

Product Ecodesign Approaches in ISO 14001 Certified Companies

Gregor Radonjič, Aleksandra P. Korda, and Damijan Krajnc

Abstract—The aim of the study was to investigate whether there is the promotion of product ecodesign measures as a result of adopting ISO 14001 certification in manufacturing companies in the Republic of Slovenia. Companies gave the most of their product development attention to waste and energy reduction during manufacturing process and reduction of material consumption per unit of product. Regarding the importance of different ecodesign criteria reduction of material consumption per unit of product was reported as the most important criterion. Less attention is paid to end-of-life issues considering recycling or packaging. Most manufacturing enterprises considered ISO 14001 standard as a very useful tool or at least a useful tool helping them to accelerate and establish product ecodesign activities. Two most frequently considered ecodesign drivers are increased competitive advantage and legal requirements and two most important barriers are high development costs and insufficient market demand.

Keywords—ecodesign, environmental management system, ISO 14001, products

I. INTRODUCTION

EUROPEAN Union environmental policies are increasingly focusing on products. However, many environmental protection approaches still seem to only focus on a single aspect of the product's life-cycle. Ecodesign of the products is defined as *"the integration of environmental aspects into product design and development with the aim of reducing adverse environmental impacts throughout a product's life cycle"* [1]. The aim of a product ecodesign is to reduce the consumption of the primary resources, optimise the production and distribution, prolong the lifespan of a product, use less hazardous materials, enhance the use of the recycled materials and/or make waste treatment easier and more efficient, both environmentally and economically. Nowadays there is a variety of possibilities for the enterprises to implement environmental policies into their business strategies. The international standard ISO 14001 has become a dominant international standard for assessing environmental management system (EMS) worldwide. However, the scope of environmental management in a way to include impacts outside the factory gate (i.e. including product's use phase and/or waste treatment) in ISO 14001 certified enterprises was often neglected.

Although some authors reported on observations of practices to link ecodesign activities also within ISO 14001

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EMS [2]- [5] the extensive initial literature review confirmed that the informations on the relationship between ISO 14001 EMS and product ecodesign practices are still limited and scarce or even contradictory sometimes. The reason is not only that both of these environmental protection options had developed separately, but also that ecodesign based on a life-cycle methodology is relatively young discipline and therefore still not widely recognized in practice. In spite of the fact that more and more studies are published on ecodesign, there is still a lack of informations about the benefits (or obstacles) of EMS on promoting ecodesign activities in different manufacturing sectors, especially for developing countries which joined the EU community later. Thus, the goal of the paper is to reveal in more detail to what extent the ISO 14001 certification can accelerate initiatives for the product ecodesign within the certified manufacturing firms. Furthermore, we investigated which are the most important environmental criteria (indicators) taken into account during product development and which are the influential drivers and barriers in such development process. In addition, the correlations between these variables were investigated.

II. RESEARCH METHODOLOGY

The research is based on the questionnaire survey during January and April 2010 conducted on a sample of ISO 14001 certified manufacturing companies that operate in the Republic of Slovenia. The case companies were chosen by using the enterprise register of Slovene National Chamber of Commerce. Only medium and large enterprises were taken into account, small enterprises were excluded. The reason was that it is more likely that the first two kind of firms have established a special department for product development supported by the staff more specialized in product development process. A total of 108 questionnaires were sent and 61 were returned. Among these five questionnaires were rejected due to the inaccurate answers giving a final response rate of 51.8 %. It was found out that 55.4 % of the sampled firms fall within medium and 44.6 % within large enterprises. To get more detailed insight into specifics of certain industrial branches, we analyzed three of them more precisely. Three branches with the highest respond rates were chosen: chemical and related industries, metal industry and manufacturers of electrical equipment and household appliances. Together they represent 50 % of respondents. Branches like production of chemicals and chemical products, production of rubber and plastic products as well as production of pulp and paper products were grouped into one category termed 'chemical and related industries' in the further text. Such grouping is sensible since the production of paper is based to a great extent on chemical processes of pulp production and the use of chemical agents. Respondents from the metal industry include enterprises of steel and primary aluminium production, steel and aluminium fabrication manufacturers as well as metal processing manufacturers.

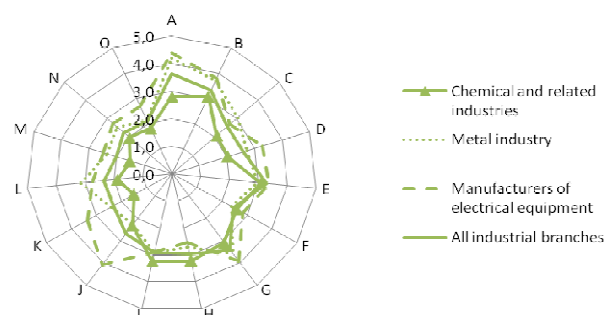
Data was analyzed with software SPSS 17.0 including descriptive statistics (means, frequencies and percentages) and contingency tables to record and analyse the relations between two categorical variables and to present multivariate frequency. Furthermore, the one-way analysis of variance ANOVA with the post-hoc Tukey HSD test was used to test differences between groups of companies regarding industrial branches and to test differences between groups of companies regarding the year of ISO 14001 acquisition. For testing the differences in case of only two independent samples, i.e. between firms that have more or less than 250 employees, the T-test was used. The general criteria for accepting the hypothesis that differences exist was the the 95 % confidence level ($p < 0.05$; two-tailed).

III. DISCUSSION

Respondents were asked to identify which ecodesign strategies in terms of different environmental criteria related to the whole life cycle of a product(s) were taken into account when developing new products. In general, Slovene companies most often take into account following environmental criteria: 'less waste generation during the manufacturing process' (94.1 %), 'less energy use during the manufacturing process' (90.2 %) and 'reducing the material consumption per unit of a product' (88.2 %). This trend is, at least to some extent, also reflected within the distribution of financial expenditures for environmental protection in Slovene industry where waste management represents main expenditure activity [6]. From the above results, it seems that the criteria related to the process optimization prevail in most companies under the study compared to more product oriented strategies. Regardless of the legislation development and market changes, it cannot be neglected that many companies seems to have a relatively narrow perception of their environmental impacts, which is mostly limited to site-specific activities. Comparison of ecodesign product strategies of Slovene certified manufacturing companies with those operating in certain developed countries shows certain differences. For example, opposite to Slovene companies, an analysis of 77 Dutch small and medium enterprises belonging to the metal, wood, plastics, textile and electronic industrial sector revealed that recycling of materials, use of recycled materials and low energy consumption are three most dominant ecodesign options [5]. Similar trend was confirmed by Santolaria et al. for Spanish companies [7].

Different kinds of products have different potentials regarding their environmental improvements. Therefore, criteria were quantified to get more precise insight which are more or less important. They were determined on a five-point scale, where 1 means 'not important at all' and 5 means 'extremely important' (see Fig. 1). The relevance of some criteria will depend on the branch and specific product. Fig. 1 shows the average importance of environmental criteria of the whole sample (cumulative values for all industrial branches included) as well as the average importance value for three individual branches. On average, the Slovene companies consider 'reduced material consumption per unit of product' as the most important environmental criteria (mean: 3.65). Criteria 'using recyclable materials' and 'increasing the

content of recycling materials' are assessed as less important as well as different possibilities concerning packaging environmental optimization.



Legend: A= reduction of material consumption per unit of product; B= replacement of toxic and hazardous substances; C= increasing the content of recycled materials; D= use of recyclable materials; E= reduced energy consumption during the manufacturing process; F= reduced water use in the process of manufacturing; G= waste reduction during manufacturing process; H= less air emissions; I= less water emissions; J= lower energy consumption of the product during its use; K= fewer components to accelerate the dismantling and recycling; L= packaging consumption reduction per unit of product; M= use of recycled packaging materials; N= use of returnable packaging; O= fewer different packaging materials for more efficient recycling.

Fig. 1 The importance of environmental (ecodesign) criteria in the new product development process with regard on their priorities (1 – not important, 2 – less important, 3 – important, 4 – very important, 5 – extremely important)

These last criteria constitute a group of less important criteria together with a criterion 'reduced water use during manufacturing process'. At a first glance, it might seem surprising that 'reduction of material consumption' is given that high priority within sampled manufacturing enterprises. However, we can link that finding with a very recent report published by European Commission which objective was to investigate in more detail the behavior and attitudes of european SMEs towards the development and uptake of eco-innovations as a response to rising prices of natural resources and resource scarcity [8]. As follows, three quarters of businesses had experienced an increase in material costs in the past five years and 26 % of respondents said material costs for their company increased dramatically (for Slovenian SMEs such costs increased dramatically for 23 % of respondents and 43 % reported that material costs increased moderately).

Chemical and related industries seem to be more prone to consider the criteria regarding the process aspects like water and air emissions or efficient energy use. What is surprising is the fact the criterion 'replacement of toxic and hazardous substances' was given a higher priority for other two studied industrial branches than for chemical and related industries. One possible explanation is that in Slovene chemical industry such substitution already happened in greater extent before the period 2004-2009 which was taken into account in this research. The so-called 'Green Chemistry' is becoming a clear trend in global chemical industry and additional stimuli for chemical companies. The other reason why manufacturers of electrical equipment and household appliances consider substitution of toxic and hazardous substances as so important is the EU legislation which came into force during last years

and is directly related to that kind of products (Directive on waste electrical and electronic equipment, Ecodesign directive on energy-using products, Restriction of hazardous substances directive). That is probably the main driver for much higher importance of the criteria 'less components to accelerate the dismantling and recycling' and 'lower energy consumption of the product during its use' for manufacturers of electrical equipment and household appliances compared to the average. This last criterion already became very important aspects of market competitiveness for such products. As concluded from a study carried out by Tukker et al. [9], it seems that within major EU industries electronic industry distinguished as one of a leading branches regarding product ecodesign applications (together with motor vehicle and packaging industries) more than ten years ago. It is exactly in these sectors where strong pressure by EU environmental 'end-of-life' regulations was developed and put on force in recent years. On the other hand, 'increasing the content of recycled materials' seems to be relatively important in Slovene metal industry (Fig. 1). Comparing these finding with our previous results [10], it seems that recycling is getting more and more importance in metal industry. However, this cannot be claimed for industry in general. Most of the analyzed companies (44 %) obtained first certificate ISO 14001 in a year 2000 or earlier. Most companies within that group (28 %) obtained a certificate in a year 2000. Thirty-six percent of the firms acquired ISO 14001 certificate between 2001 and 2004, while 20 % of firms acquired it between 2005 and 2008. After implementing EMS according to ISO 14001, 9.1 % of certified responding enterprises considered ISO 14001 standard as a necessary condition for successful environmental product design, 38.2 % as a very useful tool, and 47.3 % expressed the opinion that ISO 14001 is just a useful tool while for 5 % of the firms this standard is not important at all (Fig. 2). The majority of respondents which consider ISO 14001 certification as very useful tool is from metal industry (62 %). Opposite, the majority of respondents which consider ISO 14001 certification as useful tool only is from chemical and related industries (89 %). In a previous study we investigated the significance of ISO 14001 for the adoption of new and/or modified technology in Slovene industry, and found that much higher percentage of respondent companies described ISO 14001 as a very useful tool (63 %) and only 1.4 % as not important tool at all [3]. Successful environmental product design often implies coordination between companies involved in different stages of product life-cycle, and close co-operation between different departments within one company, such as for instance the sales/marketing department, the purchasers of supplies/inputs and the design department. In addition, for strengthening the connection between EMS and environmental product design in future, it is expected that customer demands would have to become of crucial importance [2].

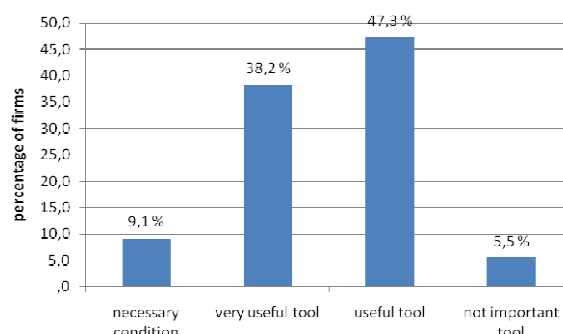
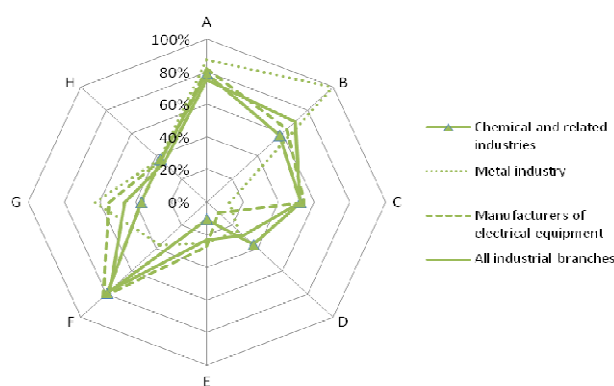


Fig. 2 Significance of ISO 14001 certification on ecodesign of new products

Fig. 3 shows which drivers (motivating factors) are considered by companies in their process of development of new products. It seems obvious that market drivers, together with legal requirements, play a leading role within product ecodesign activities. From answers obtained it seems that Slovene manufacturing firms try to follow (or are at least aware of) the importance of market changes towards the diffusion of environmentally sound products. Comparison of the cumulative (average) values with three selected industrial branches reveals certain characteristics. First, results show that firms operating in metal industry deviate for certain ecodesign drivers from average value for all industries as well as for the other two analyzed branches (Fig. 3). We can expose three ecodesign drivers, where the differences are obvious: first, firms in metal industry in much larger extent than average value refer to 'requirements of business partner' which is, together with 'legal requirements', the major new product development driver in metal industry. On the other hand, metal industry companies give 'expected improvement of company's image in public' and 'consumer demand' drivers the minor importance.



Legend: A = legal requirements, B = the requirements of business partners, C = consumer demand; D = expected improvement of company's image, E = reaction to the suppliers offer, F = increased competitive advantage, G = reducing costs for environmental protection, H = acceleration of innovation activities.

Fig. 3 Percentage of firms reporting on different drivers in new product ecodesign development

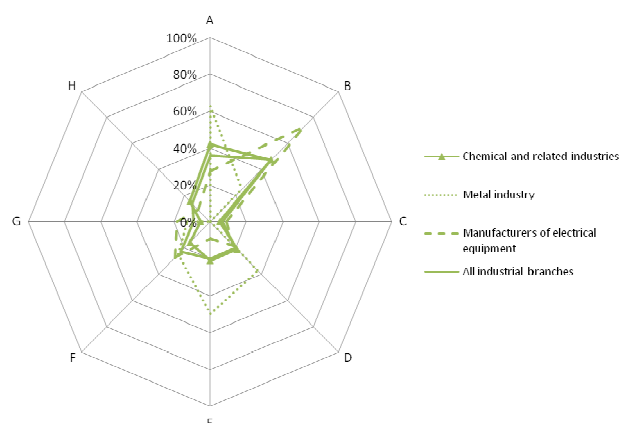
The most frequently stated ecodesign drivers for the development of new products in firms that manufacture electrical equipment and household appliances are: 'legal

requirements' (82 %) and 'increased competitive advantage' (82 %), followed by the 'requirements of business partners' (64 %) and 'consumer demand' (55 %). As mentioned earlier, the influential reason is the EU legislation which came into force during last years and is directly related to that kind of products. Less frequently quoted ecodesign drivers for these companies are 'reaction to the suppliers' offer' (27 %) and 'expected improvement of company's image in public' (9 %).

What is surprising is the fact that ecodesign activities did not accelerate innovation activities within the industrial companies to a higher extent. Namely, only 33.9 % of companies stated that consider this aspect among important drivers. The companies probably saw this driver as less relevant because the other types of drivers were predominant. Contrary to our findings, van Hemel and Cramer [5] reported in their study of Dutch manufacturing SMEs that the most influential internal drivers was innovational opportunities followed by increase of product quality. For comparison, in a very recent study of European SMEs it was reported that 25 % companies of that kind had introduced a new or significantly improved eco-innovative product on the market [8]. Knowing the fact that the great majority of chemical industry and manufacturers of electrical and electronic equipment are two of the most innovative branches in Slovenia, it is obvious that technological innovation within these industries is, in general, driven by other factors which (still) not give environmental aspects more stimulating priority.

Fig. 4 shows which barriers (obstacles) are perceived by companies in their process of development of new products. In general, the highest percentage of firms (48.2 %) perceive 'high development costs' as the most influential barrier factor in the process of environmentally more conscious product development. This is followed by 'insufficient demand' (35.7 %) and 'lack of specialized professional staff' (23.2 %). As the least problematic barrier 'insufficient support of company's top management' is quoted. Only 19.6 % of firms believe that their ecodesign process is impeded due to the 'lack of experiences and knowledge' and due to the 'lack of adequate professional informations' (19.7 %) and only 14.3 % of companies under the study mean that product development takes too much time.

The biggest difference among firms is revealed within this particular barrier aspect: namely, between companies in metal industries and those producing electrical equipment and household appliances. For the latter, 'high development costs' represent the most frequently stated barrier among all in their branch (73.0 %). Finally, firms operating in chemical and related industries are most frequently faced with 'high development costs' (47.0 %), 'insufficient demand' (42.0 %) and 'lack of adequate professional information in the process of developing environmentally sound products' (21.0 %) as barriers. In chemical and related industries not such extremes among barriers were observed as within other two selected industrial branches.



Legend: A = insufficient demand, B = high development costs, C = insufficient support of company's top management, D = lack of adequate professional information in the process of developing environmentally suitable products, E = lack of experiences and knowledge in the process of developing environmentally suitable products, F = lack of specialized professional staff, G = poor communication and interfunctional cooperation, H = product development takes too much time.

Fig. 4 Percentage of firms reporting on different barriers in new product ecodesign development

IV. CONCLUSION

From the results obtained, most Slovene manufacturing enterprises considered ISO 14001 standard as a very useful tool or at least a useful tool helping them to accelerate and establish product ecodesign activities within firms. Companies which acquired ISO 14001 earlier more intensively incorporate recycled materials into product development compared to those with shorter established environmental policy. In companies which acquired ISO 14001 certificate later (in a period 2005–2008) a criterion 'reduced energy consumption during the manufacturing process' is the most frequented criterion. Such policy is characteristic for the companies in the earlier stages of environmental policy where attention is focused mainly on the processes rather than on the products.

Although the studied companies claim that they use product ecodesign practices it seems that they mostly use certain restricted ecodesign approaches not based on the complete product life-cycle analysis. But at this point of research we restrained our investigation on a question which ecodesign criteria (defined and accepted by international scientific and professional community) enterprises consider as important in practice at all in Slovene manufacturing firms. We can imagine that different definitions and meanings of what product ecodesign means to different firms exist in Slovene industry. This dilemma of fully understanding of ecodesign in product development remains for the future research. We are also aware that significant differences among firms exist, not only regarding their size, but also regarding industrial sector and/or market orientation. In addition, the characteristics of their products vary.

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REFERENCES

- [1] ISO/DIS 14006 - Environmental management systems – Guidelines for incorporating ecodesign. International Standardization Organization, 2010.
- [2] J. Ammenberg and E. Sundin, "Products in environmental management systems: drivers, barriers and experiences," *Journal of Cleaner Production*, vol. 13, no. 4, pp. 405–415, 2005.
- [3] G. Radonjič and P. Tominc, "The impact and significance of ISO 14001 certification on the adoption of new technologies," *Management of Environmental Quality: An International Journal*, Vol. 17, no. 6, pp. 707–727, 2006.
- [4] M. Frei, "Eco-effective product design: the contribution of environmental management in designing sustainable products," *Journal of Sustainable Product Design*, vol. 7, pp. 16–25, Oct. 1998.
- [5] C. van Hemel and J. Cramer, "Barriers and stimuli for ecodesign in SMEs," *Journal of Cleaner Production*, vol. 10, no. 5, pp. 439–453, 2002.
- [6] Statistical Yearbook of the Republic of Slovenia 2010: Statistical Office of the Republic of Slovenia, Ljubljana, 2010.
- [7] M. Santolaria, J. Oliver-Solà, C. M. Gasol, T. Morales-Pinzón and J. Rieradevall, "Eco-design in innovation driven companies: perception, predictions and the main drivers of integration. The Spanish example," *Journal of Cleaner Production*, vol. 19, pp. 1315–1323, 2011.
- [8] EC Survey. Attitudes of European Entrepreneurs Towards Eco-innovation, Flash Eurobarometer 315. The Gallup Organization, March 2011, On line at: http://ec.europa.eu/public_opinion/flash/fl/fl_315_en.pdf.
- [9] A. Tukker, E. Haag and P. Eder, *Eco-design: European State of the Art*. An European Science and Technology Observatory project report, Seville: Joint Research Centre, 2000.
- [10] G. Radonjič and P. Tominc, "The role of environmental management system on introduction of new technologies in the metal and chemical/paper/plastics industries," *Journal of Cleaner Production*, vol. 15, no. 15, pp. 1482–1493, 2007.