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New products design decision making support by SimaPro software on the base of defective products management

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Abstract

The paper presents an analysis of usage the SimaPro 8 software as a tool supporting new products design decision making process on the base of defective products management. At first it briefly introduces the management of defective products concept, the specificity of design process, decision making process in case of new product design and the complexity of decisions necessary in case of designing new household goods. Then the importance of Life – Cycle – Assessment (LCA) is discussed together with presentation of SimaPro 8 software as a very useful tool for decision making in case of new household goods design on the base of information about defective products management. And finally the SimaPro 8 is presented with the practical use in case of washing machine product.
In general the paper implies the useful role of SimaPro 8 (as an IT solution example) in the processes of decision making for the companies dealing with design of new products and defective products that have to be managed properly.

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Keywords: Decision support, design, management of defective products, SimaPro 8 software, washing machine

1. Introduction

Defective products are present in modern economy for decades. They occurred in every kind of business, so to improve the company's performance it was necessary to define the proper manner of their management. For this purpose the concept of defective products management was developed. The main problem with management of defective products is the uncertainty and lack of information. In such cases the analysis of LCA might be useful. It

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allows to evaluate the materials used for product manufacturing and the whole cycle of product life. On the base with these information it is also possible to support the process of decision making in case of design new products. For this purpose the information from LCA can be used to create better features in new products and to design these products in the way that they will be able to be reuse after they will become the defective products. The very good solution for the information of LCA collection might be the SimaPro software. The paper aims to present the utility of IT software for supporting decision making process in case of new product design and to prove that information collected during the use of SimaPro8 software can effectively affect the design. Also, its goal is to show that data provided by SimaPro allows to develop such design that will make possible to avoid defective products in the future. And finally, it presents defective products as a valuable source of information that support decision making process for new product design.

2. The concept of management of defective products

Traditional management of new products is well-known in the literature, but there is a huge lack of information in case of defective products management. This is quite a big problem, because now when the policy of many companies allows for products return, the information for such problem solutions are required[1].

In general the management of defective products refers to managing products that flow into the system with reverse direction, so they come back from the market or other place that was their destiny (not necessary final)[2]. The literature often calls such products with the name of waste, but it is not correct, because these products still represent some value that might be use again[3].

Defective products can be divided into three groups by the point in the system where they come from: manufacturing point (e.g. raw material surplus, quality-control products and production left-overs), distribution point (product recalls, B2B commercial products, stock adjustments and distribution items) and market point (e.g. B2C commercial/reimbursement products, end-of-use products)[4].

Also defective products can be divided into five main categories: end-of-use products, commercial products, warranty products, production scrap and by-products, packaging[5].

The possible moments that products will become defective and will come back to the producer show up at distributor, vendor and as they are used by final consumer in warranty period, in non-warranty period and at the point of product life cycle end[6].

Management in the context of defective products relates to processes associated with quality and functional classification of these products, the decision making for their further allocation and the management manner together with submission of these products for operations aimed at maximizing the secondary value from recovery[7].

In general there are five main recovery options for defective products in management: repair – the aim is to return used products to working order, refurbishing – the aim is to bring used products up to a specified quality, remanufacturing – the aim is to bring used products up to quality standards that are as good as those for new products, cannibalization – the aim is to recover a limited set of reusable parts from used products or components, and recycling – the aim is to reuse materials from used products or components[8].

It is very important to notice here that the reverse logistics, mentioned a lot recently in the worldwide literature positions, is only a new sub-discipline of logistics management and is not equal to logistics management of defective products[9].

And it is crucial here to highlight the importance and valence of defective products as a source of information, especially the information about the reason why they become defective. On the base of such data it is possible to influence the decision making process for new products design in such way that defective products presence in the future will be reduced, minimized or even finally eliminated.

3. Decision-making processes for product design

The main goal of business performance in case of manufacturing companies is to introduce the new products on the market. With brief characteristics, product design starts with conducting preliminary studies involving the analysis of the worldwide existing products being within the sphere of project interest. This analysis covers the operating characteristics, structural characteristics, internal structure, costs and volume of production, manufacturing technologies, etc. The aim is to gather information about the products present on the market, their properties, size of the market, consumer preferences, etc. Then a couple of design concepts is created in the form of preliminary drawings, graphs or descriptions. Further the design assumptions are developing – defining what functions the product should meet, and that is the general idea of the product. It means to determine the shape and dimensions of the proposed product, the characteristics of the product functional properties (e.g. power, electricity or other resources use) and the limitations. Also, suitable materials are selected with specific physicochemical properties and technology. This step is to ensure the best operational and technical characteristics of the proposed product. After the operational design further design work shall be: a prototype (model designed to achieve the finished product), prototype testing (verification of design assumptions, observation, error detection, etc.), engineering design and development of executive and operational documentation (production possibility, cost estimate, operation, etc.). At this stage, the design (pattern) is introduced. The final step in designing a new product is to provide an information series of products. It allows to examine the behavior of new product in a variety of operating conditions after referring the products to selected groups of users. After the final analysis, followed by the introduction of any necessary adjustments, the product is implemented for regular production[10].

Even when the products are created very carefully, the companies always should expected the occurrence of some problems with their products, and then they should qualify them as defective. Such strategy, to take care not only for new products, but also for defective ones, has created the need for careful product design process and the right decision making during this stage.

The new trend is observed for product design, that assumes delivering to the market products with the possible minimal environmental burden during the whole life cycle, and also with the possibility of reuse after the end of its life. On this stage the decisions made lead to reduction of raw materials usage, the usage of environmental friendly materials, reduction of waste generated during the production processes, and to design the products with features enabling its reuse.

During the process of designing a new product it is necessary to predict the final outcome – that the introduced product will be accepted by final customers and will bring the expected benefits. The main problem here is the difficulty of future predicting on the base of current information. When making design decisions it is extremely important to accurate predict the market development and expectations of future users. During the design process there are taken countless number of decisions. The most important decisions are concerning the selection of design solutions variants, which have a major impact on design quality. Not all decisions are equally important, and not all have the same degree of difficulty and responsibility[11].

Design decision making process should include the following steps: selection criteria for the evaluation and prioritization of their validity, specifying the expected characteristics of the solution due to the specified criteria for the evaluation, comparison of the solutions based on their predicted characteristics and the selection of final solution[12].

Design decision making process has a goal to find such a solution variant that either affect the achievement of the best possible result for the specific measures used to achieve it, or leads to the minimization measures to achieve the objective[13].

Decisions made during the process of design are quantitative or qualitative, and also in decision-making should be kept in mind that the competition modifies its previous decisions and tries to predict the decisions taken by the competitors[14].

Household goods belong to the group of mechatronic products that contain in their structure elements of mechanics, automation, and information technology. Appropriate distribution of tasks between the design process specialists in the field of mechanics, and IT allows for acquisition a modern, fully specialized equipment, while maintaining the design process with as short time as possible.

The designer is responsible for finding a solution to a design problem, according to the assumptions made in detail at the stage of the product approach. In the case of household goods, the design of a new product may apply to the use of new materials, changes in size and appearance of the proposed device, the application of new technologies leading to lower power consumption and water consumption, and others. Decisions taken by the designers in the early stages of the design process are related to the determination of the requirements for the product under design. The most important decisions made by the designer in the subsequent stages of the design concern the selection of materials for individual elements. Determining the relationship between the product structure, technology process, and utility properties is critical to ensure the highest product durability with the lowest cost[10].

Important thing is the choice of the best connection of elements included in the device to ensure proper stiffness and the greatest durability, ensuring trouble-free functioning of the household goods.

Due to the special nature of household goods, necessary is an environmentally responsible approach to the design problem. Household goods, such as washing machines, have in their construction materials that at the time of products withdrawal from the use can have a detrimental impact on the environment[10]. Therefore, already at the design stage it should be ensured that these products were made in a way that provides the least possible harm to the environment when it is withdrawn from use.

And here extremely useful might be the software allowing for environmental impact of materials and products measure and evaluate. Such software is able to support decisions making process with the information necessary to predict life cycle of the product, and also various scenarios of possibilities to reuse the product when it becomes the defective product.

4. The use of SimaPro 8 software by the LCA evaluation to support design decisions in case of washing machine

Life cycle assessment (LCA) is a very useful tool for decision making in case new products design, and even is classified as a method for product design[15].

LCA is *"a technique to assess the environmental effects and resource costs associated with a product, process or service"*[16]. Generally this process takes from the beginning to the end, so from raw material source through production, distribution and consumption to the point where the materials return to the final end point. On that base it is possible to set products environmental impacts divided for each components[17].

SimaPro software[18] allows to collect, analyse and monitor the sustainability performance of products and services. It gives the possibility for easy modelling and to analyse complex life cycles in a systematic and transparent way, measure the environmental impact of products and services across all life cycle stages and identify the hotspots in all aspects of supply chain, from extraction of raw materials to manufacturing, distribution, use, and disposal.

The washing machine is a complex unit and its performance is affected by a various parameters such as water temperature, washing load, frequency of use, detergent used, which depend mainly on consumer preferences as well as the specifications of every washing machine[19].

For the research purpose the real case of washing machine was chosen. The device is marked with label X and at the end of its life it was classified as the defective product. The total life cycle of this product was 15 years and is shown on Fig. 1.

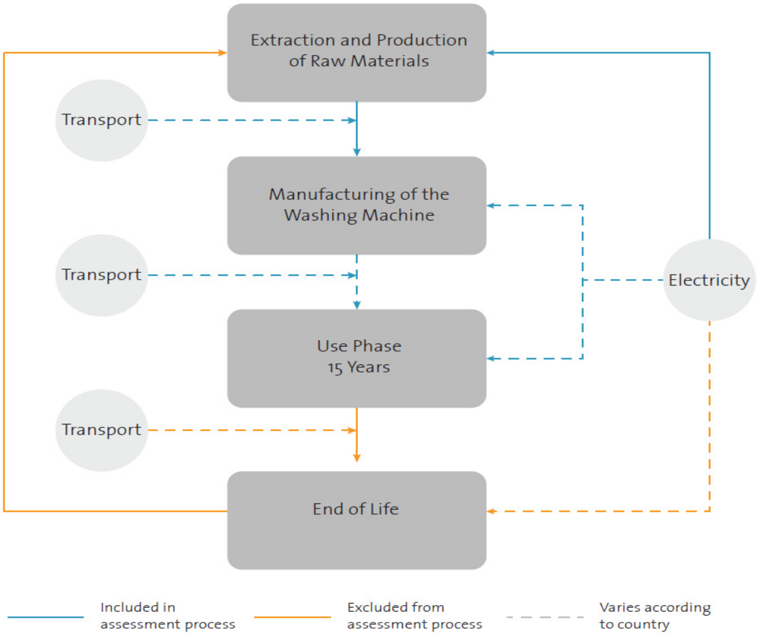


Fig. 1. Example of washing machine total life cycle[18].

The Fig. 1 presents the life cycle of X washing machine, classified at the end of life as defective product, and it is obvious that at the end of life this device still presents some value that can be reuse even in the form of raw materials. So for such purpose already at the stage of washing machine design it is possible to use information from LCA analysis to predict its further "life" when the product become defective one. And also for this analysis the best is to use the data provided by already existing defective product as washing machine X.

With the use of SimaPro 8 software it is possible to extract many detailed information about washing machine life cycle and environmental impact that are useful for design decision making process in case of household goods.

It is also so important, because most of household goods at some stage of their life cycle become the defective products, and because of it, they must be managed properly.

At first it is possible to check the materials used for washing machine X production (Fig. 2) in the form of graph, and also in tabular form (Fig. 3).

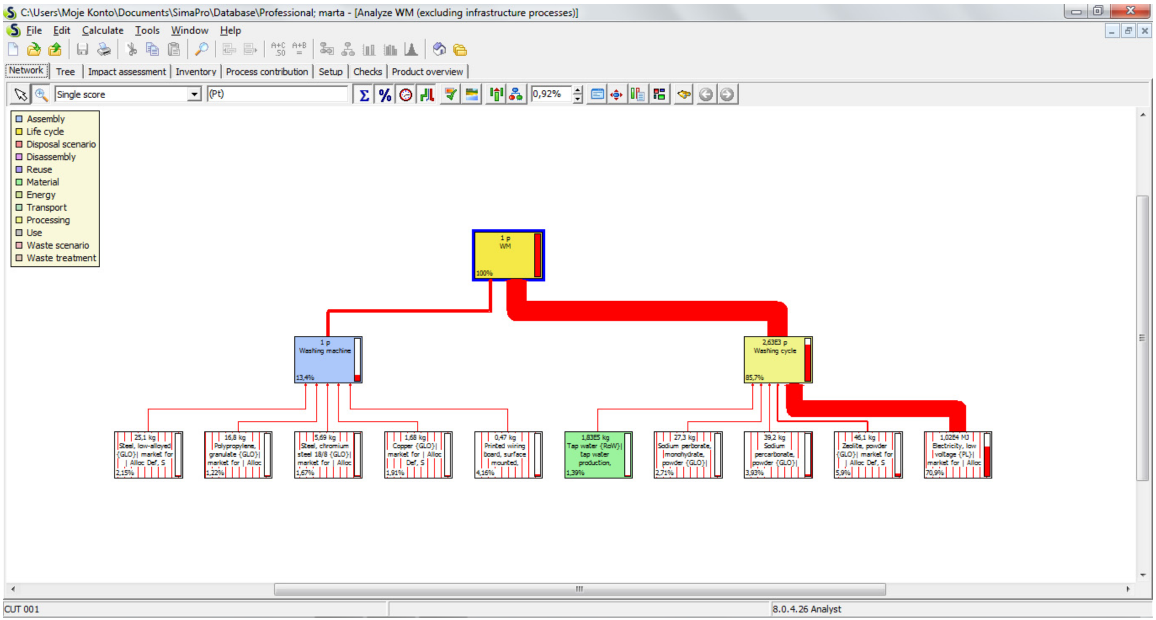


Fig. 2. Example of materials used for washing machine production in a graph form.

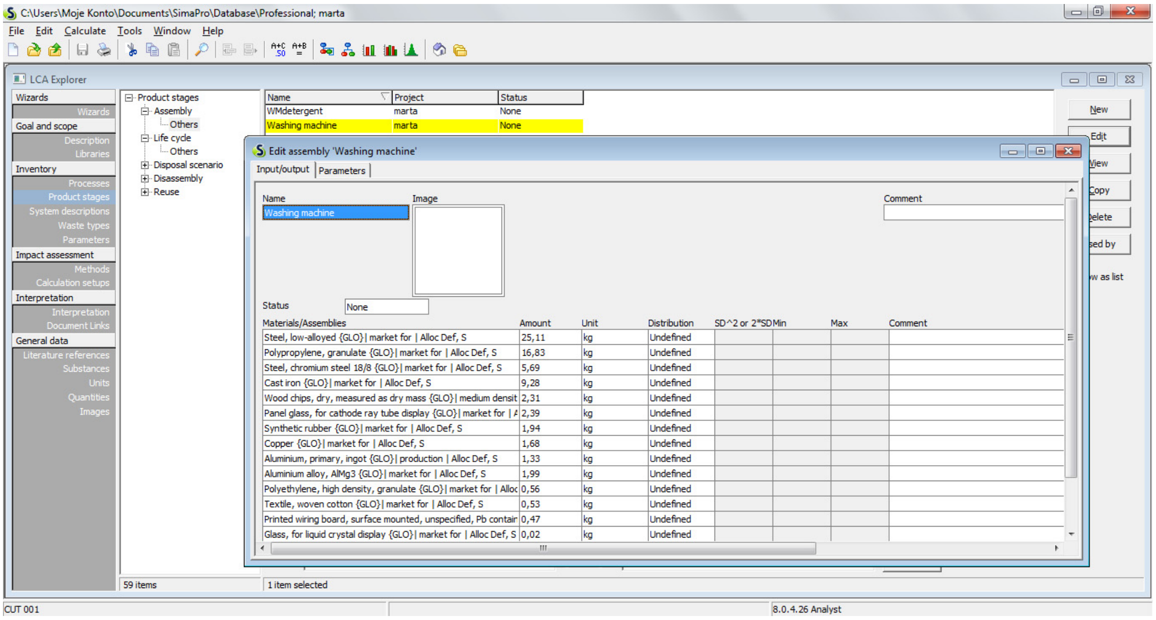


Fig. 3. Example of materials used for washing machine production in a tabular form.

SimaPro 8 also allows to present the tree of processes for washing machine X and its usage for 15 years (Fig. 4).

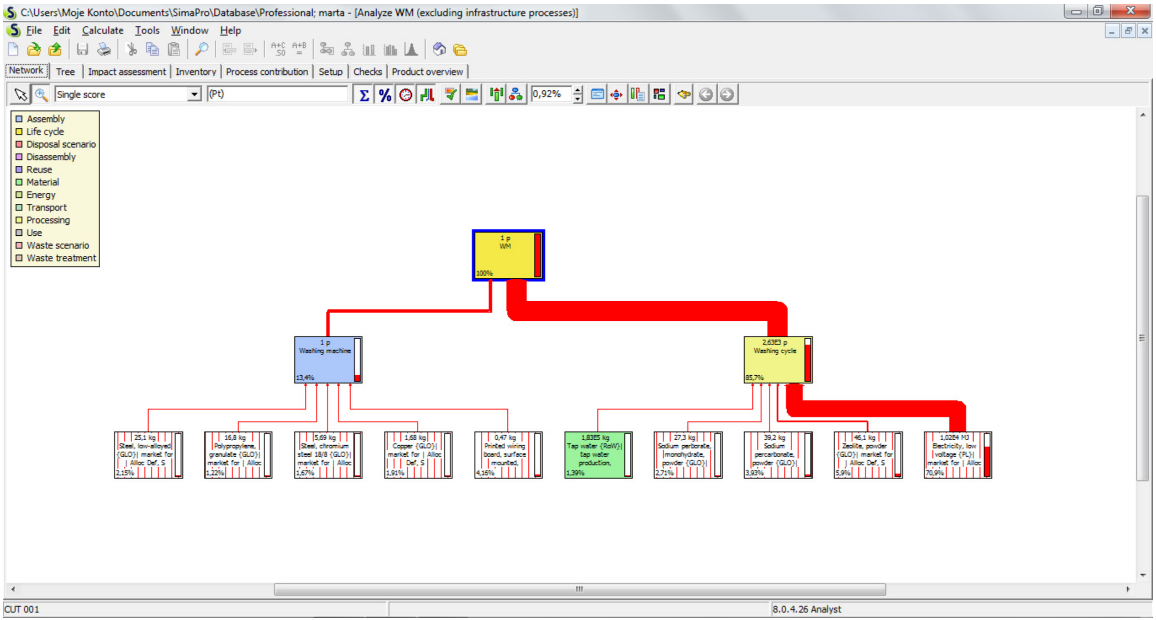


Fig. 4. Example of processes tree for washing machine and its usage for 15 years.

The normalized indicators of harms (Fig. 5).

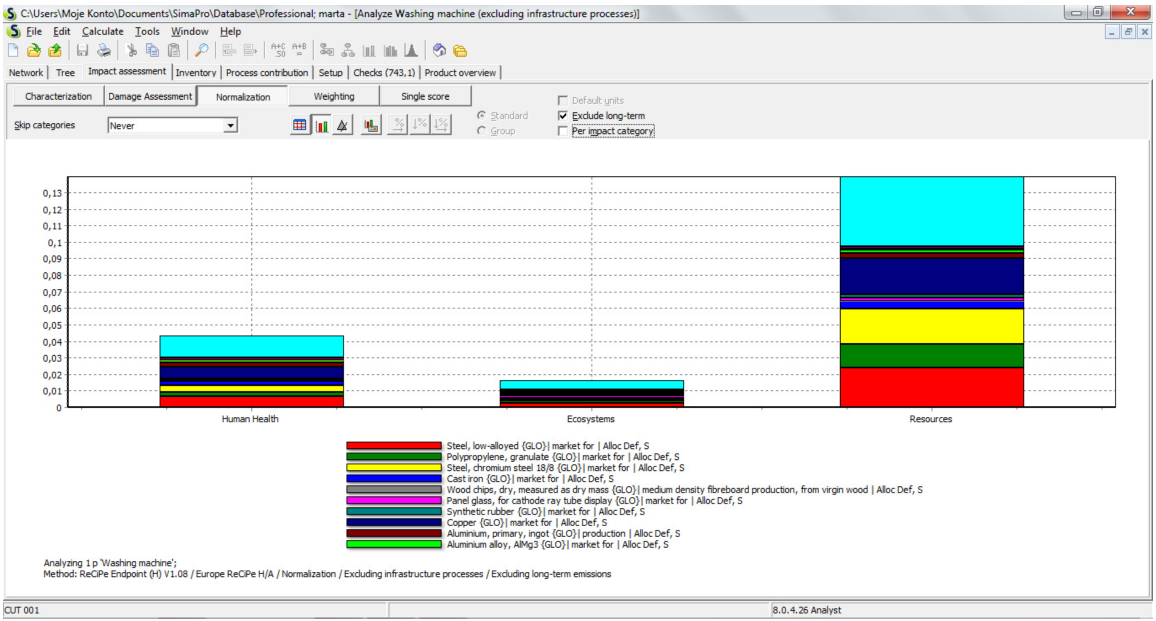
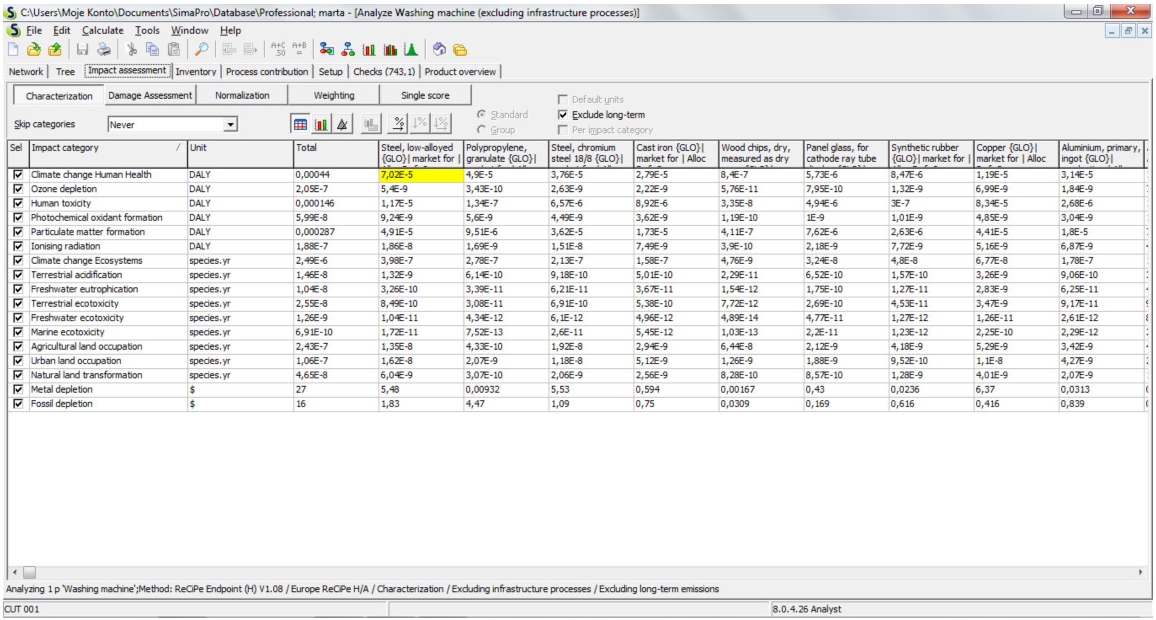


Fig. 5. Normalized indicators of harms the washing machine materials to the sustainablility.

And finally the impact indicators ReCiPe for washing machine (Fig. 6).



Sel	Impact category	Unit	Total	Steel, low-alloyed {GLO}| market for |	Polypropylene, granulate {GLO}|	Steel, chromium steel 18/8 {GLO}|	Cast iron {GLO}| market for | Alloc	Wood chips, dry, measured as dry	Panel glass, for cathode ray tube	Synthetic rubber {GLO}| market for |	Copper {GLO}| market for | Alloc	Aluminium, primary, ingot {GLO}|
☑	Climate change Human Health	DALY	0,00044	7,02E-5	4,9E-5	3,76E-5	2,79E-5	8,4E-7	5,73E-6	8,47E-6	1,19E-5	3,14E-5
☑	Ozone depletion	DALY	2,05E-7	5,4E-9	3,43E-10	2,63E-9	2,22E-9	5,76E-11	7,95E-10	1,32E-9	6,99E-9	1,84E-9
☑	Human toxicity	DALY	0,000146	1,17E-5	1,34E-7	6,57E-6	8,92E-6	3,35E-8	4,94E-6	3E-7	8,34E-5	2,68E-6
☑	Photochemical oxidant formation	DALY	5,99E-8	9,24E-9	5,6E-9	4,49E-9	3,62E-9	1,19E-10	1E-9	1,01E-9	4,85E-9	3,04E-9
☑	Particulate matter formation	DALY	0,000287	4,91E-5	9,51E-6	3,62E-5	1,73E-5	4,11E-7	7,62E-6	2,63E-6	4,41E-5	1,8E-5
☑	Ionising radiation	DALY	1,88E-7	1,86E-8	1,69E-9	1,51E-8	7,49E-9	3,9E-10	2,18E-9	7,72E-9	5,16E-9	6,87E-9
☑	Climate change Ecosystems	species.yr	2,49E-6	3,98E-7	2,78E-7	2,13E-7	1,58E-7	4,76E-9	3,24E-8	4,8E-8	6,77E-8	1,78E-7
☑	Terrestrial acidification	species.yr	1,46E-8	1,32E-9	6,14E-10	9,18E-10	5,01E-10	2,29E-11	6,52E-10	1,57E-10	3,26E-9	9,06E-10
☑	Freshwater eutrophication	species.yr	1,04E-8	3,26E-10	3,39E-11	6,21E-11	3,67E-11	1,54E-12	1,75E-10	1,27E-11	2,83E-9	6,25E-11
☑	Terrestrial ecotoxicity	species.yr	2,55E-8	8,49E-10	3,08E-11	6,91E-10	5,38E-10	7,72E-12	2,69E-10	4,53E-11	3,47E-9	9,17E-11
☑	Freshwater ecotoxicity	species.yr	1,26E-9	1,04E-11	4,34E-12	6,1E-12	4,96E-12	4,89E-14	4,77E-11	1,27E-12	1,26E-11	2,61E-12
☑	Marine ecotoxicity	species.yr	6,91E-10	1,72E-11	7,52E-13	2,6E-11	5,45E-12	1,03E-13	2,2E-11	1,23E-12	2,25E-10	2,29E-12
☑	Agricultural land occupation	species.yr	2,43E-7	1,35E-8	4,33E-10	1,92E-8	2,94E-9	6,44E-8	2,12E-9	4,18E-9	5,29E-9	3,42E-9
☑	Urban land occupation	species.yr	1,06E-7	1,62E-8	2,07E-9	1,18E-8	5,12E-9	1,26E-9	1,88E-9	9,52E-10	1,1E-8	4,27E-9
☑	Natural land transformation	species.yr	4,65E-8	6,04E-9	3,07E-10	2,06E-9	2,56E-9	8,28E-10	8,57E-10	1,28E-9	4,01E-9	2,07E-9
☑	Metal depletion	$	27	5,48	0,00932	5,53	0,594	0,00167	0,43	0,0236	6,37	0,0313
☑	Fossil depletion	$	16	1,83	4,47	1,09	0,75	0,0309	0,169	0,616	0,416	0,839

Fig. 6. Impact indicators ReCiPe for washing machine.

All presented figures highlight how many information it is possible to be received about the washing machine X by the usage of SimaPro 8 software. And also how useful can be the data extracted from existing defective product. For the design of new products the key information for the start is to collect as many as possible data about similar products existing on the markets. Many design decisions depend on the available data, so at is shown on the figures, SimaPro 8 delivers a lot of useful information for the design process. For example based on these information it is possible to analyze the materials used for washing machine X production, and for the new product choose these ones that have the lowest harmful impact on natural environment. Also on the base of these data it is possible to predict the future life cycle of the product and already at the stage of design to define the future scenarios for the product reuse at the moment when it will become the defective one.

SimaPro software is a very effective IT tool that supports decision making, especially in case of new products design on the base of defective products management. It has many features supporting decision making process that are extremely useful for design, so it should be promoted to large group of manufacturing companies as an excellent solution for their business.

5. Summary and conclusions

The paper`s aim was to present the support of new products design decisions making with the use of SimaPro 8 software. With the brief presentation of the theoretical concept of defective products management, design process and decision making process in case of new products design, it was possible to create the general view for them as the complex, difficult and with multiple decisions processes. The goal here was to highlight the necessity of support these processes, and because now the technology is high developed, it is possible to use for this purpose the IT solutions. To present the case the washing machine X example was presented. It was with the purpose to show the defective product and the information provided by its LCA analysis. The general idea was to discuss how defective product with the usage of LCA analysis by SimaPro 8 software can positively affect the decision making process in case of new product design. On this base it became possible to prove, that such software is useful for decision making process support in case of new products design. The information collected in this way can be the base for the new, better products. In general the paper also proved that the IT support is very effective in these cases and it should be used widely in the manufacturing business, together with defective products as a valuable source of data.

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References

1. Wieser P, Perret FL, Jaffeux C. *Essentials of logistics & management. The global supply chain*. 3 edition, EPEL Press, Lausanne, 2012.
1. Bardi E, Coyle J, Langley J. *Zarządzanie logistyczne*. PWE, Warszawa, 2010.
2. Grant D. *Logistics management*. Pearson Education Limited, Edinburgh, 2012.
3. Ait-Kadi D, Chouinard M, Marcotte S, Riopel D. *Sustainable reverse logistics network. Engineering and management*. Wiley & Sons, London, 2012.
4. Grant D, Trautrims A, Wong ChY. *Sustainable logistics and supply chain management. Principles and practices for sustainable operations and management*. Kogan Page, London, 2014.
5. Blanchard BS. *Logistics engineering and management*. Pearson New International Edition, Edinburgh, 2014.
6. Harrison A, van Hoek R, Skipworth H. *Logistics management and strategy. Competiting through the supply chain*. 5th edition, Pearson Education Limited, 2014.
7. Orumwense J. *Strategic Procurement and Logistics Management in the 21st Century*. LAP Lambert Academic Publishing AG & Co KG, 2012.
8. Starostka-Patyk M, Nitkiewicz T. LCA Approach to Management of Defective Products in Reverse Logistics Channels. In Proceedings of *3rd International Conference on Advanced Logistics and Transport* (ICALT'2014). 1-3 May, 2014, Hammamet, Tunisia, 2014.
9. Weiss Z, Dostatni E. Decyzje podejmowane w procesie projektowania wyrobu uwzględniające recykling. www.ptzp.org.pl/files/konferencje/kzz/artyk_pdf_2011/107.pdf viewed on 25 February 2015.
10. Zsambok CE, Klein G. *Naturalistic decision making*. Psychology Press, London, 2014.
11. Taho Y, Hung ChCh. Multiple-attribute decision making methods for plant layout design problem. *Robotics and computer-integrated manufacturing* 2007; 23.1: 126-137.
12. Wang G, Huang SH, Dismukes JP. Product-driven supply chain selection using integrated multi-criteria decision-making methodology. *International journal of production economics* 2004; 91.1: 1-15.
13. Saaty TL. *Fundamentals of decision making and priority theory with the analytic hierarchy process*. Rws Publications, Washington DC, 2000.
14. Ilgin MA, Gupta SM. Environmentally conscious manufacturing and product recovery (ECMPRO): A review of the state of the art. *Journal of Environmental Management* 2010; 91:563–591.
15. Environment Protection Agency (EPA). *Life cycle assessment: Principles and practice*. EPA/600/R-06/060, May 2006.
16. Browne M, Rizet C, Anderson S. Life cycle assessment in the supply chain: a review and case study. *Transport Reviews* 2005; 25 (6): 761-782.
17. http://www.pre-sustainability.com viewed on 21 February 2015.
18. *Washing Machine – sustainability report*. Swiss Federal Institiut of Technology, Zurich, 2011.