	18.6	21.3	25.6	30.1	18.0	18.0	19.2	22.6
M3	20.3	23.5	28.3	32.7	39.2	45.9	27.3	27.3	28.3	32.7
L3	40.2	45.4	54.0	61.9	73.8	84.6	52.1	53.9	57.5	60.2
S3v	1.2	2.6	3.4	4.5	6.1	8.2	3.8	6.7	9.9	12.4
M3v	1.9	4.1	5.7	7.7	10.8	15.0	6.6	11.3	17.6	23.0
L3v	4.7	10.4	14.7	20.4	29.6	42.3	16.0	25.4	39.3	56.7
sum SML3±	**81.9**	**101.5**	**124.8**	**148.4**	**184.9**	**226.2**	**123.9**	**142.7**	**171.8**	**207.6**
share VSD	9%	17%	19%	22%	25%	29%	21%	30%	39%	44%
							for types below, EXPENSBAU2=EXPENSBAU			
XS1	1.4	1.9	2.1	2.3	2.6	3.0	*2.1*	*2.3*	*2.6*	*3.0*
XS1v	0.1	0.7	0.8	0.9	1.0	1.1	*0.8*	*0.9*	*1.0*	*1.1*
XS3	1.6	1.9	2.3	2.6	3.1	3.7	*2.3*	*2.6*	*3.1*	*3.7*
XS3v	0.0	0.4	0.5	0.6	0.7	0.8	*0.5*	*0.6*	*0.7*	*0.8*
sum XS	**3.1**	**4.8**	**5.7**	**6.4**	**7.4**	**8.6**	***5.7***	***6.4***	***7.4***	***8.6***
share VSD	4%	21%	23%	23%	23%	22%	*23%*	*23%*	*23%*	*22%*
XL3	20.5	22.0	24.4	26.0	29.5	34.0	*24.4*	*26.0*	*29.5*	*34.0*
XL3v	1.1	5.2	8.8	13.4	20.0	27.4	*8.8*	*13.4*	*20.0*	*27.4*
sum XL	**21.6**	**27.2**	**33.2**	**39.4**	**49.5**	**61.3**	***33.2***	***39.4***	***49.5***	***61.3***
share VSD	5%	19%	27%	34%	40%	45%	*27%*	*34%*	*40%*	*45%*
ExS	0.5	0.6	0.7	0.8	1.0	1.3	*0.7*	*0.8*	*1.0*	*1.3*
ExM	1.1	1.4	1.7	2.1	2.6	3.2	*1.7*	*2.1*	*2.6*	*3.2*
ExL	2.0	2.6	3.3	4.0	5.1	6.4	*3.3*	*4.0*	*5.1*	*6.4*
sum ExSML	**3.6**	**4.6**	**5.7**	**6.9**	**8.8**	**10.9**	***5.7***	***6.9***	***8.8***	***10.9***
BrakeS	0.4	0.4	0.5	0.6	0.8	0.9	*0.5*	*0.6*	*0.8*	*0.9*
BrakeM	0.8	1.0	1.2	1.5	1.8	2.2	*1.2*	*1.5*	*1.8*	*2.2*
BrakeL	1.0	1.4	1.7	2.0	2.6	3.3	*1.7*	*2.0*	*2.6*	*3.3*
sum Brake	**2.2**	**2.8**	**3.4**	**4.1**	**5.2**	**6.4**	***3.4***	***4.1***	***5.2***	***6.4***
8poleS	0.0	0.0	0.0	0.0	0.1	0.1	*0.0*	*0.0*	*0.1*	*0.1*
8poleM	0.1	0.1	0.1	0.1	0.1	0.2	*0.1*	*0.1*	*0.1*	*0.2*
8poleL	0.1	0.1	0.2	0.2	0.3	0.3	*0.2*	*0.2*	*0.3*	*0.3*
sum 8-pole	**0.2**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	***0.3***	***0.4***	***0.5***	***0.6***
S1	**6.2**	**8.0**	**9.6**	**11.3**	**13.8**	**16.7**	***9.6***	***11.3***	***13.8***	***16.7***
Sum all	**118.8**	**149.0**	**182.7**	**216.8**	**270.0**	**330.8**	**181.8**	**211.1**	**256.8**	**312.2**

Table 7.15. Total User Expense, continued

Lot	EXPENSECO (with effect of CR 640/2009 and new measures on SML3)				EXPENSECO3 (with effect of new measures on all types)			
Lot	**2015**	**2020**	**2025**	**2030**	**2015**	**2020**	**2025**	**2030**
S3	*18.0*	18.0	19.2	22.5	*18.0*	*18.0*	*19.2*	*22.5*
M3	*27.3*	27.3	28.3	32.5	*27.3*	*27.3*	*28.3*	*32.5*
L3	*52.1*	53.9	57.4	60.1	*52.1*	*53.9*	*57.4*	*60.1*
S3v	*3.8*	6.8	9.9	12.3	*3.8*	6.8	9.9	12.2
M3v	*6.6*	11.3	17.6	22.9	*6.6*	11.3	17.6	22.8
L3v	*16.0*	25.4	39.3	56.6	*16.0*	25.4	39.2	56.5
sum SML3±	***123.9***	**142.7**	**171.6**	**206.8**	***123.9***	**142.7**	**171.5**	**206.6**
share VSD	*21%*	30%	39%	44%	*21%*	30%	39%	44%
	for types below, EXPENSECO=EXPENSBAU2							
XS1	*2.1*	*2.3*	*2.6*	*3.0*	*2.1*	2.4	2.8	3.1
XS1v	*0.8*	*0.9*	*1.0*	*1.1*	*0.8*	0.9	1.1	1.1
XS3	*2.3*	*2.6*	*3.1*	*3.7*	*2.3*	2.6	3.1	3.5
XS3v	*0.5*	*0.6*	*0.7*	*0.8*	*0.5*	0.6	0.7	0.8
sum XS	***5.7***	***6.4***	***7.4***	***8.6***	***5.7***	**6.4**	**7.6**	**8.5**
share VSD	*23%*	*23%*	*23%*	*22%*	*23%*	23%	23%	23%
XL3	*24.4*	*26.0*	*29.5*	*34.0*	*24.4*	26.0	29.5	33.8
XL3v	*8.8*	*13.4*	*20.0*	*27.4*	*8.8*	13.4	19.9	27.2
sum XL	***33.2***	***39.4***	***49.5***	***61.3***	***33.2***	**39.4**	**49.3**	**61.0**
share VSD	*27%*	*34%*	*40%*	*45%*	*27%*	34%	40%	45%
ExS	*0.7*	*0.8*	*1.0*	*1.3*	*0.7*	0.8	1.0	1.2
ExM	*1.7*	*2.1*	*2.6*	*3.2*	*1.7*	2.1	2.6	3.2
ExL	*3.3*	*4.0*	*5.1*	*6.4*	*3.3*	4.0	5.1	6.4
sum ExSML	***5.7***	***6.9***	***8.8***	***10.9***	***5.7***	**6.9**	**8.7**	**10.7**
BrakeS	*0.5*	*0.6*	*0.8*	*0.9*	*0.5*	0.6	0.8	0.9
BrakeM	*1.2*	*1.5*	*1.8*	*2.2*	*1.2*	1.5	1.8	2.2
BrakeL	*1.7*	*2.0*	*2.6*	*3.3*	*1.7*	2.0	2.6	3.2
sum Brake	***3.4***	***4.1***	***5.2***	***6.4***	***3.4***	**4.1**	**5.2**	**6.3**
8poleS	*0.0*	*0.0*	*0.1*	*0.1*	*0.0*	0.0	0.1	0.1
8poleM	*0.1*	*0.1*	*0.1*	*0.2*	*0.1*	0.1	0.1	0.2
8poleL	*0.2*	*0.2*	*0.3*	*0.3*	*0.2*	0.2	0.3	0.3
sum 8-pole	***0.3***	***0.4***	***0.5***	***0.6***	***0.3***	**0.4**	**0.5**	**0.6**
S1	***9.6***	***11.3***	***13.8***	***16.7***	***9.6***	**11.3**	**13.8**	**16.5**
Sum all	**181.8**	**211.1**	**256.6**	**311.4**	**181.8**	**211.2**	**256.6**	**310.2**

Annex 8. ASSESSING DOUBLE COUNTING OF MOTOR REGULATION IMPACTS

Introduction

As set out in the main report, the Commission has taken great care to choose a product scope that is efficient, effective and avoids as much as possible 'overlap' with existing regulations.

Industrial motors in the scope of the current motor regulation are used in a host of intermediate and end-products of which some are also regulated through Ecodesign and/or energy labelling measures. For the accounting of the total impacts of not only the motor regulation but also the motor-applications this double or in some cases even triple counting should be taken into account to avoid overestimating the absolute number of impacts and savings for the total of all Ecodesign regulations.

The problem of 'double counting' has two dimensions:

1. It is an accounting problem that needs to be solved in a clear, unambiguous and consistent way, using a simple principle that also non-technical analysts can apply. The principle that is used in the recent VHK Ecodesign Impact Accounting (EIA) study for the Commission entails that all impacts, and savings on these impacts, are first fully partitioned to the end-products and only then to the next upstream components. In the case of electric motors this means that only the impacts that are not Ecodesign-regulated anywhere else are attributed to the motor regulation.
2. It is a policy making problem. Policy makers would like to know the real impact of a policy measure, in all its technical and economic implications, and –albeit subjective—seek an answer to a question like "What savings would we miss, or what impacts are avoided when we do not take the measure?". This assessment requires a detailed technical understanding of all Ecodesign-regulations and some knowledge of the markets involved.

It is important to make a distinction between the two dimensions.

A relatively simple example is the Ecodesign regulation of water pumps No (EU) 547/2012. The energy use of this product is motor energy and thus there is a full double-counting according to the accounting approach. However, the water pump regulation does not regulate the motor-efficiency but the so-called 'shaft efficiency'. This is the energy ratio between output of motor shaft and the output of the pump. It is not the energy ratio between the electricity input to the motor and the output of the pump. In other words, an 'efficient' and compliant water pump according to the water pump regulation can have a very inefficient motor that is not at all compliant with the motor-regulation. In that case, there is no double-counting from the point of view of the policy maker: The impacts of the motor-regulation fully apply to motors in water pumps.

'Double counting', i.e. identifying the above mentioned over-estimations, has been discussed qualitatively in the various ecodesign studies and platforms for several years including in the MEErP 2011 methodology[89].

[89] Kemna, R.B.J., Methodology for the Ecodesign of Energy-related Products (MEErP) – Part 2, VHK for the European Commission, 2011.

The current specific contract is the first where double counting is explicitly part of a more detailed investigation for a single product, i.e. the electric motors and VSDs. The following discusses first the accounting dimension and then the policy making dimension.

Methodology

Calculation basis for the assessment is the EIA-Part 1 study. The accounting covers projections for the period 2010-2050, with inputs going as far back as 1990 and earlier. Studies of 33 product groups with over 180 base case products were harmonised and complemented to fit the methodology. For the period up to 2025-2030 inputs were derived from the available preparatory and impact assessment studies. The period beyond 2025-2030 is an extrapolation of the existing trends.

For the purposes of the specific contract it is assumed that the assessments in the EIA study (reference date 1.11.2013) are representative for the current situation. The EIA study did not only include that 24 products that were regulated under Ecodesign in November 2013, but also 9 product groups for which measures were planned at that date (and for which enough data were available). In the meanwhile, i.e. between November 2013 and May 2015, most – but not all – of these latter Ecodesign measures have been adopted. There are new product groups for which measures are underway, e.g. standard air compressors, and existing product groups where reviews will be undertaken, e.g. on industrial fans, but overall the changes are small[90].

For the purposes of the specific contract it is assumed that the ECO scenario represents the realistic expectation for the future with the existing and currently planned measures.

For industrial motors the relevant parameter is the electricity consumption.

There are considerable uncertainties to be taken into account when trying to estimate non-regulated motor-electricity from the missing parts of the EIA accounting.

Furthermore, it must be considered that especially large motors (> 1 MW) are not part of Eurostat's final energy consumption but are used in the energy transformation sector, e.g. in power plants, fuel distribution but also in parts of the (petro)chemical or other process industry.

Last but not least, it must be considered that electric motors are used in the transportation sector, a sector usually considered out of the scope of Ecodesign (at least as regards new vehicle parts) but certainly a sector with motors that might appear in motor market statistics. At the moment this electricity use is confined mainly to railroads, but in the future the electric motors used in cars may take up a considerable part of the market.

There are market and energy figures for industrial motors in the EIA study, based on the scope of the current motor regulation and derived from the available preparatory study, but also here the uncertainties are high.

Based on the above, it is clear that a 'top-down' approach in estimating double counting in motor applications is a hazardous undertaking. The only way forward seems to be a 'bottom-up' approach, summing from data on regulated products.

This certainly also applies to the extended scope in the draft Working Document.

The draft Working Document for a revised Motor Regulation proposes to expand the scope to a power range of 0.12 to 1000 kW (1 MW) and includes VSDs.

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90 Note that the sections with an italic font relate to possible consequences for the double counting exercise in this Annex. The normal font describes the data and other characteristics of the EIA study.

Product groups

Overview

There are product groups in the EIA study with:

- no motors (light sources, most electronics and communication products, hobs, distribution transformers, battery chargers and external power supplies, tyres),
- with small motors (<120 W output) or otherwise out of the scope (residential ventilation units, household ovens, some imaging equipment, vacuum cleaners, etc.),
- partially in the scope e.g. for only one of the motors in the end-product or only part of the regulated range of the end-products (room air conditioners, heating boilers, heat pump water heaters, circulators, central air conditioners and heating products, some large computers, larger imaging equipment),
- fully in the scope of the motor regulation but only part of the energy use depending on the motor (washing machines, dishwashers, local convection heaters, etc.) and
- fully in the scope of the motor regulation and the motor being the main or only energy using component (e.g. fans, pumps, most range hoods).

The regulated motors can be:

- Integrated in a non-regulated component or end-product (no double-counting).
- Integrated in a regulated component (fan, circulator)
- Integrated directly in a regulated end-product (washing machine, laundry drier)
- Integrated in a regulated component, which then is integrated in a regulated end-product (ventilation unit, air conditioners, heat pump heating boiler, etc.)

It must be considered that the motor regulation regulates only specific types of motors, e.g. AC motors, and that in many applications these motors compete with non-regulated, usually more efficient motors like EC (electronically commutated) motors. At the low-end of the market, e.g. some consumer products that are used only periodically for a short time (blenders, vacuum cleaners) there may be competition with universal AC/DC motors that are also not in the scope because they use commutators.

Hereafter the possible double counting of motors is discussed per product group.

Heating boilers and water heaters

The motors for combustion-fans, solar thermal circulators and heating circulators in residential and light-commercial heating boilers and water heaters with a heating capacity up to around 70 kW are generally (far) below the threshold of 120 W motor output and thus out of scope. A typical 20-30 kW (heating capacity) boiler has a combustion-fan of 30-40 W and a circulator that consumes 40-60 W. The load factor is around 20 %, which means that in an average EU climate with a heating season of around 5000 hours they run the equivalent of 1000 full-load hours.

Above 70 kW heating capacity (up to the Lot 1 scope of 400 kW), the circulator pumps and combustion fans of boilers and water heaters come into the scope (>120 W). This segment represents 5 % of unit sales and 25 % of the total boiler/water heater energy.

Also in the scope of the motor regulation are most boilers and water heaters that use heat pumps, usually with an electric resistance or gas-fired heater back-up. A typical space heating heat pump might have a heating output of 10 kW and a SCOP of 3. This means that compressor (80 %), source fan or source circulator (15 %) and heating system circulator (5 %)

would in total have an electric power consumption of 3.3 kW, which means that these motors would be in scope.

For a heat pump water heater similar numbers are assumed.

The EIA study does not specify the heat pumps. The split-up in Table 8.1 is an estimate based on EHPA statistics[91] and BRG Consult communication.

Local space heaters may feature a small fan to help dissipate the heat, or assist flue gas extraction, etc. but generally the power of these fans is below the 120 W threshold.

Central air heating and cooling

This group comprises electric and fossil-fuel fired chillers, air-conditioners (AC) and heaters. The nominal cooling load of the base cases varies between 14 kW for AC splits and 894 kW for Large Water-cooled chillers ('CHWL') and generally their motors are included in the scope. The seasonal efficiency for cooling of the electric appliances is in the range of 3.5 for the air-cooled chillers, 4 for the ACs and 5 (small) or 6 (large) for the water-cooled chillers. For the fossil-fuel fired appliances (calculating primary energy) the seasonal cooling efficiency or SEER (Seasonal Energy Efficiency Ratio) is around 1.5.

For heating, the ACs have a seasonal efficiency or SCOP (Seasonal Coefficient of Performance) of around 3.7. The fossil-fuel fired (gas/oil) heaters have an efficiency of around 60%.

The SCOP and SEER figures allow to calculate the annual energy consumption.

For electric appliances in this group, approximately 80 % of the energy consumption goes to compressor motors (or gas heaters) and around 15 % to the condenser (in cooling mode) or evaporator (in heating mode) convection fan. For evaporative cooling towers this share may be more (and some pumping energy is included) and for dry cooling fans (air cooled chillers) it may be slightly less, but their SEER/SCOP is lower. The remaining 5 % is estimated to go to circulators and controls.[92]

The dissipation of cooling/heat from chillers, air conditioners and heaters to the inside of the buildings/rooms also involves motors, i.e. to drive the (centrifugal or cross-flow) fans in fan-coil units, air terminal units, plenum fans, etc. These units, apart from product information requirements foreseen for fan-coil units, are not regulated in Ecodesign. Also their energy use is much smaller than that of an outdoor cooling fan mentioned earlier. Most will stay below the threshold of 120 W output.

The exception is the fossil-fuel air heater where a strong fan (500-2000 W) is an essential part of dissipating the heat over a large area (e.g. in an industrial hall). Also VRF (Variable Refrigerant Flow) air conditioners may have a fan with enough power to be in scope.

The full-load running hours for cooling are set at 600 h/year and for heating at 1400 h/year.

Room air conditioners

The average cooling load of room air conditioners is 1150 kWh/year and the heating load is around 2000 kWh/year. The corresponding SEER is 4 (over 600 h) and the SCOP 3.5 (1400h). This means that the compressor-motor (ca. 500-1000 W) is in scope as well as the outdoor fans of the larger types (>4 -5 kW cooling capacity). The indoor (cross flow) fan motors are out of scope, because their rated output is too low.

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91 European Heat Pump Association, annual series.

92 Note that this is an approximate approach, which is sufficient for our purpose. An actual energy flow diagram would show minor differences with these general figures.

Ventilation units

By definition, the fan motors of residential ventilation units have a maximum electric power input of 125 W, roughly equivalent to 50 W mechanical output, and thus they are out of scope of the motor regulation.

For non-residential ventilation units it is estimated that more than half of the fan-motors up to 2.5 kW are out of scope because they are either too small (<300 W electrical input, equivalent to 120 W output) or they are equipped with EC motors. EBM-Papst, for instance, a manufacturer that has a significant market share (>20 %) in this sector for fans up to 10 kW claims that half of their motors are EC motors (the other half AC). All in all, it is estimated that 50 % of unit sales and 25 % of energy use of non-residential ventilation units are out-of-scope of the motor regulation.

Household refrigeration

The power of motors for residential refrigeration compressors (isobutane) is too low to be in scope (electric 90-150 W). Some larger side-by-side ‘American’ fridge/freezers may be the exception but their market share is modest/negligible (<5 %, in most countries 1-2 %).

Motors in hermetic compressors are also excluded from the scope on the grounds that they cannot be taken out and independently tested without permanent mechanical damage.

Professional refrigeration

Cooling compressor-motors in professional refrigeration are included in the scope.

Compressors for professional service cabinets (2555 kWh/year) and blast cabinets (3030 kWh/year) are in the range of 800-1000 W (typically 40 % on - 60 % off).

The average walk-in cold room (12587 kWh/year) has compressors with 5 times more power (around 4-5 kW).

Medium and Low temperature industrial chillers use 419 MWh/year, meaning – at 6000 h/year — an average power of 70 kW.

The average walk-in cold room (12587 kWh/year) was included in the scope in the original proposals and thus included in EIA. But in the latest 2014 WTO document it was taken out of the scope. Instead, which is assumed to be more or less equivalent in terms of impact, some remote condensing units were included (not in the EIA study).

Commercial refrigeration

Compressor-motors in commercial refrigeration appliance are included in the scope. There is some energy consumption for lighting, but > 90 % of electricity consumption is for the compressor motor.

The base-cases include an open vertical chilled multi-deck and open horizontal frozen island, both consuming around 27 MWh/year (7-8 kW, 40 % load factor, 8760 h/year) as well as one door beverage coolers (2.5 MWh/year, 700 W), a horizontal ice cream freezer (1.5 MWh/year, 430 W) and a spiral vending machine (2.5 MWh, 700 W).

Cooking appliances

The household cooking appliances group includes electric and gas-fired hobs and ovens as well as range hoods.

The circulation fans in the household ovens are out of scope because their power demand is below 120 W.

The only motors that could be in scope are those in range hoods, typically in a range of 200-300 W. Assuming 400 hours and an average of 250 W they will use around 100 kWh/year.

Energy use for lighting and controls is estimated at 25 % of the total (33 kWh/year). However, closer investigation shows that the motor efficiency in range hoods is very low (< 20 %) and thus the actual mechanical output of the fan motors is below the 120W limit of the motor-regulation.

Laundry and dishwashing appliances

Washing machines have AC motors from 300-400 to 1200 W, working with a belt drive. The nominal capacity is mainly determined by the spinning cycle at uneven load (worst case). The average power consumption during washing and rinsing cycle may be as low as 50-100 W. Direct drive motors (high pole number, torque-motors, typically EC/inverter) have a significant market share (assumed 50 %). The real-life efficiency of a washing machine motor is roughly some 40 % lower than its nominal efficiency, i.e. AC motors hardly reach 30 % and SRMs, with nominally 90 % motor efficiency, may barely reach 50 %.

The drum motors of laundry driers do not need to spin, so their mechanical output is below 0.12 kW and they are out of scope. The same goes for the small motors that are driving the pumps and fans in dishwashers, laundry driers and washing machines. The only possible exception may be the fans in heat pump laundry driers, where the power of compressor+convection fan+circulation fan is in the range of 1200 W (assumed to be split in 80+15+5 %) rather than the 2700-3000 W of e.g. a condensing drier. For the market share of heat pump driers figures are found of 14 % (2010), 22 % (2011) and 35 % (2012). It is assumed that in 2015 the share will be 50 %.

Household dishwashers have pumps and possibly fans (for drying). The power of motors for these devices is generally too low to be in the scope of the motor regulation.

Non-residential, ‘commercial laundry appliances and dishwashers (Lot 24) will have motors for driving drums, conveyors, pumps and circulation fans that are in scope, but these products are not (yet) regulated.

Water pumps

The Ecodesign regulation on water pumps does not mention a minimum power for the scope but maximum values are in the range of up to 150-300 kW shaft power, depending on type. Most of the borehole and end-suction and other water pumps will be in a much lower range.

This means that most of the motors of the water pumps will be in the scope of the motor regulation. The average load is around 1000 W during 4500 hours with an average efficiency of 68%. This means an average input power of approximately 1.5 kW electrical input.

The new motor regulation proposes to exclude ‘motors designed to operate wholly immersed in a liquid’. It is unclear whether, on this basis, certain immersion pumps – which would be part of the water pumps product group – are excluded or whether this only applies to situations where the stator/rotor are actually immersed in a liquid (e.g. oil with specific electric characteristics). For the moment, the latter is assumed, and thus 80 % of the water pumps (excluding the ones with EC motors or being too small) are assumed to be in the scope.

It must be mentioned that these water pumps, borehole pumps, end-suction pumps etc., are end-products in their own right and not components that necessarily go into other end-products.

Circulators up to 2.5 kW

Circulators up to 2.5 kW are mainly components, i.e. parts of a heating boiler or a heat exchanger loop with a chiller. Residential circulators, e.g. for boilers up to 70 kW, are too small to be in the scope of the motor regulation. Only circulators for larger boilers will be included in Table 8.1.

Distribution transformers

Very large or high-power transformers (with capacities of thousands of kVA) may have cooling fans or oil pumps for cooling. However, it is not certain whether these motor-applications – with high demands on safety – would still be in the scope of the (new) regulation.

It can be assumed that 10 % of the power transformer energy losses can be attributed to the cooling fans/pumps. Power transformers are one of the seven base-cases in this group but responsible for 59 TWh electricity use in 2015 (half of the total). Losses amount to 725 MWh/year per unit (90 kW during 8000 h), which means that the fan/pump motor is 9 kW and consumes 72.5 MWh/year. There are currently 82,000 of these transformers in the EU, consuming thus 5.9 TWh/year in motor energy.

These 9 kW fans can appear in market statistics, but – as mentioned in the EIA study – the distribution transformers (and their cooling fan) are part of the energy transformation sector and do not constitute a final end-use of electricity. In other words, they are not relevant for double counting the end-use and will thus not be included in Table 8.1 hereafter.

Fans

The scope of the fan regulation is from 125 W to 375 kW electrical input versus 120 W to 1 MW mechanical output as proposed scope of the new motor regulation. This means that fans with electrical input between 125 and 300W are out-of-the scope of the motor regulation, but included in the fan regulation. Also the fans with EC motors (and other non-AC motors) are out of scope. All in all, it is estimated that 30 % of units sales and 20 % of the energy of the fans-regulations is out-of-scope of the motor regulation.

Vacuum cleaners

Vacuum cleaner fan motors are (or were) typically low-efficiency cheap universal motors in the range of 800 to 3000 Watt (average 1800 W), running at high speeds of 8000 rpm or more. In principle there is no reason why they should be excluded from the motor regulation, except perhaps if they cannot be dismounted without 'permanent physical damage'. Still, they are excluded from the fan regulation and it is assumed that manufacturers will use them in integrated constructions so that physical damage during dismounting is unavoidable. For that reason they are considered to be out-of-scope of the motor regulation.

Apart from the above, the new ecodesign and energy measures for vacuum cleaners may revolutionise the VC-motors and more and more efficient EC motors or similar will be used. Thus they would also be excluded on those grounds.

Electronics

In computers, displays, etc. there may be cooling fans, but the motor capacity is usually too low to be in the scope of the motor regulation. The exception may be cooling fans in professional imaging equipment, but the energy share is assumed to be negligible.

Double counting: The accounting dimension

The findings in the main report are combined with the findings in the EIA study and additional research. The result is given in Table 8.1. The acronyms used in the table are given at the end of this annex.

Table 8.1. Regulated motors (0.12-1000 kW output) in regulated components & end-products, EU 2015

	sales	**stock**	**input Pe**	**full-load hours**	**elec/ unit**	**elec EU total**	**elec EU total, TWh split by component**			
	x1000	*x1000*	*kW elec*	*h/year*	*kWh/year*	*TWh/year*	Compr.	Fan	Pump	Other
water heating heat pump	40	300	1.0	1800	1800	0.5	0.4	0.08	0.02	-
space heating (incl. solid fuel)										
Air-water heat pump	200	2200	4.3	2500	10714	23.6	18.9	3.5	1.2	-
Ground source-water heat pump	100	2500	3.4	2800	9600	24.0	19.2	3.6	1.2	-
Exhaust air heat pump	30	300	1.7	1800	3000	0.9	0.7	0.1	0.0	-
Other (reversibles etc. no overlap with AC)	87	1306	4.3	2500	10714	14.0	11.2	2.1	0.7	-
Circulators in heating system	1500	20700	0.1	3144	377	8.5	-	-	8.5	-
Combustion/extraction fans heating	1000	15000	0.1	3144	377	5.7	-	5.7	-	-
Wood chip boiler, fan(s)	6	102	3.2	2000	6400	0.7	-	0.7	-	-
air cooling & heating										
CHAS Chillers, Air-cooled, Small	97	1589	13.3	600	7991	12.7	10.2	1.9	0.6	-
CHAL Chillers, Air-cooled, Large	6	119	212.1	600	127243	15.1	12.1	2.3	0.8	-
CHWS Chillers, Water-cooled, Small	10	160	13.8	600	8260	1.3	1.1	0.2	0.1	-
CHWL Chillers, Water-cooled, Large	3	46	176.2	600	105727	4.8	3.9	0.7	0.2	-
AC rooftop (cooling)	23	470	21.5	600	12901	6.1	4.8	1.2	-	-
AC splits (cooling)	255	3198	3.6	600	2144	6.9	5.5	1.4	-	-
AC VRF (cooling)	107	940	12.2	600	7349	6.9	5.5	1.4	-	-
ACF Fossil fuel fired	1	8	35.5	600	21325	0.2	0.1	0.0	0.0	-
AC rooftop, rev (heating mode)	(18)	(302)	25.4	1400	35504	10.7	8.6	2.1	-	-
AC splits, rev (heating mode)	(197)	(2118)	4.3	1400	6069	12.9	10.3	2.6	-	-
AC VRF, rev (heating mode)	(83)	(642)	15.0	1400	21007	13.5	10.8	2.7	-	-
AHF Fossil-fuel fired Air Heaters	82	1421	1.2	1400	1680	2.4	-	2.4	-	-
Room air conditioner (cool&heat)	7190	65115	0.5	1400	741	48.3	38.6	7.2	-	2.4
non-residential ventilation units										
NRVU Central Unidir. CEXH (1 fan)	141	2240	0.5	3588	1872	4.2	-	4.2	-	-
NRVU Balanced CHRV (2 fans)	194	2526	0.3	2691	802	2.0	-	2.0	-	-
NRVU Balanced AHU-S (2 fans)	44	582	0.6	2691	1748	1.0	-	1.0	-	-
NRVU Balanced AHU-M (2 fans)	150	1944	2.1	2691	5622	10.9	-	10.9	-	-
NRVU Balanced AHU-L (2 fans)	165	2140	8.6	2691	23052	49.3	-	49.3	-	-
Commercial & professional refrigeration										
CF open vertical chilled multi deck (RCV2)	182	1492	7.7	3504	27083	40.4	34.4	6.1	-	-
CF open horizontal frozen island (RHF4)	24	196	8.1	3504	28495	5.6	4.7	0.8	-	-
CF Plug in one door beverage cooler	890	6833	0.7	3504	2456	16.8	14.3	2.5	-	-
CF Plug in horizontal ice cream freezer	381	2928	0.4	3504	1570	4.6	3.9	0.7	-	-
CF Spiral vending machine	178	1382	0.7	3504	2614	3.6	3.1	0.5	-	-
PF Service cabinets	401	3485	0.7	3504	2555	8.9	7.6	1.3	-	-
PF Blast cabinets	196	1618	0.9	3504	3030	4.9	4.2	0.7	-	-
PF Walk in cold rooms	94	1494	3.6	3504	12587	18.8	16.0	2.8	-	-
PF CH MT & LT industrial chillers (avg)	7	93	119.6	3504	419000	39.1	33.2	5.9	-	-
Household cleaning appliances										
Washing machine drum motor	7000	105180	0.1	440	31	3.2	-	-	-	3.2
Heat pump hh. laundry drier	2830	15000	1.2	200	240	3.6	3.1	0.5	-	-
Water pumps	1791	18 355	1.5	4000	5882	108.0	-	-	108.0	-
TOTAL/ AVG reg. end-products with reg. motors (**0.12**-1000 kW)	**25323**	**281540**	**1.047**	**1815**	**1901**	**544**	**286**	**131**	**121**	**6**
TOTAL reg. motor components in non-reg. end-products (fans)						107		107		
TOTAL Multi-counted, of which 149.5 (141 fans & 8.5 circ. pumps) triple and rest double						**651**	**286**	**238**	**121**	**6**
*reg. end-prod. w/ reg.motors (**0.75**-1000 kW)*	*6961*	*61435*			*7182*	*441*	*222*	*107*	*113*	*0*
Note: reg. motor components not in scope of motor reg. (fans & circulators)						*64.9*		*59.4*	*5.5*	

The main finding is that there is a total of 651 TWh double or triple counting between the proposed revised motor regulation (scope 0.12-1000 kW) and other ecodesign regulated products, i.e. 544 TWh in end-products and 107 TWh in components.

Overlap in impact: Policy making dimension

Table 8.1 shows the double counting of motor energy. This is not the same as an overlap in the impact of measures:

- For water pumps, the electricity consumption is ultimately all attributable to electric motors, but only the shaft power efficiency is actually regulated and not the electric motor efficiency is regulated by the Ecodesign measures for water pumps. This means that, without the motor regulation, a hydro-dynamically efficient water pump could still have a very inefficient motor. So there is no overlap in impact between the two measures for water pumps and motors.
- For ventilation units, industrial fans and circulators where the respective Ecodesign (and labelling for circulators) measures are so stringent that in order to meet the targets manufacturers will practically be forced to improve their motor efficiency beyond levels that are required by the current motor regulation. For these products, industry is supportive of more stringent requirements for motors because it will help them reaching their own requirements at lower costs. Here there is a full overlap because the improvement of motor efficiency is likely to occur anyway.
- There are regulated product-groups like heat pumps, central air conditioners, refrigeration appliances that mainly rely on the Carnot cycle. For these groups it will typically be necessary to improve the motor efficiency of the main component, i.e. the compressor (80 % of electricity), but it might not be the most economical option to also tackle the motor efficiency of condenser and/or evaporator fans. Instead they could e.g. increase the condenser and evaporator heat exchanger surface. Here the motor regulation has e.g. a 15-20 % impact and the overlap is only 80 %.
- For washing machine motors, there is a high share of very efficient direct drive motors, but this is a choice of the manufacturer. The motor energy is only a relatively small fraction of the total washing machine energy (most goes to water heating) and it is possible, without the motor regulation, to choose a relatively inefficient motor and still meet the Ecodesign limits. Here the overlap between the impact of the Ecodesign measures for motors and washing machines is estimated to be in the order of magnitude of 50 %.

The above are estimates, but at the moment they are the best available. The results of the overlap in impact between the (new) motor regulation and the existing other Ecodesign measures is given in Table 8.2.

The main finding is that the overlap in impacts amounts to 477 TWh/year. This is roughly one-third of the scope of the new motor regulation (1425 TWh/year in 2015). In other words, an estimated one-third of the savings calculated for the whole scope of the motor regulation should be attributed to other Ecodesign measures, i.e. they would have happened anyway, and two-thirds to the motor regulation.

Table 8.2. Estimated overlap between impact of motor regulation and other ecodesign regulations, EU 2015

	sales	stock	input Pe	full-load hours	Elec/ unit	Elec EU total	Elec EU total, TWh split by component			
	x1000	*x1000*	*kW elec*	*h/year*	*kWh/year*	*TWh/year*	Compr.	Fan	Pump	Other
water heating heat pump	40	300	0.8	1800	1440	0.4	0.4	-	-	-
space heating (incl. solid fuel)										
air-water heat pump	200	2200	3.4	2500	8571	18.9	18.9	-	-	-
groundsource-water heat pump	100	2500	2.7	2800	7680	19.2	19.2	-	-	-
exhaust air heat pump	30	300	1.3	1800	2400	0.7	0.7	-	-	-
Other (reversibles etc. not overlapping with AC)	87	1306	3.4	2500	8600	11.2	11.2	-	-	-
circulators in heating system	1500	20700	0.1	3144	409	8.5	-	-	8.5	-
combustion/extraction fans heating	1000	15000	0.1	3144	377	5.7	-	5.7	-	-
wood chip boiler, fan(s)	6	102	3.2	2000	6400	0.7	-	0.7	-	-
air cooling & heating										
CHAS Chillers, Air-cooled, Small	97	1589	10.7	600	6393	10.2	10.2	-	-	-
CHAL Chillers, Air-cooled, Large	6	119	169.7	600	101794	12.1	12.1	-	-	-
CHWS Chillers, Water-cooled, Small	10	160	11.0	600	6608	1.1	1.1	-	-	-
CHWL Chillers, Water-cooled, Large	3	46	141.0	600	84581	3.9	3.9	-	-	-
AC rooftop (cooling)	23	470	17.2	600	10321	4.8	4.8	-	-	-
AC splits (cooling)	255	3198	2.9	600	1715	5.5	5.5	-	-	-
AC VRF (cooling)	107	940	9.8	600	5879	5.5	5.5	-	-	-
ACF Fossil fuel fired	1	8	28.4	600	17060	0.1	0.1	-	-	-
AC rooftop, rev (heating mode)	18	302	20.3	1400	28403	8.6	8.6	-	-	-
AC splits, rev (heating mode)	197	2118	3.5	1400	4855	10.3	10.3	-	-	-
AC VRF, rev (heating mode)	83	642	12.0	1400	16806	10.8	10.8	-	-	-
AHF Fossil-fuel fired Air Heaters	82	1421		1400	0	0.0	-	-	-	-
Room air conditioner (cool&heat)	7190	65115	0.4	1400	593	38.6	38.6	-	-	-
non-residential ventilation units										
NRVU Central Unidir. CEXH (1 fan)	141	2240	0.5	3588	1872	4.2	-	4.2	-	-
NRVU Balanced CHRV (2 fans)	194	2526	0.3	2691	802	2.0	-	2.0	-	-
NRVU Balanced AHU-S (2 fans)	44	582	0.6	2691	1748	1.0	-	1.0	-	-
NRVU Balanced AHU-M (2 fans)	150	1944	2.1	2691	5622	10.9	-	10.9	-	-
NRVU Balanced AHU-L (2 fans)	165	2140	8.6	2691	23052	49.3	-	49.3	-	-
Commercial & professional refrigeration										
CF open vertical chilled multi deck (RCV2)	182	1492	6.6	3504	23021	34.4	34.4	-	-	-
CF open horizontal frozen island (RHF4)	24	196	6.9	3504	24221	4.7	4.7	-	-	-
CF Plug in one door beverage cooler	890	6833	0.6	3504	2088	14.3	14.3	-	-	-
CF Plug in horizontal ice cream freezer	381	2928	0.4	3504	1334	3.9	3.9	-	-	-
CF Spiral vending machine	178	1382	0.6	3504	2222	3.1	3.1	-	-	-
PF Service cabinets	401	3485	0.6	3504	2172	7.6	7.6	-	-	-
PF Blast cabinets	196	1618	0.7	3504	2576	4.2	4.2	-	-	-
PF Walk in cold rooms/ remote cond.	94	1494	3.1	3504	10699	16.0	16.0	-	-	-
PF CH MT & LT industrial chillers (avg)	7	93	101.6	3504	356150	33.2	33.2	-	-	-
Household cleaning appliances										
Washing machine drum motor	7000	105180	0.03	440	15	1.6	-	-	-	1.6
Heat pump hh. laundry drier	2830	15000	1.0	200	207	3.1	3.1	-	-	-
Water pumps	1791	18 355	-	-	-	-	-	-	-	-
TOTAL/ AVG reg. end-products with reg.motors (**0.12**-1000 kW)	**25323**	**281540**	**0.781**	**1656**	**1294**	**370**	**286**	**74**	**8**	**2**
TOTAL reg. motor components in non-reg. end-products (fans)						107		107		
TOTAL Overlap in impact (TWh)						**477**	**286**	**181**	**8**	**2**

Acronyms used in Annex 8

AC	Air Conditioning or (for electrical devices) Alternate Current
AHF	Air Heaters, Fossil-fuel fired
AHU	Air Handling Unit (distinguished AHU-S, AHU-M, AHU-L for small, medium and large units)
CEXH	Central unidirectional (Extraction) ventilation unit
CF	Commercial Refrigeration
CH HT/MT/LT	Chiller, High/Medium/Low Temperature
CHAL	CHillers, Air-cooled, Large
CHAS	CHillers, Air-cooled, Small
CHRV	Central Heat Recovery Ventilation units
CHWL	CHillers, Water-cooled, Large
CHWS	CHillers, Water-cooled, Small
Compr.	Compressor
COP	Coefficient of Performance
EC	European Commission or (for motors) Electronically Commutating
EIA	Ecodesign Impact Accounting (study for the European Commission 2015)
Elec	Electric(ity)
hh.	Household
IE (motor)	International Efficiency: Efficiency class defining minimum energy efficiency in relation to the motor size and pole number
IE (VSD)	International Efficiency: Efficiency class defining maximum losses compared to a reference value
IE1 (motor)	Standard efficiency
IE2 (motor)	High efficiency
IE3 (motor)	Premium efficiency
kVA	Kilo Volt Ampere (power unit used for transformers or batteries)
kWh	Kilo Watt hour, 10^3 Watt hour (unit of energy)
MEErP	Methodology for the Ecodesign of Energy-related Products
MW	Mega Watt, 10^6 Watt (unit of power)
MWh	MW hour, 10^6 Watt hour
NRVU	Non-residential Ventilation Unit
PF	Professional refrigeration
RCV2	Open chilled vertical multi-deck commercial refrigeration unit, base case nr. 2
RHF4	Open horizontal frozen island commercial refrigeration unit, base case nr. 4
SCOP	Seasonal COP, outdoor-temperature weighted COP value as a proxy of actual heating 'efficiency' for air conditioners
SEER	Seasonal Energy Efficiency Ratio, outdoor-temperature weighted COP value as a proxy of actual cooling 'efficiency' for air conditioners used specifically as cooling 'efficiency' for room air conditioners
TWh	Tera Watt hour, 10^{12} Watt hour (unit of energy)
VC	Vacuum Cleaner (used with motors)
VRF	Variable Refrigerant Flow
VSD	Variable Speed Drive
WEEE	Waste electrical and electronic equipment

Annex 9. OUTCOME OF THE LIFE CYCLE COST ASSESSMENT

9.1 Overview

Annex II of the Ecodesign directive stipulates that the "*the level of energy efficiency or consumption must be set aiming at the life cycle cost minimum to end-users for representative product models, taking into account the consequences on other environmental aspects*". In the review process of the motors regulation, consideration of the life-cycle costs for end-users has been a key element for setting the revised energy efficiency requirements. This annex presents the outcome of these calculations.

LCC calculations have been performed during the review study[93] and led to the following conclusions:

- IE2 is the optimum for small motors (0.12 kW – 0.75 kW), both single-phase and 3-phase.
- IE3 is the optimum for the small and average motors (0.75 kW up to 11 kW), noting that IE4 looks attractive for large motors (110 kW and 550), "*but these products to date have only limited availability*".
- For VSDs, IE1 is the optimum.
- Explosion proof and brake motors should be brought into scope.

See figures 9.1 and 9.2 below for detailed results.

[93] Anibal De Almeida, Hugh Falkner, João Fong, *EuP Lot 30: Electric Motors and Drives - Task 7: Improvement Potential - ENER/C3/413-2010 - June 2014 - Final*

			Lifetime cost, by phase (Euros)															
Basecase	Description	Basecase			Basecase		BAT1		BAT2		BAT3		BAT4		BAT5	
		Size (kW)	Installation	Maintenance	Purchase	Energy	Purchase	Energy	Purchase	Energy	Purchase	Energy	Purchase	Energy	Purchase	Energy
1	Small induction motor - 1 phase IE1	0.37	20	-	60	114	69	99	78	95	-	-				
2	Small induction motor - 3 phase IE1	0.37	20	-	200	571	250	493	325	473	500	454	625	454	-	-
3	Medium induction motor (S) - 3 phase IE2	1.1	40	-	150	1,978	188	1,914	244	1,846	375	1,789	469	1,789	375	1,789
4	Medium induction motor (M) - 3 phase IE2	11	80	700	600	23,761	720	23,345	900	22,821	1,440	22,366	1,800	22,366	1,440	22,366
5	Medium induction motor (L) - 3 phase IE2	110	250	6,000	6,000	695,915	6,900	689,350	8,280	682,907	13,800	676,584	17,250	676,584	13,800	676,584
6	Large induction motor - LV IE2	550	1,500	20,000	25,000	3,450,487	28,750	3,421,882	34,500	3,411,277	-	-				
7	Large induction motor - MV IE2	550	2,000	25,000	35,000	4,196,118	40,250	4,161,332	48,300	4,148,435	-	-				
8	VSD - Very Small	0.37	200	-	200	140	220	112	770	98	-	-				
9	VSD - Small	1.1	280	-	280	221	322	177	1,159	155	-	-				
10	VSD - Medium	11	1,130	200	1,130	1,514	1,300	1,212	4,938	1,060	-	-				
11	VSD - Large	110	5,320	1,200	5,320	20,594	6,384	16,475	25,536	14,416	-	-				
12	VSD - Very Large	550	41,790	1,200	41,790	156,152	50,148	124,922	225,666	109,307	-	-				
16	Submersible borehole motor - Small	2.2	20	250	400	1,215	480	1,176	-	-	-	-				
17	Submersible borehole motor - Large	37	40	8,000	4,000	103,744	4,800	101,928	-	-	-	-				
18	Motor + VSD - Very Small	0.37	220	-	420	-	470	-	545	-	-	-	758	-	-	-
19	Motor + VSD - Small	1.1	320	-	472	-	510	-	566	-	-	-	679	-	586	-
20	Motor + VSD - Medium	11	1,210	900	1,900	-	2,020	-	2,200	-	-	-	2,978	-	2,618	-
21	Motor + VSD - Large	110	5,570	7,200	12,384	-	13,284	-	14,664	-	-	-	33,269	-	29,819	-
22	Motor + VSD - Very Large	550	43,290	21,200	75,148	-	78,898	-	84,648	-	-	-				

Figure 9.1 Lifetime cost data for different options in the review study, by product

Basecase = IE class specified in ‘description column. For small motors BAT1=IE2; BAT2=IE3, for larger motors BAT1=IE3; BAT2=IE4)

Basecase Ref	Description	Basecase Size (kW)	Total LCC (Euros)					
			Basecase	BAT1	BAT2	BAT3	BAT4	BAT5
1	Small induction m	0.37	194	**188**	193			
2	Small induction m	0.37	791	**763**	818	974		
3	Medium induction	1.1	2,168	2,142	**2,130**	2,204		
4	Medium induction	11	25,141	24,845	**24,501**	24,586		
5	Medium induction	110	708,165	702,500	697,437	**696,634**		
6	Large induction m	750	3,496,987	3,477,882	**3,467,277**			
7	Large induction m	750	4,258,118	4,236,632	**4,223,735**			
8	VSD - Very Small	0.37		**532**	1,068			
9	VSD - Small	1.1		**779**	1,594			
10	VSD - Medium	11		**3,841**	7,328			
11	VSD - Large	110		**29,379**	46,472			
12	VSD - Very Large	550		**218,060**	377,963			
16	Submersible boreh	2.2	**1,885**	1,926				
17	Submersible boreh	37	115,784	**114,768**				
18	Motor + VSD - Very	0.37	**640**	690	765		978	
19	Motor + VSD - Sma	1.1	**792**	830	886		999	906
20	Motor + VSD - Med	11	**4,010**	4,130	4,310		5,088	4,728
21	Motor + VSD - Larg	110	**25,154**	26,054	27,434		46,039	42,589
22	Motor + VSD - Very	550	**139,638**	143,388	149,138			

Figure 9.2 Life Cycle Costs of different Options in the review study (Base case = IE1; BAT1=IE2; BAT2=IE3; BAT3=IE4)

At the review study stage, there was no separate LLC calculation for single phase motors above 0.75 kW, nor for 8-pole motors (that are less efficient and more expensive than the more common 2-4-6 poles motors). This has been carried out in the context of the impact assessment. Additionally, some LCC calculations made during the review study have been re-done when new elements justified it. This has been the case for small and single-phase motors for which the energy savings calculated during IA2 were lower than expected at the review study stage, hence the need to check LCC conclusions. Different combinations of motor price and load factor have been considered, in order to build a series of 'cases' which reflect reality in a more robust manner than through the examination of a single case. Calculations have been redone for VSDs as well.

Common assumptions for all motors LCC calculations (unless specified otherwise):

- Efficiencies IE1-IE2-IE3: minimum value required by EN 60034-30-1 for 50 Hz, 4-pole
- Efficiency IE0: undefined, assumed 20% more losses than for IE1
- Electricity prices from Eurostat, industrial users, Band IC: 500 MWh < Consumption < 2000 MWh, excluding VAT and other recoverable taxes and levies, in Euro/kWh escalation rate 4%, discount rate 4%.
- LCC calculations exclude installation and maintenance, as they are not likely to be affected by the motor efficiency class. Only acquisition and energy costs are considered.
- Motor prices have been revised according to an update of the market research.
- As in the review study, a typical 'base case' is defined for each power range (for example a 0.37 kW motor is used as representative motor in the range 0.12-0.75 kW).

The outcome of the LLCC calculations made during the impact assessment is the following:

- Small motors (single-phase and 3-phase): IE2 is the optimum, noting that for 3-phase there is a case for requiring IE3, but not as compelling as for the larger 3-phase motors. See discussion in section 6.3.3.
- For small single-phase motors (0.75 kW-7.5 kW), IE2 is the optimum
- For 8-Pole motor, IE3 is the optimum
- For VSDs, ECO2 (or even higher) is the optimum above 0.75 kW. Below 0.75 kW there is no economic justification for regulation.

This confirms the policy options presented at the Consultation Forum in September 2014, except for VSD for which the new calculations suggest that IE2 is more relevant for the end-user than IE1. These cost-optimum requirements (those that match the least life cycle cost for end-users) are those proposed in the various ECO scenarios.

See the sections below for the detailed results.

9.2 Small motors 0.12-0.75 kW

For small motors, it is necessary to distinguish the application: motors designed to be used for the industry differ significantly from motors made for household appliances. Industrial motors are more robust, need to resist water projections from all directions, etc. Single phase motors for household products are usually produced in very large quantities, are less robust and therefore tend to be cheaper than their industrial counterparts. It is also necessary to consider that motors in household appliances are not used as intensively as in industrial applications, but that households face higher electricity prices than industry do.

a) Single-phase - industrial application

- Average power: 0.37 kW
- Load factor: 62.5% (review study) and 40% (as a variation)
- Annual operating hours: 2000 h/a
- Lifetime: 10 years
- Price: A great variety of prices is observed on the market, depending on quality, quantity and features. Industrial single-phase motors imported in large quantities from Asia can be as cheap as 25€, while some motors are quoted over 150€ on the European market for a single piece. However provided that a sufficient quantity is ordered, price is expected to be lower. A central value for the base case (IE1) of 70€ has been used, with -20 € / +30€ variations to reflect different situations/applications.
- Price difference between consecutive IE classes: 15% suggested by CEMEP, but for small motors might be higher (15% and 33% considered)

Table 9.1: LCC calculations for small industrial single-phase motors

Motor type	nominal power [kW]	load factor [%]	annual hours [h/a]	output energy [kWh/a]	efficiency [%]	input energy [kWh/a]	price for IE1 (€)	price variation vs. IE1	Acquisition €	LCC 10 years	LLCC 10 years	Pay back time (years)
1-phase IE0	0.37	40%	2000	296	59.2%	500.0		-33%	33.5	610.3	536.2	
1-phase IE1	0.37	40%	2000	296	66.0%	448.5	50		50	567.3	IE2	4.0
1-phase IE2	0.37	40%	2000	296	72.7%	407.2		33%	67	536.2		
1-phase IE0	0.37	40%	2000	296	59.2%	500.0		-33%	46.9	623.7	562.8	
1-phase IE1	0.37	40%	2000	296	66.0%	448.5	70		70	587.3	IE2	5.0
1-phase IE2	0.37	40%	2000	296	72.7%	407.2		33%	93	562.8		
1-phase IE0	0.37	40%	2000	296	59.2%	500.0		-33%	67	643.8	602.7	
1-phase IE1	0.37	40%	2000	296	66.0%	448.5	100		100	617.3	IE2	7.0
1-phase IE2	0.37	40%	2000	296	72.7%	407.2		33%	133	602.7		
1-phase IE0	0.37	63%	2000	463	59.2%	781.3		-33%	33.5	934.7	800.3	
1-phase IE1	0.37	63%	2000	463	66.0%	700.8	50		50	858.3	IE2	3.0
1-phase IE2	0.37	63%	2000	463	72.7%	636.2		33%	67	800.3		
1-phase IE0	0.37	63%	2000	463	59.2%	781.3		-33%	46.9	948.1	826.9	
1-phase IE1	0.37	63%	2000	463	66.0%	700.8	70		70	878.3	IE2	4.0
1-phase IE2	0.37	63%	2000	463	72.7%	636.2		33%	93	826.9		
1-phase IE0	0.37	63%	2000	463	59.2%	781.3		-33%	67	968.2	866.8	
1-phase IE1	0.37	63%	2000	463	66.0%	700.8	100		100	908.3	IE2	5.0
1-phase IE2	0.37	63%	2000	463	72.7%	636.2		33%	133	866.8		
1-phase IE0	0.37	40%	2000	296	59.2%	500.0		-15%	42.5	619.3	527.2	
1-phase IE1	0.37	40%	2000	296	66.0%	448.5	50		50	567.3	IE2	2.0
1-phase IE2	0.37	40%	2000	296	72.7%	407.2		15%	58	527.2		
1-phase IE0	0.37	40%	2000	296	59.2%	500.0		-15%	59.5	636.3	550.2	
1-phase IE1	0.37	40%	2000	296	66.0%	448.5	70		70	587.3	IE2	3.0
1-phase IE2	0.37	40%	2000	296	72.7%	407.2		15%	81	550.2		
1-phase IE0	0.37	40%	2000	296	59.2%	500.0		-15%	85	661.8	584.7	
1-phase IE1	0.37	40%	2000	296	66.0%	448.5	100		100	617.3	IE2	4.0
1-phase IE2	0.37	40%	2000	296	72.7%	407.2		15%	115	584.7		
1-phase IE0	0.37	63%	2000	463	59.2%	781.3		-15%	42.5	943.7	791.3	
1-phase IE1	0.37	63%	2000	463	66.0%	700.8	50		50	858.3	IE2	2.0
1-phase IE2	0.37	63%	2000	463	72.7%	636.2		15%	58	791.3		
1-phase IE0	0.37	63%	2000	463	59.2%	781.3		-15%	59.5	960.7	814.3	
1-phase IE1	0.37	63%	2000	463	66.0%	700.8	70		70	878.3	IE2	2.0
1-phase IE2	0.37	63%	2000	463	72.7%	636.2		15%	81	814.3		
1-phase IE0	0.37	63%	2000	463	59.2%	781.3		-15%	85	986.2	848.8	
1-phase IE1	0.37	63%	2000	463	66.0%	700.8	100		100	908.3	IE2	3.0
1-phase IE2	0.37	63%	2000	463	72.7%	636.2		15%	115	848.8		
Special cases												
1-phase IE0	0.37	40%	1000	148	59.2%	250.0		-33%	46.9	335.3	327.9	
1-phase IE1	0.37	40%	1000	148	66.0%	224.2	70		70	328.7	IE2	N.A.
1-phase IE2	0.37	40%	1000	148	72.7%	203.6		33%	93	327.9		
1-phase IE0	0.37	40%	2000	296	59.2%	500.0		-33%	95.81	672.6	659.8	
1-phase IE1	0.37	40%	2000	296	66.0%	448.5	143		143	660.3	IE2	N.A.
1-phase IE2	0.37	40%	2000	296	72.7%	407.2		33%	190	659.8		

As shown in table 9.1, in all considered cases, IE2 is the optimum solution. The extra investment for an IE2 motor (compared to an IE1) is paid back between 2 to 7 years depending on the case. The end-user saves between 2.5% and 8% of the costs over the whole life of the product compared to an IE1, or between 6% and 16% compared to an IE0. Two 'special' cases have been calculated showing that IE2 remains the best option if the number of running hours goes down to 1000 hours per year, or if the IE2 motor is purchased at 190€.

b) Household applications

- Average power: 0.37 kW
- Load factor: 62.5% (review study) and 40% (as a variant)
- Annual operating hours: 400 h/a
- Lifetime: 8 years and 10 years as variants
- Price: Single-phase motors for household appliances can be as cheap as 15€ for very large quantities, but higher prices are more representative of the average situation on the European market. A central value of 40€ has been considered for the 'base case' (IE1), with +/- 10€ variations to reflect different situations.
- Price difference between consecutive IE classes: 15% suggested by CEMEP, but for small motors it might be higher (15% and 33% are considered).
- Eurostat Prices for households, including all taxes and levies, Band DC : 2 500 kWh < Consumption < 5 000 kWh

Table 9.2: LCC calculations for small household single-phase motors

Motor type	nominal power [kW]	load factor [%]	annual hours [h/a]	output energy [kWh/a]	efficiency [%]	input energy [kWh/a]	price for IE1 (€)	price variation vs. IE1	Acquisition €	LCC 8 years	LCC 10 years	LLCC 8 years	LLCC 10 years	Pay back time (years)
1-phase IE0	0.37	40%	400	59	59.2%	100.0		-33%	20.1	184.1	225.1	173.4	206.8	
1-phase IE1	0.37	40%	400	59	66.0%	89.7	30		30.0	177.1	213.9	IE2	IE2	6.0
1-phase IE2	0.37	40%	400	59	72.7%	81.4		33%	39.9	173.4	206.8			
1-phase IE0	0.37	40%	400	59	59.2%	100.0		-33%	26.8	190.8	231.8	186.7	220.1	
1-phase IE1	0.37	40%	400	59	66.0%	89.7	40		40.0	187.1	223.9	IE2	IE2	8.0
1-phase IE2	0.37	40%	400	59	72.7%	81.4		33%	53.2	186.7	220.1			
1-phase IE0	0.37	40%	400	59	59.2%	100.0		-33%	33.5	197.5	238.5	197.1	233.4	
1-phase IE1	0.37	40%	400	59	66.0%	89.7	50		50.0	197.1	233.9	IE1	IE2	10.0
1-phase IE2	0.37	40%	400	59	72.7%	81.4		33%	66.5	200.0	233.4			
1-phase IE0	0.37	63%	400	93	59.2%	156.3		-33%	20.1	276.4	340.4	248.6	300.7	
1-phase IE1	0.37	63%	400	93	66.0%	140.2	30		30.0	259.8	317.3	IE2	IE2	4.0
1-phase IE2	0.37	63%	400	93	72.7%	127.2		33%	39.9	248.6	300.7			
1-phase IE0	0.37	63%	400	93	59.2%	156.3		-33%	26.8	283.1	347.1	261.9	314.0	
1-phase IE1	0.37	63%	400	93	66.0%	140.2	40		40.0	269.8	327.3	IE2	IE2	5.0
1-phase IE2	0.37	63%	400	93	72.7%	127.2		33%	53.2	261.9	314.0			
1-phase IE0	0.37	63%	400	93	59.2%	156.3		-33%	33.5	289.8	353.8	275.2	327.3	
1-phase IE1	0.37	63%	400	93	66.0%	140.2	50		50.0	279.8	337.3	IE2	IE2	7.0
1-phase IE2	0.37	63%	400	93	72.7%	127.2		33%	66.5	275.2	327.3			
1-phase IE0	0.37	40%	400	59	59.2%	100.0		-15%	25.5	189.5	230.5	168.0	201.4	
1-phase IE1	0.37	40%	400	59	66.0%	89.7	30		30.0	177.1	213.9	IE2	IE2	3.0
1-phase IE2	0.37	40%	400	59	72.7%	81.4		15%	34.5	168.0	201.4			
1-phase IE0	0.37	40%	400	59	59.2%	100.0		-15%	34.0	198.0	239.0	179.5	212.9	
1-phase IE1	0.37	40%	400	59	66.0%	89.7	40		40.0	187.1	223.9	IE2	IE2	4.0
1-phase IE2	0.37	40%	400	59	72.7%	81.4		15%	46.0	179.5	212.9			
1-phase IE0	0.37	40%	400	59	59.2%	100.0		-15%	42.5	206.5	247.5	191.0	224.4	
1-phase IE1	0.37	40%	400	59	66.0%	89.7	50		50.0	197.1	233.9	IE2	IE2	5.0
1-phase IE2	0.37	40%	400	59	72.7%	81.4		15%	57.5	191.0	224.4			
1-phase IE0	0.37	63%	400	93	59.2%	157.5		-15%	25.5	283.8	348.4	244.8	297.4	
1-phase IE1	0.37	63%	400	93	66.0%	141.3	30		30.0	261.7	319.6	IE2	IE2	2.0
1-phase IE2	0.37	63%	400	93	72.7%	128.3		15%	34.5	244.8	297.4			
1-phase IE0	0.37	63%	400	93	59.2%	157.5		-15%	34.0	292.3	356.9	256.3	308.9	
1-phase IE1	0.37	63%	400	93	66.0%	141.3	40		40.0	271.7	329.6	IE2	IE2	3.0
1-phase IE2	0.37	63%	400	93	72.7%	128.3		15%	46.0	256.3	308.9			
1-phase IE0	0.37	63%	400	93	59.2%	157.5		-15%	42.5	300.8	365.4	267.8	320.4	
1-phase IE1	0.37	63%	400	93	66.0%	141.3	50		50.0	281.7	339.6	IE2	IE2	3.0
1-phase IE2	0.37	63%	400	93	72.7%	128.3		15%	57.5	267.8	320.4			
Special cases														
1-phase IE0	0.37	52%	220	42	59.2%	70.8		-24%	30.4	146.5	175.566	144.2	167.8	
1-phase IE1	0.37	52%	220	42	66.0%	63.5	40		40	144.2	170	IE2	IE2	N.A.
1-phase IE2	0.37	52%	220	42	72.7%	57.7		24%	50	144.2	168			
1-phase IE0	0.37	52%	400	76	59.2%	128.8		-24%	55.1	266.3	319.038	261.8	304.8	
1-phase IE1	0.37	52%	400	76	66.0%	115.5	72.5		73	261.9	309	IE2	IE2	N.A.
1-phase IE2	0.37	52%	400	76	72.7%	104.8		24%	90	261.8	305			

As shown in table 9.2, IE2 is the optimum solution in all considered cases but one. The extra investment for an IE2 motor (compared to an IE1) is paid back between 2 to 10 years depending on the case. In the best case the end-user saves 39€ (about 15%) over the lifetime of the product if he uses an IE2 motor instead of an IE1, in the worst case, he loses 3€. The gains achieved are larger if we compare with an IE0 motor (up to 50€).

Two special cases have case have been constructed showing that IE2 remains the best option if the number of running hours goes down to 220 hours per year, or if the IE2 motors costs 90€ to the end-user, for a 'central case'.

c) 3-phase - industrial application

The assumptions are the same as single phase motors, however a separate calculation was needed in order to assess the economic feasibility of requiring IE3 level. IE3 is more economical in 8 out the 12 cases. There is a case for requiring IE3, but not as strong for the larger 3-phase motors. See discussion in section 6.3.3.

Table 9.3 LCC calculations for small industrial three-phase motors

Motor type	nominal power [kW]	load factor [%]	annual hours [h/a]	output energy [kWh/a]	efficiency [%]	input energy [kWh/a]	price for IE1 euros	price variation vs. IE1	Acquisition €	LCC 10 years	LLCC 10 years	Pay back time (years)
3-phase IE0	0.37	40%	2000	296	59.2%	500.0		-33%	33.5	610.25	530	
3-phase IE1	0.37	40%	2000	296	66.0%	448.5	50		50	567	IE3	8
3-phase IE2	0.37	40%	2000	296	72.7%	407.2		33%	67	536		
3-phase IE3	0.37	40%	2000	296	77.3%	382.9		33%	88	530		
3-phase IE0	0.37	40%	2000	296	59.2%	500.0		-33%	46.9	623.65	563	
3-phase IE1	0.37	40%	2000	296	66.0%	448.5	70		70	587	IE2	-
3-phase IE2	0.37	40%	2000	296	72.7%	407.2		33%	93	563		
3-phase IE3	0.37	40%	2000	296	77.3%	382.9		33%	124	566		
3-phase IE0	0.37	40%	2000	296	59.2%	500.0		-33%	67	643.75	603	
3-phase IE1	0.37	40%	2000	296	66.0%	448.5	100		100	617	IE2	-
3-phase IE2	0.37	40%	2000	296	72.7%	407.2		33%	133	603		
3-phase IE3	0.37	40%	2000	296	77.3%	382.9		33%	177	619		
3-phase IE0	0.37	63%	2000	463	59.2%	781.3		-15%	42.5	943.672	756	
3-phase IE1	0.37	63%	2000	463	66.0%	700.8	50		50	858	IE3	2
3-phase IE2	0.37	63%	2000	463	72.7%	636.2		15%	58	791		
3-phase IE3	0.37	63%	2000	463	77.3%	598.3		15%	66	756		
3-phase IE0	0.37	63%	2000	466	59.2%	787.5		-15%	59.5	967.881	788	
3-phase IE1	0.37	63%	2000	466	66.0%	706.4	70		70	885	IE3	3
3-phase IE2	0.37	63%	2000	466	72.7%	641.3		15%	81	820		
3-phase IE3	0.37	63%	2000	466	77.3%	603.1		15%	93	788		
3-phase IE0	0.37	63%	2000	466	59.2%	787.5		-15%	85	993.381	828	
3-phase IE1	0.37	63%	2000	466	66.0%	706.4	100		100	915	IE3	4
3-phase IE2	0.37	63%	2000	466	72.7%	641.3		15%	115	855		
3-phase IE3	0.37	63%	2000	466	77.3%	603.1		15%	132	828		

9.3 Small single-phase motors (0.75 kW-7.5 kW)

- Average power: 1.1 kW
- Load factor: 50%
- Annual operating hours: This type of motor is considered to be used in a variety of applications (e.g. light industrial applications) with an average of 800 operating hours per year (less than 3-phase industrial applications but more than household appliances).
- Lifetime: 10 years
- Price: A great variety of prices is observed on the market, depending on quality, quantity and features. Industrial single-phase 1.1 kW motors imported in large quantities from Asia can be as cheap as 40 euros, while some motors are quoted over 200€ on the European market for a single piece. Provided that a sufficient quantity is ordered, price is expected to be lower. A central value for the base case (IE1) of 150€ has been used + / - 40 €.

- Price difference between consecutive IE classes: 15% suggested by CEMEP, but for single phase motors might be higher (15% and 25% considered).

Table 9.4: LCC calculations for small single-phase industrial motors >= 0.75kW

Motor type	nominal power [kW]	load factor [%]	annual hours [h/a]	output energy [kWh/a]	efficiency [%]	input energy [kWh/a]	price for IE1 euros	price variation vs. IE1	acquisition	LCC 10 years	LLCC 10 years	Pay back time (years)
1-phase IE0	1.1	50%	800	440	70.0%	628.6		-25%	82.5	808	761.0	
1-phase IE1	1.1	50%	800	440	75.0%	586.7	110		110	787	IE2	6.0
1-phase IE2	1.1	50%	800	440	81.4%	540.5		25%	138	761		
1-phase IE0	1.1	50%	800	440	70.0%	628.6		-25%	112.5	838	811.0	
1-phase IE1	1.1	50%	800	440	75.0%	586.7	150		150	827	IE2	8.0
1-phase IE2	1.1	50%	800	440	81.4%	540.5		25%	188	811		
1-phase IE0	1.1	50%	800	440	70.0%	628.6		-25%	142.5	868	861.0	
1-phase IE1	1.1	50%	800	440	75.0%	586.7	190		190	867	IE2	9.0
1-phase IE2	1.1	50%	800	440	81.4%	540.5		25%	238	861		
1-phase IE0	1.1	50%	800	440	70.0%	628.6		-15%	93.5	819	750.0	
1-phase IE1	1.1	50%	800	440	75.0%	586.7	110		110	787	IE2	4.0
1-phase IE2	1.1	50%	800	440	81.4%	540.5		15%	127	750		
1-phase IE0	1.1	50%	800	440	70.0%	628.6		-15%	127.5	853	796.0	
1-phase IE1	1.1	50%	800	440	75.0%	586.7	150		150	827	IE2	5.0
1-phase IE2	1.1	50%	800	440	81.4%	540.5		15%	173	796		
1-phase IE0	1.1	50%	800	440	70.0%	628.6		-15%	161.5	887	842.0	
1-phase IE1	1.1	50%	800	440	75.0%	586.7	190		190	867	IE2	6.0
1-phase IE2	1.1	50%	800	440	81.4%	540.5		15%	219	842		
Special case												
1-phase IE0	1.1	50%	500	275	70.0%	392.9		-20%	120	573	569.7	
1-phase IE1	1.1	50%	500	275	75.0%	366.7	150		150	573	IE2	N.A.
1-phase IE2	1.1	50%	500	275	81.4%	337.8		20%	180	570		

As shown in table 9.4, IE2 is the optimum solution in all considered cases. The extra investment for an IE2 motor (compared to an IE1) is paid back between 4 and 9 years depending on the case. The end-user saves between 0.5% and 5% of the costs over the whole life of the product compared to an IE1, or up to 8% compared to an IE0 motor. A special case has case have been constructed showing that IE2 remains the best option if the number of running hours goes down to 500 hours per year, for a 'central case'.

9.4 8-Pole motors

- Average power: 1.1 kW; 11 kW and 110 kW
- Load factor: 57 and 52%
- Annual operating hours: 2250; 3000 and 6000 respectively
- Lifetime: 9, 11 and 16 years
- Price: Base on market study, it is considered that prices of 8-pole motors are on average 60% above the price of the corresponding 4-poles motor.

Table 9.5: LCC calculations for 8-pole industrial motors

Motor type	nominal power [kW]	load factor [%]	annual hours [h/a]	output energy [kWh/a]	efficiency [%]	input energy [kWh/a]	price ref	price variation between classes	acquisition	LCC 9 years	LCC 11 years	LCC 16 years	LLCC 9 years	LLCC 11 years	LLCC 16 years	Payback time (yrs)
8-poles IE0	1.1	57%	2250	1411	59.8%	2,359	192	11%	192	2641	3,185	4,546	2,411	2620.6	3667.8	
8-poles IE1	1.1	57%	2250	1411	66.5%	2,121	214	13%	214	2416	2,905	4,129	IE3	IE3	IE3	4
8-poles IE2	1.1	57%	2250	1411	70.8%	1,993	241	31%	241	2310	2,770	3,919				
8-poles IE3	1.1	57%	2250	1411	77.7%	1,816	317		317	2202	2,621	3,668				
8-poles IE0	11	52%	3000	17160	82.0%	20,927	762	12%	762	22487	27,315	39,384	23,447	25,681	36,852	
8-poles IE1	11	52%	3000	17160	85.0%	20,188	853	13%	853	21812	26,469	38,113	IE3	IE3	IE3	4
8-poles IE2	11	52%	3000	17160	86.9%	19,747	966	15%	966	21466	26,021	37,410				
8-poles IE3	11	52%	3000	17160	88.6%	19,368	1106		1106	21213	25,681	36,852				
8-poles IE0	110	52%	6000	343200	89.3%	384,236	7000	11%	7000	405895	494,538	716,147	432,704	474,954	686,203	
8-poles IE1	110	52%	6000	343200	91.1%	376,729	7802	14%	7802	398903	485,815	703,093	IE3	IE3	IE3	3
8-poles IE2	110	52%	6000	343200	92.3%	371,831	8874	15%	8874	394891	480,672	695,126				
8-poles IE3	110	52%	6000	343200	93.7%	366,275	10206		10206	390454	474,954	686,203				

Table 9.4 shows that IE3 is the optimum solution in all considered cases. The extra investment for an IE2 motor (compared to an IE1) is paid back between 3 and 5 years depending on the case. The end-user saves between 1% and 5% of the costs over the whole life of the product compared to an IE2, or up to 9% compared to an IE1 motor. IE3 remains the optimum solution even when the running hours go as low as 1000 hours (1.1 and 11 kW) or 1500 hours (110 kW).

9.5 VSDs

VSDs should only be considered for variable speed applications, in which case significant savings can be generated. Although the IE3 VSD class is not defined in the relevant VSD standard, calculations included a hypothetical IE3 class with 50% less losses than IE1. LLC calculations for VSD have been performed for various cases (always assuming variable speed application). In each case, two motor efficiencies have been considered (e.g. IE1 and IE2 for small motors or IE2 and IE3 for medium-large motors).

The results are as follows:

Table 9.6: Synthesis of LCC calculations for VSDs

Motor type	Worthwhile to use a VSD ?	Most economic VSD solution	Payback time of VSD
0.12-0.75 kW 1-phase	N	IE0	-
0.12-0.75 kW 3-phase	N	IE0	-
0.75-7.5 kW 1-phase	N	IE0	-
0.75-7.5 kW 3-phase	Y	IE3	7
7.5-75 kW 3-phase	Y	IE3	6
75-375 kW 3-phase	Y	IE3	2
375-1000 kW 3-phase	Y	IE3	3

For applications for small motors under 0.75 kW and single-phase motors, the calculations show that a VSD does not generate obvious economic benefits, and that, should a VSD be used, there is not benefit in selecting an energy-efficient one. For 3-phase motors above 0.75 kW the conclusion is that the use of a VSD makes economic sense (in variable speed applications) and that purchasing an energy-efficient VSD is cost-economic, even beyond the IE2 class. This is reflected in the ECO2 and ECO3 scenarios in the main part of the report in which it is proposed to regulate the efficiency of VSDs from 0.75 kW. The IE2 level is proposed as IE3 is not defined yet in international standards. However, a revision of the regulation should be planned in order to accommodate higher requirements in the future.

The following tables show the calculations in the case of a VSD for single-phase motors (0.12-0.75 kW) and for medium size 3-phase motors (7.5-75 kW).

Table 9.7: LCC calculations for VSDs for single phase motors 0.12-0.75 kW

Motor type	output	these are at nominal power				input							cumulative costs (including installation and maintenance)							
small 1-phase	nominal	motor	motor	induced	VSD	nominal	load	annual	input	motor price	motor	motor	VSD price	VSD	VSD	year	year	year	LLCC	LLCC
IE1 motor	power	efficiency	losses	losses	losses	power	factor	hours	energy	excl. install	install	maint	excl. install	install	maint	0	8	10	8 years	10 years
(household	[kW]	[%]	[W]	[W]	[W]	[kW]	[%]	[h/a]	[kWh/a]	euros	euros	euros/a	euros	euros	euros/a	acquisition	+nrg cost	+nrg cost		
appliances)																+install	+maint	+maint		
no VSD	0.37	66.0%	191	0	0	0.56	40%	400	89.7	40	15	0	0	0	0	55	138	158	137.8	158.5
VSD IE0	0.37	66.0%	191	29	148	0.74	24%	400	70.7	40	15	0	180	100	0	335	400	417	no VSD	no VSD
VSD IE1	0.37	66.0%	191	29	118	0.71	24%	400	67.9	40	15	0	200	100	0	355	418	433		
VSD IE2	0.37	66.0%	191	29	89	0.68	24%	400	65.1	40	15	0	220	100	0	375	435	450	400.3	416.6
VSD IE3	0.37	66.0%	191	29	59	0.65	24%	400	62.2	40	15	0	240	100	0	395	452	467	IE0	IE0
	output	these are at nominal power				input							cumulative costs (including installation and maintenance)							
small 1-phase	nominal	motor	motor	induced	VSD	nominal	load	annual	input	motor price	motor	motor	VSD price	VSD	VSD	year	year	year	LLCC	LLCC
IE2 motor	power	efficiency	losses	losses	losses	power	factor	hours	energy	excl. install	install	maint	excl. install	install	maint	0	8	10	8 years	10 years
(household	[kW]	[%]	[W]	[W]	[W]	[kW]	[%]	[h/a]	[kWh/a]	euros	euros	euros/a	euros	euros	euros/a	acquisition	+nrg cost	+nrg cost		
appliances)																+install	+maint	+maint		
no VSD	0.37	72.7%	139	0	0	0.51	40%	400	81.4	53	15	0	0	0	0	68	143	162	143.1	161.9
VSD IE0	0.37	72.7%	139	21	148	0.68	24%	400	65.0	53	15	0	180	100	0	348	408	423	no VSD	no VSD
VSD IE1	0.37	72.7%	139	21	118	0.65	24%	400	62.2	53	15	0	200	100	0	368	425	440		
VSD IE2	0.37	72.7%	139	21	89	0.62	24%	400	59.4	53	15	0	220	100	0	388	443	456	408.0	423.0
VSD IE3	0.37	72.7%	139	21	59	0.59	24%	400	56.5	53	15	0	240	100	0	408	460	473	IE0	IE0
Motor type	output	these are at nominal power				input							cumulative costs (including installation and maintenance)							
small 1-phase	nominal	motor	motor	induced	VSD	nominal	load	annual	input	motor price	motor	motor	VSD price	VSD	VSD	year	year	year	LLCC	LLCC
IE1 motor	power	efficiency	losses	losses	losses	power	factor	hours	energy	excl. install	install	maint	excl. install	install	maint	0	8	10	8 years	10 years
(industrial	[kW]	[%]	[W]	[W]	[W]	[kW]	[%]	[h/a]	[kWh/a]	euros	euros	euros/a	euros	euros	euros/a	acquisition	+nrg cost	+nrg cost		
application)																+install	+maint	+maint		
no VSD	0.37	66.0%	191	0	0	0.56	40%	2000	448.5	70	15	0	0	0	0	85	499	602	498.9	602.3
VSD IE0	0.37	66.0%	191	29	148	0.74	24%	2000	353.6	70	15	0	180	100	0	365	691	773	no VSD	no VSD
VSD IE1	0.37	66.0%	191	29	118	0.71	24%	2000	339.5	70	15	0	200	100	0	385	698	777		
VSD IE2	0.37	66.0%	191	29	89	0.68	24%	2000	325.3	70	15	0	220	100	0	405	705	780	691.3	772.9
VSD IE3	0.37	66.0%	191	29	59	0.65	24%	2000	311.1	70	15	0	240	100	0	425	712	784	IE0	IE0
	output	these are at nominal power				input							cumulative costs (including installation and maintenance)							
small 1-phase	nominal	motor	motor	induced	VSD	nominal	load	annual	input	motor price	motor	motor	VSD price	VSD	VSD	year	year	year	LLCC	LLCC
IE2 motor	power	efficiency	losses	losses	losses	power	factor	hours	energy	excl. install	install	maint	excl. install	install	maint	0	8	10	8 years	10 years
(industrial	[kW]	[%]	[W]	[W]	[W]	[kW]	[%]	[h/a]	[kWh/a]	euros	euros	euros/a	euros	euros	euros/a	acquisition	+nrg cost	+nrg cost		
application)																+install	+maint	+maint		
no VSD	0.37	72.7%	139	0	0	0.51	40%	2000	407.2	93	15	0	0	0	0	108	484	578	483.7	577.7
VSD IE0	0.37	72.7%	139	21	148	0.68	24%	2000	325.1	93	15	0	180	100	0	388	688	763	no VSD	no VSD
VSD IE1	0.37	72.7%	139	21	118	0.65	24%	2000	310.9	93	15	0	200	100	0	408	695	767		
VSD IE2	0.37	72.7%	139	21	89	0.62	24%	2000	296.8	93	15	0	220	100	0	428	702	770	688.0	763.0
VSD IE3	0.37	72.7%	139	21	59	0.59	24%	2000	282.6	93	15	0	240	100	0	448	709	774	IE0	IE0

Table 9.8: LCC calculations for VSDs for 3-phase motors 7.5-75 kW

Motor type	output	these are at nominal power				input							cumulative costs (including installation and maintenance)					
medium 3-phase	nominal	motor	motor	induced	VSD	nominal	load	annual	input	motor price	motor	motor	VSD price	VSD	VSD	Year	Year	LLCC
IE2 motor	power	efficiency	losses	losses	losses	power	factor	hours	energy	excl. install	install	maint	excl. install	install	maint	0	11	11 years
	[kW]	[%]	[W]	[W]	[W]	[kW]	[%]	[h/a]	[kWh/a]	euros	euros	euros/a	euros	euros	euros/a	acquisition	+nrg cost	
																+install	+maint	
no VSD	11	81.4%	2514	0	0	13.5	52%	3500	24595	598	85	64	0	0	0	683	32594	23208
VSD IE0	11	81.4%	2514	377	980	14.9	31%	3500	16135	598	85	64	1020	600	18	2303	23677	with VSD
VSD IE1	11	81.4%	2514	377	784	14.7	31%	3500	15922	598	85	64	1110	600	18	2393	23497	
VSD IE2	11	81.4%	2514	377	588	14.5	31%	3500	15709	598	85	64	1235	600	18	2518	23353	23208
VSD IE3	11	81.4%	2514	377	392	14.3	31%	3500	15497	598	85	64	1360	600	18	2643	23208	IE3
	output	these are at nominal power				input							cumulative costs (including installation and maintenance)					
medium 3-phase	nominal	motor	motor	induced	VSD	nominal	load	annual	input	motor price	motor	motor	VSD price	VSD	VSD	0	11	LLCC
IE3 motor	power	efficiency	losses	losses	losses	power	factor	hours	energy	excl. install	install	maint	excl. install	install	maint	2020	2030	11 years
	[kW]	[%]	[W]	[W]	[W]	[kW]	[%]	[h/a]	[kWh/a]	euros	euros	euros/a	euros	euros	euros/a	acquisition	+nrg cost	
																+install	+maint	
no VSD	11	84.1%	2080	0	0	13.1	52%	3500	23805	676	85	64	0	0	0	761	31670	22599
VSD IE0	11	84.1%	2080	312	980	14.4	31%	3500	15593	676	85	64	1020	600	18	2381	23068	with VSD
VSD IE1	11	84.1%	2080	312	784	14.2	31%	3500	15381	676	85	64	1110	600	18	2471	22889	
VSD IE2	11	84.1%	2080	312	588	14.0	31%	3500	15168	676	85	64	1235	600	18	2596	22744	22599
VSD IE3	11	84.1%	2080	312	392	13.8	31%	3500	14955	676	85	64	1360	600	18	2721	22599	IE3