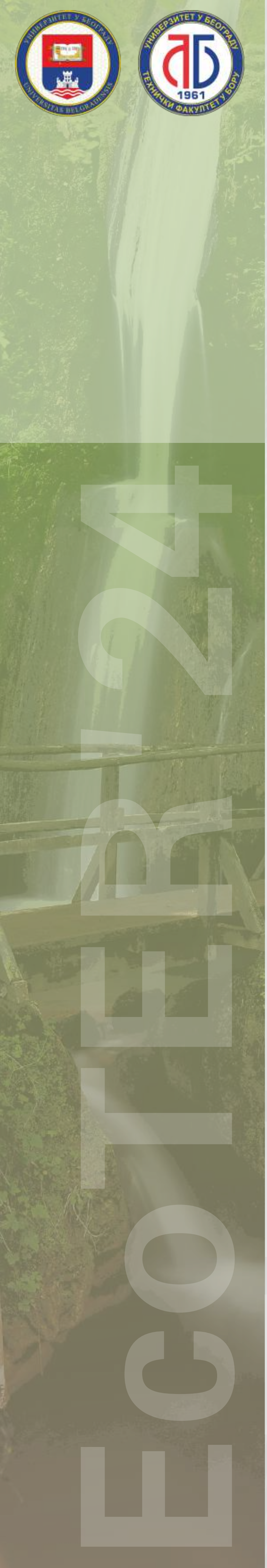

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Technical Faculty in Bor

31st International conference

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Editor
Prof. Dr Snežana Šerbula

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PREFACE

The 31st international conference Ecological Truth & Environmental Research – EcoTER'24 focuses on showing the latest research findings and innovations in the field of ecology, environmental protection and sustainable development. The conference will be held in Sokobanja (Serbia) in hotel Sunce in the period of 18–21 June 2024.

The aim of the conference is to connect the experts in various fields in order to transform attitudes and behaviors in everyday practices, as well as in the industry and economy sector which is essential for achieving the desired changes that our society must undergo.

The 31st international conference Ecological Truth & Environmental Research – EcoTER'24 is organized by the University of Belgrade, Technical Faculty in Bor, and co-organized by the University of Banja Luka, Faculty of Technology; the University of Montenegro, Faculty of Metallurgy and Technology – Podgorica; the University of Zagreb, Faculty of Metallurgy – Sisak; the University of Pristina, Faculty of Technical Sciences – Kosovska Mitrovica and the Society of Young Researchers – Bor.

These Proceedings encompass 119 papers from the authors coming from the universities, research institutes and industries in 15 countries: Brazil, Norway, USA, Spain, Austria, Libya, Italy, Israel, Slovenia, Croatia, Romania, Bulgaria, Montenegro, Bosnia and Herzegovina, North Macedonia, and Serbia. It is a great honor and pleasure to cordially wish a warm welcome to all the participants of the conference.

As a part of this year's conference, the 6th Student Section – EcoTERS'24 will be held. We appreciate the contribution of the students and their mentors who have also participated in the conference and hope that students will continue to explore and to be curious, since education is a never-ending process, and knowledge is continuously growing.

The organization of the EcoTER'24 conference has been financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

The support of the Donors and their willingness and ability to cooperate has been of great importance for the success of the EcoTER'24 conference. The organizing committee would like to extend their appreciation and gratitude to the Platinum donors of the conference – Serbia ZiJin Copper doo Bor and HBIS SERBIA, to the Gold donor of the conference – Elixir Group, as well as to the Silver donor of the conference – Serbian Chamber of Engineers.

We would like to express our sincere appreciation to all the authors who have contributed to the Proceedings. We would also like to express our gratitude to the members of the scientific, organizing and honorary committees, reviewers, speakers, chairpersons and all the conference participants for their support of the EcoTER'24. Sincere thanks go to all the people who have contributed to the successful organization of the EcoTER'24.

Prof. Snežana Šerbula,

President of the scientific and organizing committee

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LIFE CYCLE ASSESMENT OF THE HAIR DRYER WITH ECO-it SOFTWARE

Danijela Nikolić[1*], Saša Jovanović[1], Dajana Mikić[1], Zorica Đorđević[1]
[1]University of Kragujevac, Faculty of Engineering, Sestre Janjić 6, 34000 Kragujevac, SERBIA
[*]*danijela1.nikolic@gmail.com*

Abstract

The key step towards achieving sustainable development is the assessment of the impact on the environment due to the consumption of goods and services. Life Cycle Assessment (LCA) is a process of collecting and evaluating data on inputs, outputs, and possible impacts of a product system on the environment, throughout its entire life cycle. Household appliances play an important role and should be thoroughly assessed, i.e. all phases of the life cycle should be taken into account. This paper presents the assessment of the hair dryer's environmental impact using the Eco-it software and the potential reduction of the environmental impact at different scales. With LCA analysis and Eco-it software, it will be presented the technical evaluation of the product, as well as its redesign, due to better performance and decreasing environmental impact.

Keywords: Life Cycle Assessment, hair dryer, ECO-it software, environmental impact.

INTRODUCTION

Since the middle of the last century, there has been constant population growth in the world, and therefore the need for material resources is increasing. The industrial way of production became necessary, and the improvement of living standards came about due to the availability of natural resources, along with the development of technology [1]. Traditionally, products were designed and developed without considering their harmful impact on the environment. Conventional regulation focuses only on the emissions from the manufacturing processes. However, harmful impacts on the environment occur from the other life cycle stages such as use, disposal, distribution, and raw material acquisition [2].

In recent decades, many corporations recognized the importance of the product's environmental impacts and began to include environmental aspects in product design and development processes. This includes the activities, processes, and materials starting from raw materials acquisition, manufacturing, distribution, use, and to disposal, i.e. during the entire life cycle. Thus, there was a need for systematic analytical tool for the product environmental assessment during the entire life cycle. This tool is a Life Cycle Assessment, which is a quantitative analysis of the environmental aspects of a product over its entire life cycle. It offers a “cradle to grave” look at a product or process, considering environmental aspects and potential impacts on ecosystems, human health, and natural resources [3,4].

Home appliances are currently a key area of energy consumption in developed and developing countries, and projections related to the population growth predict that more and more people will use these appliances in the future [5]. A recent study showed that household appliances account for 70% of China's carbon dioxide emissions and that air conditioners, refrigerators and televisions are responsible for 50% of these emissions [6]. These devices should be evaluated taking into account all phases of the life cycle, as well as their technological efficiency, and based on this, a plan for potential reduction of impacts at different scales should be developed.

This paper presents an LCA analysis of the hair dryer impact on the environment, using the eco-indicator methodology and software ECO-it 1.4. A comparative analysis was made for the hair dryer and its redesigned version, and the possibility of reducing the harmful impact on the environment was shown through the improvement of the hair dryer design.

MATERIALS AND METHODS

Life Cycle Assessment

Life cycle assessment (LCA) is a tool for decision-making on the production or quality of a certain product while identifying its impact on the environment, throughout the entire life cycle, starting from resources and material exploitation to final disposal. LCA is actually an analytical instrument in the environmental field that provides an understanding and comparison of different products or services through a “cradle to grave” approach [7]. This method can analyze all and/or more stages of the life cycle and thus helps companies to decide to what level it is necessary to “incorporate” environmental issues into the process of deciding on the characteristics of a certain product or on the types of services.

The Life Cycle Assessment includes four phases and key considerations (Figure 1):

1. Goal and scope definition.
2. The life cycle inventory (LCI).
3. The life cycle impact assessment (LCIA).
4. Life cycle interpretation.

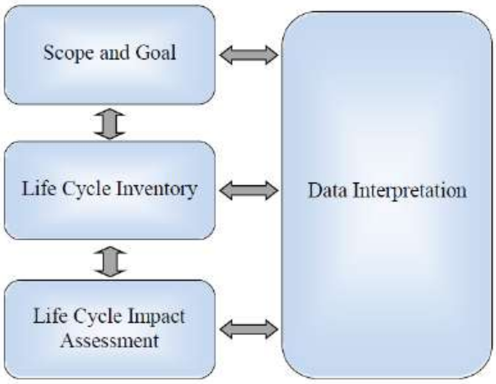


Figure 1 *Phases of an LCA*

The methodological structure of the Life Cycle Assessment is given in the ISO 14040 series of standards: ISO 14040:2008 - LifeCycle Assessment - Principles and Framework and ISO 14044:2008 - Life Cycle Assessment – Requirements and Guidelines.

Eco-indicator Method

The eco-indicator method (implemented in ECO-it 1.4 software) is one of the most developed methods for life cycle impact assessment. With the aim of presenting the LCA results at all levels, this model was developed to link the LCI results with the procedures for determining the weighting coefficients. This included the processes of characterization and normalization. The results can be presented as one quantified result - eco-indicator, which can facilitate the work of designers and production managers in the decision-making process related to the harmfulness of products to the environment [8].

The idea of the emergence of ecological indicators was initiated in the late 1990s by the Dutch Ministry of Construction, Spatial Planning and the Environment with the intention of encouraging care for the environment. The main idea of eco indicators is to compare two products or two variants of the same product from the aspect of environmental impact, and the values of eco indicators point to possible directions for product improvement [8]. The eco indicator calculation method has a modular structure. In order to ensure the correct use of eco-indicators, there are several steps that must be followed: determining the purpose of calculating eco-indicators, defining the lifetime of the analysed product, quantifying materials and processes, filling out the form for calculating eco indicators and results interpretation

Model of analyzed hair dryer

In this analysis, a hair dryer Solride 2-Professional (Figure 2) of low power and small dimensions, intended for home use, will be analzyed. The hair dryer has a power of 800 W and three speed levels. The purpose of the hair-dryer analysis is to determine the overall eco-indicator of the hair dryer's life cycle and then to determine which processes have the most significant impact on the environment. In this case, there will be no comparison of two products of the same purpose, but an analysis of the impact of one product on the environment, with the aim of its improving.

According to the estimates, the average life-cycle of a hair dryer is from 70 to 1000 working hours. Also, in an average household on a weekly basis, a hair dryer is used about 1.5 hours, so the life-cycle of this device is estimated at 10 to 12 years.

Figure 2 *Analzyed hair-dryer Solride 21-Professional*

The components of the hair dryer are shown in Table 1.

Table 1 *Constituent parts of hair dryer*

Name	Mass (g)	Material	Quantity
Front housing	120	Plastic	1
Rear housing	114	Plastic	1
Motor holder	47	Plastic	1
Coil	12	Aluminum	1
Back net	8	Stainless steel/plastic	2
Front neck	6	Stainless steel	1
Heater	13	NiCr alloy	4
Engine	30	-	1
Heater housing	64	Aluminum	2
Propeller	25	Plastic	1
Cable	126	Copper/rubber	1
Screw	9	Steel	11

Using the ECO-it 1.4 software, the eco-indicator for the observed individual process can be calculated, by multiplying the tabular eco-indicator, which is expressed in points per kilogram of some raw material, with the amount of raw material (or energy) that is characteristic of the observed process [9]:

$$EI_n = ei_n \cdot m_n \quad (1)$$

where:

EI_n - eco-indicator for the observed process;

ei_n - tabular eco indicator (expressed by characteristic size for a process);

m_n - mass of raw material in the observed process;

e_n - amount of energy in the observed process.

Entering data into the ECO-it 1.4 software is performed in three phases: the production phase, the use phase and the disposal phase. Then, software calculates eco-indicator for each process. These value is expressed in millipoints (mPt) and can be presented graphically.

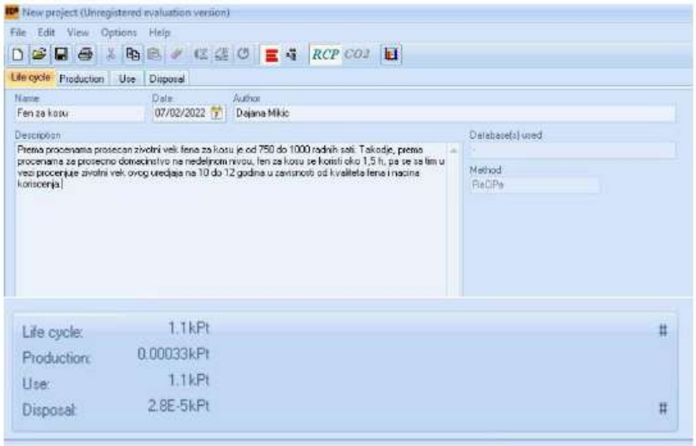
RESULTS AND DISCUSSION

Results for analyzed hair dryer Solride 2-Professional

After defining the life cycle, classifying materials and processes in the 3 mentioned phases, points are calculated for each phase, as well as the eco-indicator. In Figure 3a), it can be seen that the total eco-indicator of the analyzed hair dryer is 1100 Pt. Since the largest share of points is in the use phase (it cannot be influenced in the calculation and consideration phase of the product), the points for this part of the analysis are ignored. Figure 3b) shows the eco-indicator for the hair dryers without the use phase (362 mPt).

Hair dryer has the greatest impact on the environment in the production phase, while waste disposal is significantly less in case without consideration of use phase. Waste disposal and waste sorting in Serbia is still not fully defined, so, in this part of the analysis all hair dryer waste goes to the landfill. In the further part of the work, changes will be proposed in order to reduce energy consumption and the environmental impact of hair dryer.

a)



b)

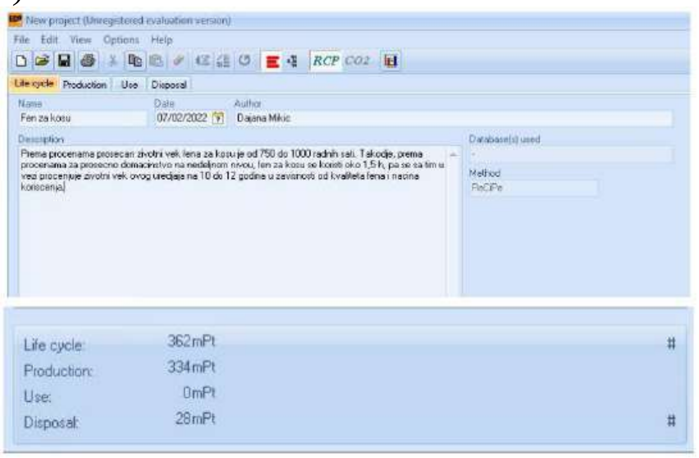


Figure 3 *Results of hair dryer LCA analysys a) with use phase; b)without use phase*

Results for redesigned hair dryer

In the production phase, it is possible to redesign the hair-dryer housing, as well as all the parts that go with it, by reducing their volume of 10%. This would not affect the function of the product, and there would be a reduction in the production of plastic materials. With such a redesign, it is possible to reduce the number of required connecting elements.

The use phase consumes a certain amount of energy, which depends on the way of use. It is possible to reduce this consumption by introducing IC heaters. By installing IR heaters, energy savings of 20% are achieved. Energy consumption in this case amounts to 6400 kWh, while in the previous phase this amount was 8000 kWh during the entire life of the product.

And at the very end, the phase of waste disposal, which has a great impact on the environment, can be reduced by recycling individual parts of the hair dryer.

By redesigning the case and the parts that go with it, that is, by reducing the volume by 10% and installing an IR heater, the overall eco-indicator of the observed product is significantly reduced, which is now 896 Pt (in the previous case it was 1100 Pt). By comparing the original and the redesigned hair dryer, it can be seen that the redesigned hair dryer is less harmful to the environment.

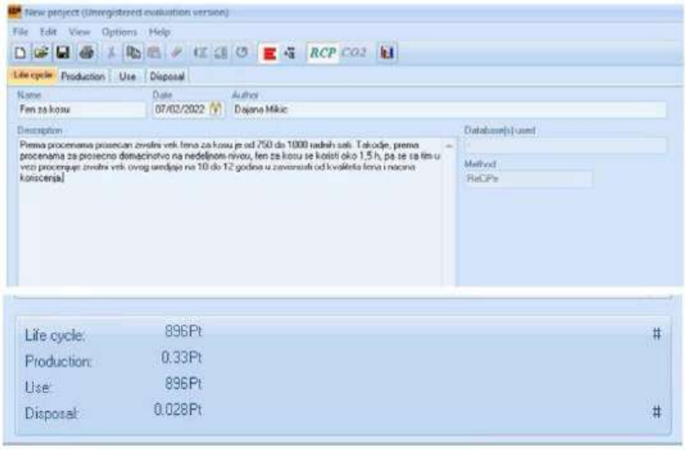


Figure 4 *Results of LCA analysys for redesigned hair dryer with use phase*

CONCLUSION

The Life Cycle Assessment method is a tool that can be used to assess the impact of a product on the environment throughout its entire life cycle. In this paper, the method of evaluating the product's harmfulness to the environment. The methodology Eco-it 99 and software ECO-it 1.4 were chosen, which was applied to the LCA of hair dryers. The LCA of the hair dryer was carried out in three phases: the production phase, the use phase, and the disposal phase. The production phase has the greatest impact on the environment.

An analysis of the redesigned hair dryer was also done - the housing material was changed and IC heater was implemented.

The recycling of certain materials after the hair dryer use is also foreseen. The entire redesign process was aimed at reducing the harmful impact of hair dryer on the environment. Analysis of the redesigned hair dryer has shown that its impact on the environment has decreased. If such changes were be introduced in other devices, they would lead to a big move and more visible results related to harmful impact on the environment.

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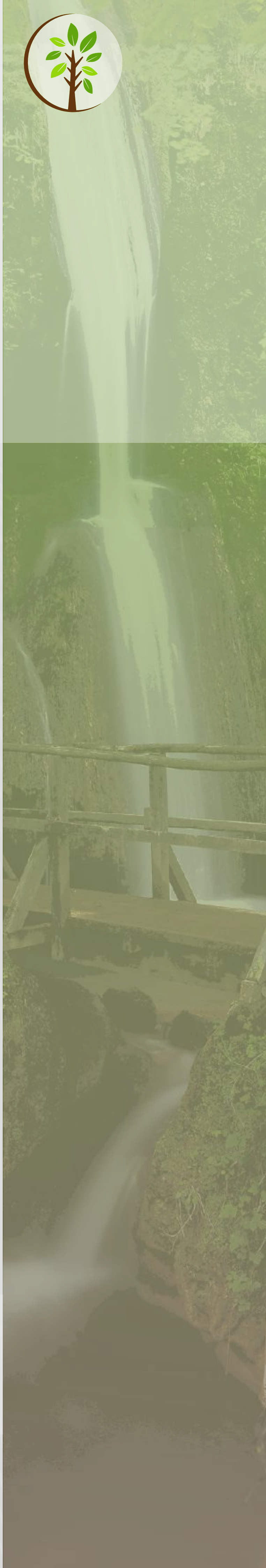

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