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STUDIES REGARDING THE USE OF RECLAIMED WOOD IN THE MANUFACTURE OF MODERN FURNITURE – PART II

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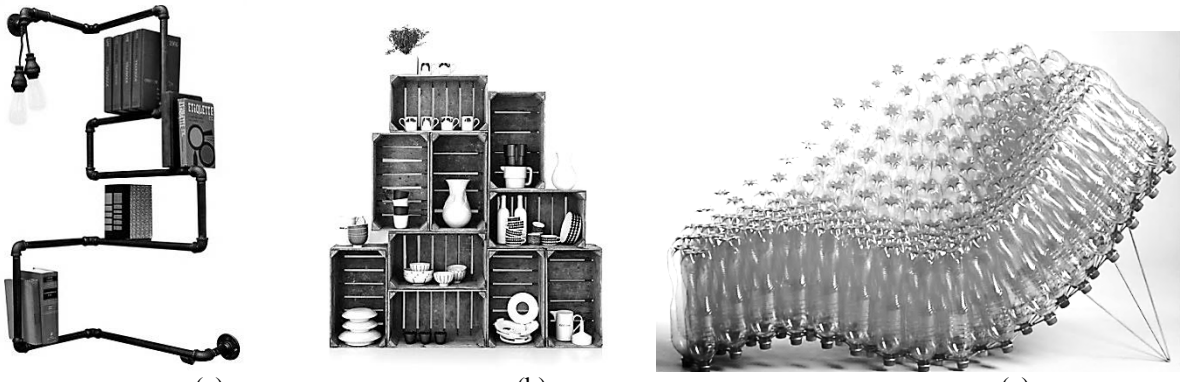
Abstract: *This paper represents the second part of a complex study regarding the possibilities to use reclaimed wood as a raw material in the furniture industry as replacement for new wood. The authors of this paper wish to highlight the issues related to the environmental costs of such an approach, by using Life Cycle Analysis. The study is based on two different versions of the same product – one using new materials vs. one using reclaimed materials - and seeks to determine the major sustainability issues at product level. These are translated into environmental costs generated by each version during their projected life cycle and the end of life scenarios, contributing to a more robust and forward thinking product design in the furniture industry.*

Key words: *Furniture, sustainability, reclaimed wood, life cycle analysis.*

1. INTRODUCTION AND GENERAL CONSIDERATIONS

Even if we speak of a smaller variety, there are however furniture products attesting the approach of using reclaimed materials in one way or another. Thus, according to their use in the manufacture of furniture, salvaged materials may be classified into the following two main categories:

A. Reclaimed assemblies and assembly components that will become parts or even stand-alone products without a further alteration of their shape or size (Figure 1); at most, depending on their origin and state of deterioration, these structures will be subjected to one or more treatment processes such as cleaning, grinding, surface treatment and / or painting. It can be said that the great majority of such examples fall into the so-called category of up-cycling. It should be noted that, with regard to this type of furniture products, the emphasis is on the aesthetic function of the products and it reveals a clear desire to send the user a message on the origin of the materials used. One may say that, most often, precisely



(a) (b) (c)

Fig. 1. a) Bookcase made of recovered steel pipes [1]; b) Reuse of wooden boxes as a set of shelves [2]; c) Armchair made of reclaimed plastic bottles [3]

this antique and obsolete appearance of a product is the main attraction element, whereby the user perceives the history of the product, its uniqueness and value added factor.

B. Reclaimed assemblies and assembly components that will become parts or stand-alone products following their passing through a series of treatments intended to interfere with their shape, structure and overall dimensions (Figure 2). The majority of these materials are subjected to a recycling process, which is aimed at delivering a well finished product that does not transmit clearly the place of origin of the materials used, the latter being an element communicated to the user by the manufacturer. As with the first category described above, this information is targeting those particular qualities perceived by the user in regard to the purchased product that relate to sustainability, environmental care and the value-added factor provided by its history.

The choice of using reclaimed materials in the manufacture of a new furniture product should not affect its quality. For this reason, quality assurance for products made from reclaimed materials should start from the identification of the main risk factors [7], to which a furniture manufacturer willing to choose such a resource is subject to. Another equally important criterion in this matter is the cost, ie the total amount of expenditure necessary for the identification of such a resource, as well as for the recovery, preparation, processing and finally, the use of the reclaimed material.

Wood is classified as an organic material and therefore it is subject to biological and chemical degradation over time [8]. In addition to these possible factors of degradation, depending on the origin and purpose previously served, recovered wood may also be damaged as a result of building and merging elements that it has incorporated up until its recovery (eg. nails). In this respect, there are a number of studies regarding the possibilities of reusing the timber that has already been used for a long time, based on its physical properties [9].The great majority of these studies are based on complex testing methods or require specific knowledge in materials resistance.

However, the testing of the physical properties of reclaimed wood does not prevent its use among furniture manufacturers as much as the lack of clear predictions regarding the risks and environmental costs arising from the use of such materials.

2. THE ANALYSIS OF ENVIRONMENTAL COSTS REGARDING THE USE OF RECLAIMED WOOD IN THE MANUFACTURE OF FURNITURE

The product used for the analysis is the lounge chair presented in the figure below:

Fig. 3. Lounge chair designed for outdoor areas

In order to assess the environmental costs regarding the two product versions, the authors decided to use as a tool for conducting the comparative study the Life Cycle Analysis (LCA) through SimaPro software, version number 8.0.3.14.

Life Cycle Analysis is a tool for quantifying the environmental performance of a product in the light of all its life cycle stages, starting from the point where the raw materials are being obtained and ending with its final disposal, including various end of life scenarios, such as recycling [10]. Although its applications provide answers regarding issues concerning the various ways to improve a product by identifying those key points of its life cycle that contribute significantly to the environmental load, the reason for choosing the LCA in this paper is to obtain a comparison between the two embodiments of the chosen product, in terms of environmental costs that could be

generated by the life cycle stages of each version in part, according to the choice of materials.

For the lounge chair from freshly harvested timber by means of forestry processes, modeling the life cycle will include all the processes necessary to obtain the raw material, to the point where it will be processed according to the design specifications of the product. According to the LCA simulation in SimaPro software, all these processes should include within the specification corresponding to each process, the following matters:

- amount of raw materials extracted from the forest and emissions released into the environment during this procedure; these emissions refer to both the amount of wood believed to be useless and which will remain in the forest at the end of the process, as well as the amount of polluting compounds resulting from the use of wood cutting machines;
- transport to the enclosure where the feedstock will be processed and the resulting emissions from this process, namely the polluting agents released into the environment over the whole route by the transportation vehicle, as well as the environmental impact resulting from the processes of obtaining the fuel required for this process;
- amount of raw materials resulting from the wood processing in the form of planks and emissions associated with this process; these emissions include the amount of wood resulted in the form of bark and wood chips due to the slicing process, compounds of pollutants released into the environment, as well as the amount of electricity used during this process;
- heat energy used by the kiln for the drying process of wood and the amount of emissions released to the environment during this process; it should be noted that, at this stage, the environmental impact can be significantly reduced by opting for the use of wood resulted in the form of bark and chips during slicing, in order to generate the heat energy required by the drying process.

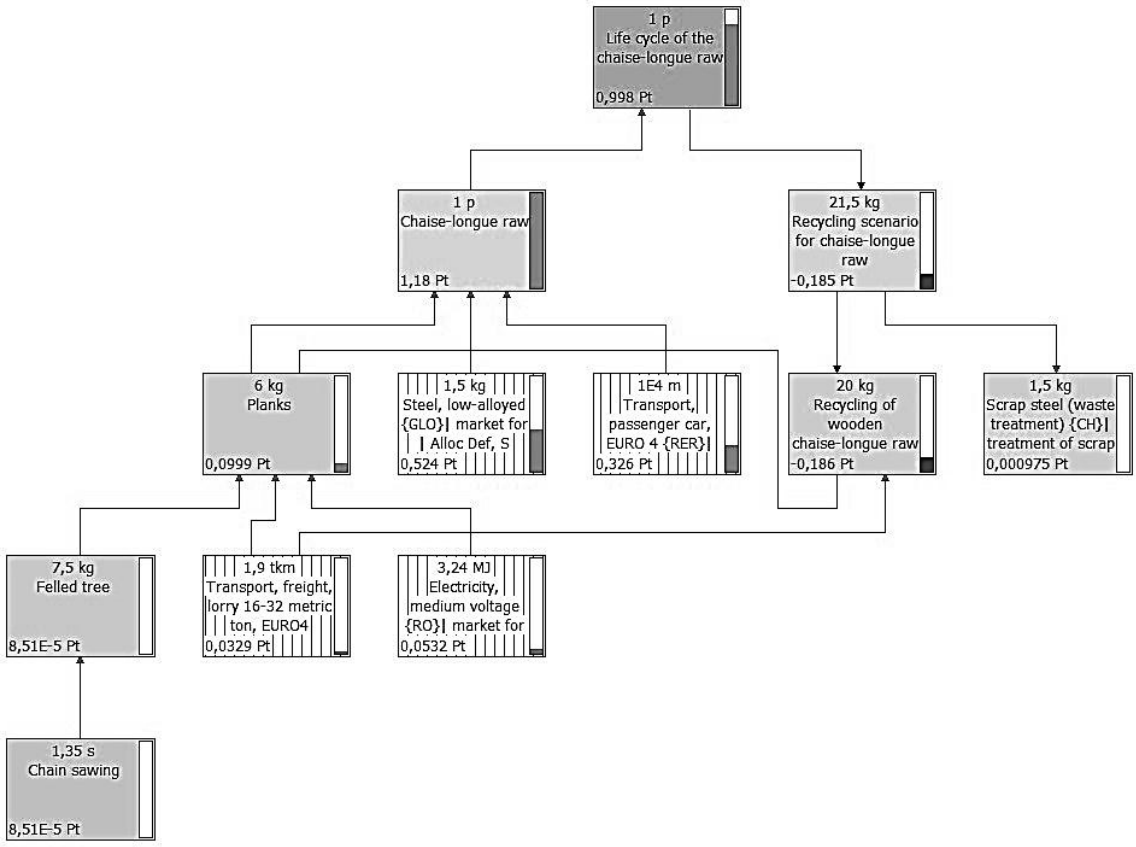


Fig. 4. Life cycle modeling for the lounge chair made from new materials

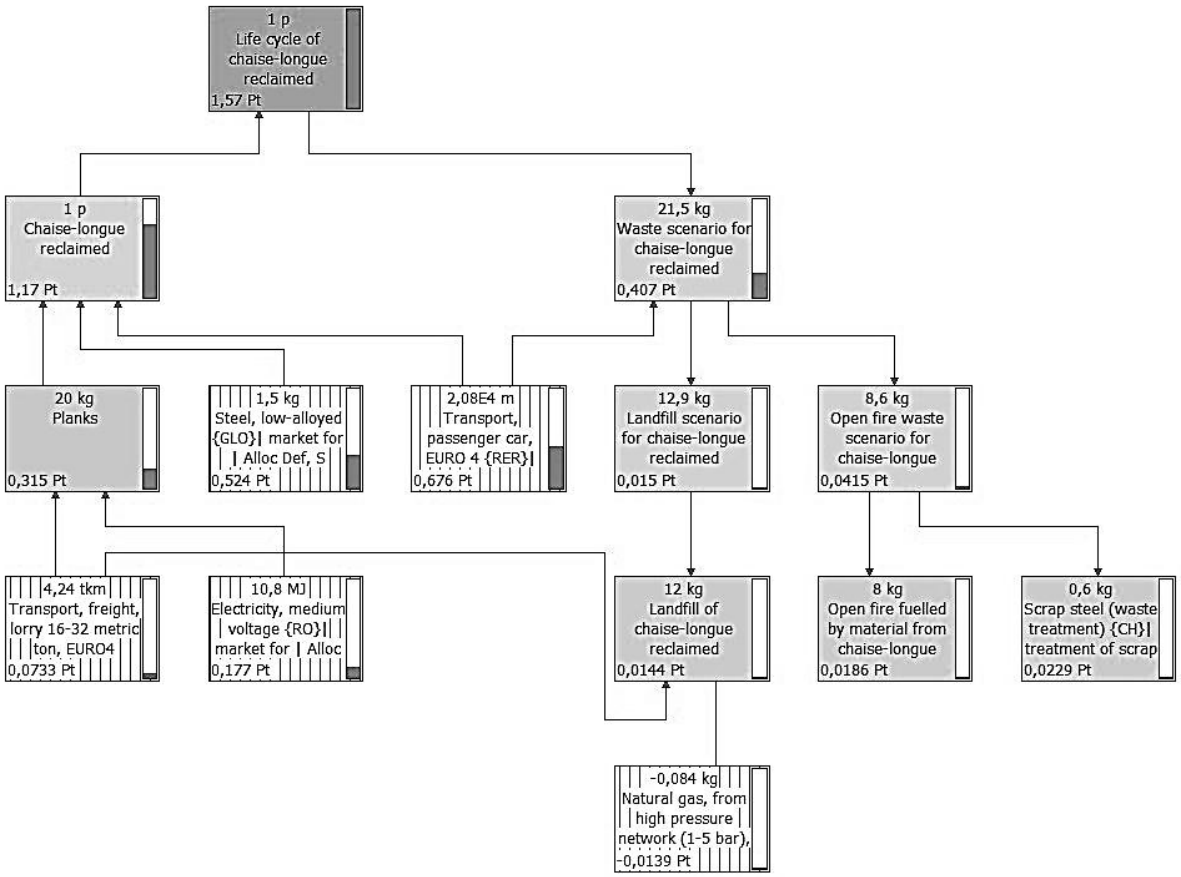


Fig. 5. Life cycle modeling for the lounge chair made from reclaimed wood

In a similar manner, the LCA simulation for the product version made of reclaimed wood will include all the processes necessary to produce the raw materials up until the stage where these can be used to manufacture the product according to its design specifications. Given the origin of the material used, the modeling of the life stages for this product version is considerably reduced compared to the case described above, due to the lack of the stage regarding the procurement of the raw material through industrial means. Thus, the first stage of the life cycle for the lounge chair using reclaimed wood consists of the processing of the salvaged material, with all the necessary related environmental specifications, as described above. It is easy to see that in this point of comparison between the two versions, the product made from reclaimed wood has the advantage of a lower environmental impact on the environment.

Further, modeling the lifecycle for both versions excludes all those stages relating to the actual manufacturing process of the product, its commissioning on the market and its period of use, and continues with the depiction of the product's end of life scenarios. The reason for such an approach, consists of the authors desire to simplify the analysis, by pointing out only those stages of the life cycle that may show the differences between the two versions of the product.

Regarding the modeling phase of a product's end of life, SimaPro software provides a wide variety of scenarios that include both the possibility of its full dismantling, as well as its recycling and / or reuse in various percentage combinations. For the present comparison, the authors have resorted to different scenarios, one for each of the two product versions. The scenarios were chosen based on the type of materials used for the manufacturing of the seat, namely the origin of the wood used. Thus, for the lounge chair made from new materials, the proposed scenario for the final stage of the life cycle consists in the recycling of 80% of

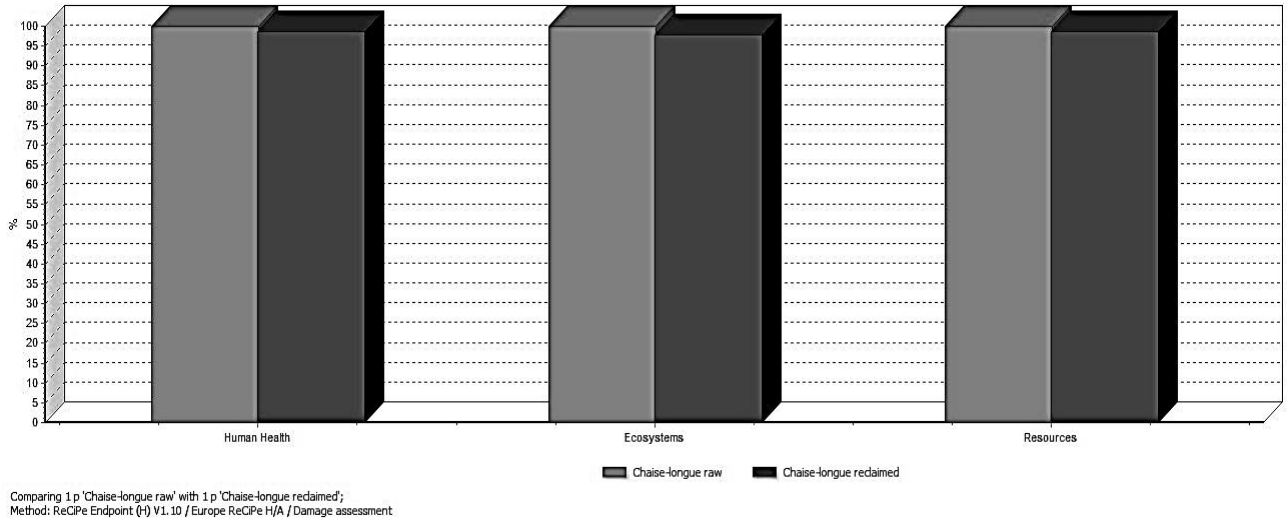


Fig. 6. A comparison between the two versions of the same product in terms of three main impact categories: human health, ecosystems and natural resources

the wood used for the seat and incineration at a specially designated area for the remaining of 20%.

The choice for such a scenario is based both on the idea of promoting sustainability, as well as on the assumption that the recycled material in this scenario is only at the end of its first life cycle, having yet an unexploited potential of value. On the contrary, for the second version of the product, the proposed scenario for the reclaimed wood, which is at least at its second use, has excluded any form of recycling; instead, the entire amount of salvaged wood components of the seat are intended for incineration in a specially designated area for waste handling. The reason for choosing incineration is due to a lower environmental impact regarding the amount of emissions emitted during this process, as opposed to emissions from natural decomposition of wood, noting that the specially designated area for incineration is provided with a system for methane collection that will be subsequently used as a fuel gas in other industrial processes.

The sequence and the components of the life cycle stages for the two product versions are illustrated as a network of interconnected boxes known as the Life Cycle Inventory Assessment

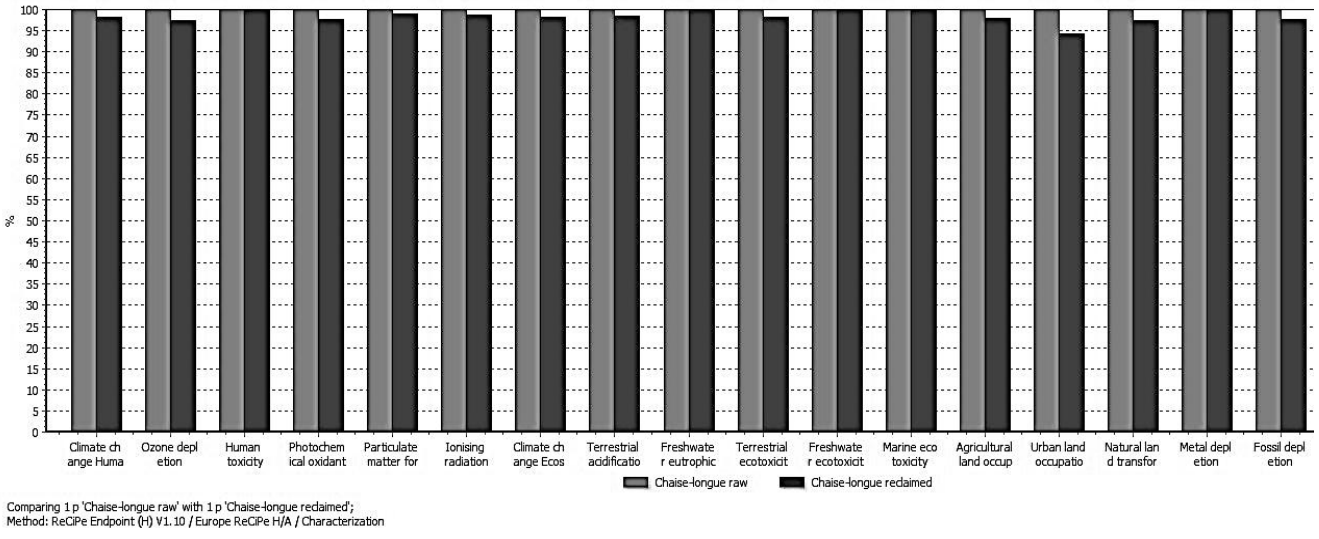


Fig. 7. A detailed comparison between the two versions of the same product in terms of the three main impact categories - The comparative characterization graph

(LCIA) (Figures 4 and 5). The scale within each box represent the environmental impact of the process or the raw material used, depending on the parameters specified when modeling the life cycle.

Further, for the conversion of the two sets of inventory data regarding the environmental impact, the authors have chosen as a valuation method an analytical tool often used by SimaPro users, namely ReCiPe Endpoint (H). The aim of this method is to convert the inventory generated in the first part of the analysis into three main categories of performance indicators that are easily interpreted, as follows: the impact on human health, ecosystems and natural resources. In this regard, Figure 6 shows a comparison between the two product versions based on three main categories of impact, while Figure 4 provides a more detailed view thereof. Moreover, the graph in Figure 5 renders the general damage for each product version by the summation of the three impact categories mentioned above.

Both the graphs in Figure 6, as well as the one in Figure 7, are using the same comparative principle according to which the product version with the greatest environmental impact becomes a standard for the second product version, whose impact is shown in percentages and in relation to the established standard impact.

According to the results provided by SimaPro, the difference between the two versions of the same product is relatively small, with a lower impact on the environment in the case of the lounge chair made from reclaimed wood. The closeness in the percentages of impact values between the two versions is largely due to the different scenarios chosen for modeling the end of life stages of the products. The scenario in which it has been considered the option of recycling, at the expense of incineration, has inclined the balance in favor of the product made from entirely new materials.

However, according to the characterization graph generated by the SimaPro software (Figure 7), it can be easily noticed that the greatest difference regarding the environmental damage - of 6% - is scored within the urban land occupation category in favor of the product version made from reclaimed wood. It is in fact the only percentage situated below the value of 95%, while the remaining differences between the two versions are ranging between 0 and 3%, also in favor of the product using reclaimed wood, as follows:

- the level of *ozone depletion* and the impact on *natural land transformation* located at a rate of 97% compared to the standard impact (determined by the version made exclusively of new materials);
- the level of *photochemical oxidant*, the impact on *agricultural land occupation*, as well as the level of *fossil depletion* located

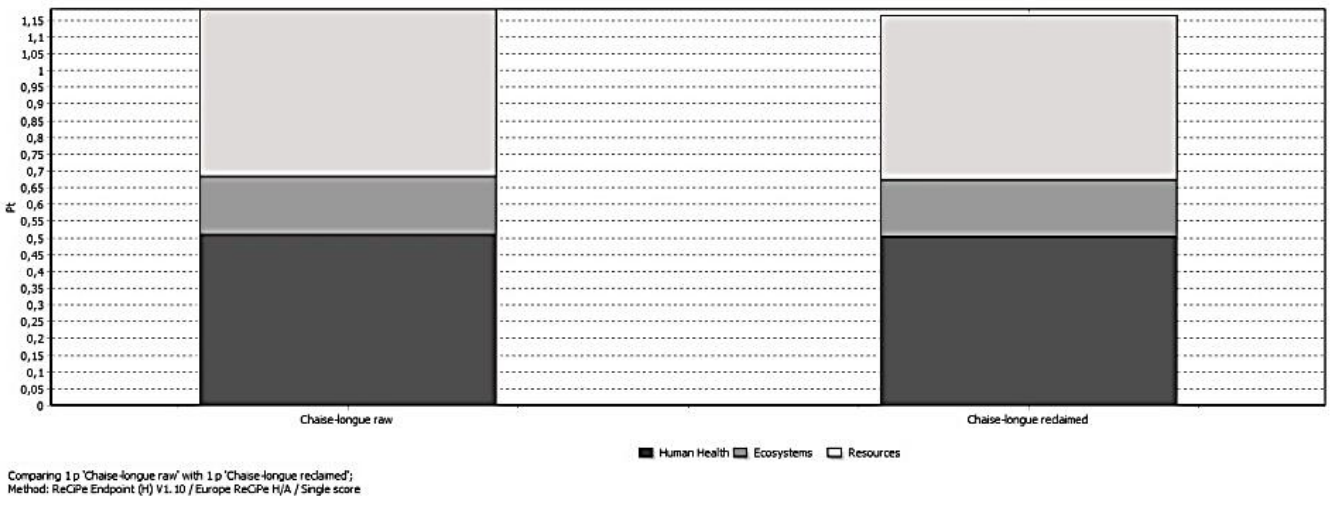


Fig. 8. A comparison of the two versions of the product in which the overall environmental impact is comprised of the percentages of the three main impact categories

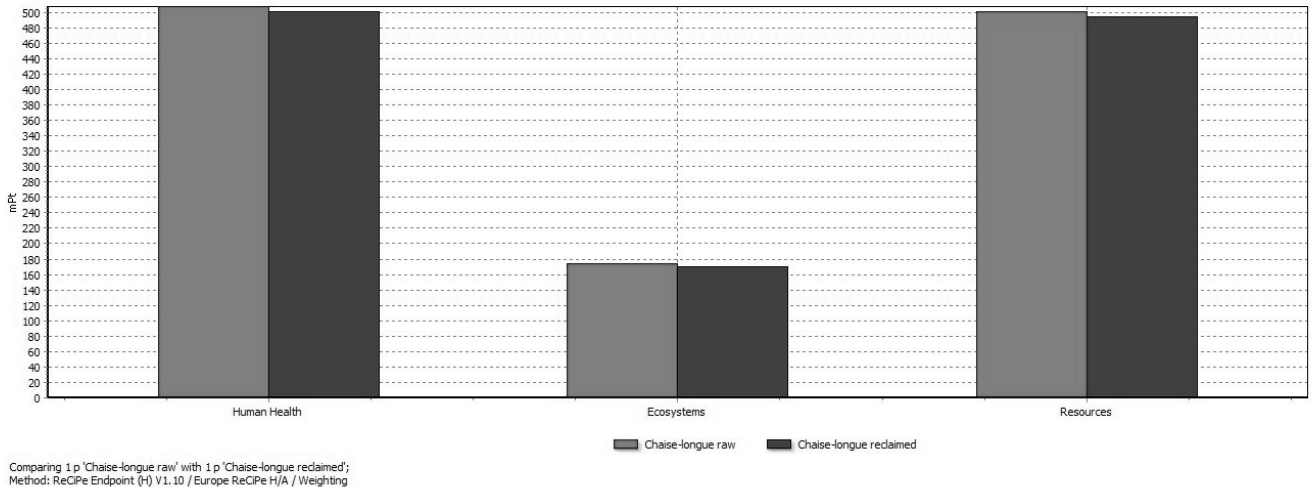


Fig. 9. Comparative analysis of the two product versions based on the weight of effects

at a rate of 98% of the standard impact;

- the impact on *climate change* – both in human health and ecosystems, as well as the level of *terrestrial acidification* and *eco-toxicity* located at a percentage of 98,5% compared to the standard impact.

According to the above results, it can be said that the mere use of recovered wood for the manufacturing of the analyzed product contributes significantly to the overall reduction of environmental impact for this product version. However, it should be noted that in some categories, such as the one regarding human toxicity and those referring to aquatic ecosystems, both products have generated similar results.

The weight of the three impact categories in relation to the total damage is shown in Figure 8, while Figure 9 shows the weight of these categories relative to themselves. In this sense, one can easily notice that the weight of effects for the impact categories regarding human health and natural resources is almost equal in value, but these categories are more prejudiced than the ones concerning the ecosystems. In the case of this diagram, as well as in those previously shown, the differences regarding the environmental impact for the two product versions are easy to observe.

4. CONCLUSION

For the studied situation, in terms of LCA, whose purpose was to compare the environmental impact of the two product versions, the results have tipped the balance in favor of the product made from reclaimed wood. Although the closeness in percentages of impact values between the two versions (where the lounge chair made of reclaimed wood did not manage to score a greater difference than 6% compared to the conventional version), it is largely due to the different end of life scenarios projected for the two products, it is worth noting that the mere use of reclaimed wood contributes significantly to the overall reduction of the environmental impact.

In conclusion, one can say that the LCA complements in good way the risk analysis presented in the first part of the study and helps the company to make better decisions.

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Studii privind utilizarea lemnului recuperat la fabricarea mobilierului modern - Partea a II-a

Abstract: *Această lucrare reprezintă a doua parte a unui studiu complex privind posibilităţile de utilizare a lemnului recuperat ca materie primă în industria mobilei în locul lemnului nou. Autorii acestei lucrări doresc să scoată în evidenţă aspectele legate de costurile de mediu ale unei astfel de abordări, utilizând instrumentul Life Cycle Analysis. Studiul se bazează pe două versiuni diferite ale aceluiaşi produs – una folosind materiale noi faţă de una folosind materiale recuperate – şi urmăreşte să determine problemele majore de sustenabilitate la nivelul produsului. Acestea sunt transpuse în costuri de mediu generate de fiecare versiune pe durata ciclului său de viaţă preconizat şi a scenariilor de final al acestuia, contribuind la proiectarea unor produse mai robuste şi mai moderne în industria mobilei.*

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