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ABSTRACT

It has been proposed that the EU Ecodesign Directive can promote resource efficiency through relevant ecodesign requirements. This paper examines the potential for rare earth element (REE) resource efficiency improvements in the event the current regulation for electric motors under the Ecodesign Directive is to be extended to comprise REE-based permanent magnet motors. The research is based on literature studies, questionnaires and semi-structured interviews with representatives from industry and academia. It is found that standards addressing the design and use phase could yield highest resource efficiency improvements of REE in permanent magnet motors. Highly ranked are stricter EU energy efficiency ratings and design for dismantling if and when recycling of REE was to be commercialized.

INTRODUCTION

A diligent use of natural resources is inherent in the Resource Efficient Europe flagship initiative of the Europe 2020 Strategy which aims to facilitate sustainable economic growth. (European Commission [EC], 2011) The aim of attaining higher resource efficiency has been formulated when the criticality of certain resources, such as rare earth elements (REE) was acknowledged. These elements are essential in cleaner energy technologies, which must be applied more widely to achieve stipulated carbon dioxide emission reduction targets. They are also key components in numerous industrial uses and high-tech consumer appliances.

The EU product-oriented environmental policy represents one of several policy options which can facilitate the sustainable use of resources by emphasizing resource efficiency through addressing the entire product life cycle. (Dalhammar, 2007) Multiple instruments work towards this objective, whereby most of them address a specific life cycle phase. Among the mandatory instruments only the Ecodesign Directive 2009/125/EC has an integrated life cycle perspective albeit its primary objective of increasing the energy efficiency of energy-related products. (Official Journal of the European Union, 2009a)

The Ecodesign Directive and its electric motor product group regulation

A vast number of products, classified into 31 product groups, are regulated under the Directive definition of energy-related products and they consume both a significant share of energy and a considerable amount of resources within the EU. (Official Journal of the

European Union, 2009)Recognizing that many issues are product-specific, the study- which formed part of a larger project conducted in 2011-2013 - has been narrowed down to the product group of electric motors, which account for 30 to 40 per cent of the generated electrical energy worldwide. In industry, electric motors are often part of electric motor driven systems which account for about 70 per cent of industrial electricity. The cost-effective improvement of the energy efficiency of electric motor driven systems is estimated at up to 60 per cent whereby the use of energy efficient electric motors accounts for one of the main factors in such improvements. Thus, electric motors demonstrate significant ecodesign improvement potential. (Grundfos, 2008)

The electric motor product group regulation 640/2009 entered into force in July 2009 (Lot 11) and set minimum requirements for the ecodesign of electric motors and the use of variable speed drives. (Official Journal of the European Union, 2009b) The EC regulation is more limited in its scope than the international standard IEC 60034-30. The regulation is not comprehensive enough to account for all efficiency potential savings which could possibly be achieved among electric motors, as not all types of motors are covered. (CEMEP, 2011)

Rare earth element use in permanent magnet motors
Against this background, a preparatory study on lot 30, which aims at identifying the potential for environmental improvement of other motor products outside the scope of Regulation 640/2009 has commenced.(ISR-University of Coimbra and Atkins, 2012)This extension of the current electric motor is envisaged to potentially include permanent magnet (PM) motors. Neodymium-Iron-Boron (NdFeB) and Samarium-Cobalt (SmCo) alloys are prominent in the manufacture of the permanent magnets used in these motors as the magnetic properties inherent to the REE allow for high energy densities in the magnets and thus contribute to make the motors more energy efficient. (De Almeida, Falkner, Fong, and Jugdoyal, 2012)

The aim of this case study was to conduct an ex-ante assessment of whether an extension of the current electric motor regulation to PM motors could foster sustainable product development capable of achieving resource efficiency improvements of REE. Against pressing needs to increase resource efficiency, predominantly of the before mentioned critical REE, the extension of the electric motor group regulation appears to have considerable potential to facilitate product design improvements.

METHODOLOGY

The case study was guided by Geels (2002) Multi-level Perspective on Technological Transitions and innovation drivers selected from Blind (2012), Jänicke (2008), Van den Ende and Kemp (1999). The extent to which these drivers, namely export intensity, price volatility, uncertainty, rule set and anticipation, the Ecodesign Directive, and its potential extension to PM motors affect the development of PM motors and especially the technological transition towards more resource efficiency of REE, has been explored. The data has been collected through questionnaires filled in by representatives of PM manufacturers who attended the first preparatory study meeting in June 2012 for the product group extension. The questionnaire was also sent out to attendants of industry associations and other companies manufacturing motors, however not as a core activity, in order to draw comparisons in the tendencies which were depicted in the responses of PM motor manufacturers. These responses were

complemented by three semi-structured in-depth interviews with permanent magnet material experts from academia and a European PM manufacturer. Obtained data was analysed qualitatively according to the selected innovation drivers, which were integrated into the Multi-level Perspective on Technological Transitions.

RESULTS

In summary, the anticipated extension of the electric motor product group regulation to PM motors and its influence on PM motor innovation activities appeared to be of less importance to manufacturers than both the price volatility of the REE-containing-PM magnets and the market demand for them. Despite this observation, it has been noted that the inclusion of new and stricter EU energy efficiency ratings would have the potential to accelerate product innovations and thereby potentially improve resource efficiency in this product group. This finding has been reiterated in the evaluation of the rule set indicator, comprising regulatory standards, which has been pointed out as having the highest influence on innovation activities.

Standards facilitating resource efficiency improvements and perceived feasibility

Potential legal standards and the respective legal instruments, predominantly the Ecodesign Directive, through which these standards could be fostered, were grouped into the product life cycle categories of design, manufacture, use and end-of-life and their perceived feasibility for application on PM motors was discussed. In the design phase of PM motors, legal standards on product composition, which could emphasize the use of the bill of materials and a standard on modularisation which would require design for dismantling, were perceived to be feasible for implementation through the Ecodesign Directive and could potentially contribute to increased resource efficiency of REE in PM motors. Their effectiveness would depend on the development of cost efficient REE recycling methods. The Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) addresses the chemical content of products and has already led to the classification of powder materials used in the production of sintered NdFeB magnets as chemicals. Options for resource efficiency improvement in the production phase of the product life cycle appeared to be rather restricted.

In the product use phase, the enforcement of stricter energy efficiency requirements through the Ecodesign Directive was considered to have the highest potential regarding resource efficiency improvements. These higher energy efficiency class achievements are enabled by the use of REE-containing permanent magnet in motors. The enforcement of stricter energy efficiency standards would, on one hand, continue to promote the use of REE-based permanent magnets in motors but, on the other, if the availability of individual REE was to be restricted in the future and REE market prices are to increase, innovations in permanent magnets would be encouraged which would presumably foster efficient REE use.

Resource efficiency improvements in the end-of-life phase are dependent on the improvement of REE recycling technology which allows for its economically feasible commercialization. Against this precondition, a feasible legal standard in the motor end-of-life phase was seen in a standard requiring the take-back of motors by producers at its end-of-life, which is seen as one of the key pillars in the resource efficiency improvement of REE in PM motors. It is being acknowledged that the long motor lifetime could present a hindering factor in achieving this legal standard which could be jointly facilitated through a closer alignment of the Waste

Electrical and Electronic Equipment (WEEE) Directive with the Ecodesign Directive. The feasibility of other available legal standards, such as a material concentration to facilitate recycling, was viewed as being dependent on preceding innovations in PM manufacturing technology.

CONCLUSION

In conclusion, the potential expansion of the Ecodesign Directive electric motor regulation to comprise REE-based PM motors could possibly achieve resource efficiency improvements of REE through the elaboration of stricter energy efficiency standards in the use phase, and a focus on standards addressing product composition and modularization in the design phase.

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