IMPACT OF LEATHER PRODUCTION ON THE FOOTWEAR CARBON FOOTPRINT

V. Segarra, M. Roig, M. A. Martínez, J. Ferrer, A. Zapatero, G. Rubio, N. Cuesta

Footwear Technological Institute (INESCOP). Polígono Industrial Campo Alto - 03600 Elda (Spain)
medioambiente@inescop.es

ABSTRACT:
The greenhouse effect is a natural phenomenon by which the greenhouse gases (GHG), which are part of the atmosphere, retain some of the energy emitted by the Earth causing a natural warming of the earth's surface without which life, as we know it, would not be possible.

The industry is partly responsible for these GHG, thus contributing to global warming. The carbon footprint is an environmental indicator that is used to measure the total sets of GHG emissions to the atmosphere caused by a product, service or organisation throughout its whole lifecycle.

INESCOP is carrying out the European LIFE project "Footwear carbon footprint (CO2Shoe)" which aims to develop a tool for measuring the carbon footprint and to implement it in shoe factories within the European Union. Using this tool, it will be possible to quantify the carbon footprint associated with each shoe production process, including the leather tanning process, and to identify the processes that generate the greatest environmental impact in order to minimize them by implementing the most appropriate measures to reduce CO_2 emissions and, hence, the carbon footprint.

This paper presents the main results obtained in the project so far.

Keywords: leather, footwear, CO_2, emissions, greenhouse effect, carbon footprint.

INTRODUCTION

Over the last few years, there has been a growing interest in environmental issues, particularly in those related to climate change. More and more industrial sectors are interested in knowing about the environmental repercussions of their activities. In this sense, the "carbon footprint" concept is currently considered as one of the main environmental indicators when it comes to the quantification of the environmental impact of a product, an organisation or a service.

In the particular case of products, the carbon footprint allows the quantification of the total set of greenhouse gas (GHG) emissions and/or removal caused by a product throughout its life cycle. It can be considered a simplified Life Cycle Assessment (LCA) in which only the impact category of climate change is taken into consideration.

Although there are different GHG contributing to global warming, the carbon footprint only includes the emissions of gasses to which reference is made in the Kyoto Protocol [1]: carbon dioxide (CO2), methane (CH4), nitrous oxide (NO2), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).

The contribution of each of these gases to climate change is different (they have a different global warming potential). Therefore, in order to use the same measuring unit, all gases are referred to CO2, as this is the most common and well-known gas, by applying the corresponding characterisation factors. This way, the carbon footprint results are expressed as grams or kilograms of CO2 equivalent (CO2e).

In the particular case of footwear manufacture, the GHG to be considered are CO2, CH4 and NO2, the emissions of which are mainly related to the use of fossil resources and energy. The other 3 GHG mentioned in the Kyoto Protocol (HFCs, PFCs and SF6) should not be released into the atmosphere, since footwear containing GHG fluorinated gases shall not be placed on the market [2].

The study of the carbon footprint results makes it possible to identify the hot spots of the system under study, i.e. the stages, processes, materials, etc. causing the greatest environmental impact. Subsequently, according to the human and financial resources available, a plan for the mitigation of GHG emissions and, hence, the improvement of the environmental performance of companies should be established.

Some examples of the environmental improvements that can be applied stem from previous research works conducted by INESCOP. For instance, the European Eco-Innovation Project "Thermoplastic Polyurethane from Renewable Sources Applied in Footwear (EcoTPU)" [3] focused on the production of footwear components (outsoles, toe puffs and counters) from renewable sources (plant oils) to replace fuel. The use of such alternative materials reduces CO2 emissions significantly.

Particularly in the leather industry, some examples of environmental improvements that can be implemented are based on the results obtained from two research projects recently completed by INESCOP, such as the Eco-Innovation Project "Eco-friendly Leather Tanned with Titanium (TiLeather)" [4] and the LIFE Project "Environmentally-friendly Oxazolidine Tanned Leather (OXATAN)" [5].

Despite the companies' interest in knowing about and reducing their environmental impact, most of them do not have the necessary resources available to address these issues. In the EU, the footwear industry is mainly comprised by small and medium sized companies that employ 10-20 workers on average.

Furthermore, another issue is that there is currently a broad spectrum of methodologies for the calculation of the carbon footprint of products (more than 40 different methods), which account for the large differences observed in the results obtained according to the methodology employed and the impossibility to compare such results.

The LIFE CO2Shoe project

Faced with this situation, the LIFE CO2Shoe project "Footwear Carbon Footprint" was launched, which aims to create a carbon footprint calculation tool specific for the footwear sector. Such tool will allow the measurement of GHG emissions caused by a pair of shoes.

During the project execution (October 2013 – March 2017), the carbon footprint calculation tool will be tested in Spanish, Italian, Polish and Portuguese footwear companies, although it is also expected to be extended to all EU countries.

For each footwear model analysed, the results obtained will allow the identification of those footwear processes and footwear components manufacturing having greater impacts so as to be able to implement strategies aiming to reduce the carbon footprint of the end products and hence improve the environmental performance of footwear manufacturers and their suppliers.

The scope of this study will be limited to those stages of the footwear life cycle on which footwear manufacturers have direct control and, therefore, can act to improve their environmental performance.

Experimental: materials and methods

The first project stage focused on reviewing the main existing standards about Life Cycle Assessment (LCA) and the Carbon Footprint of Products (CFP).

Table 1. Standards analysed

Standard
ISO 14040: 2006 – Environmental management – Life cycle assessment – Principles and framework
ISO 14044: 2006 – Environmental management – Life cycle assessment – Requierments and guidelines
JRC European Commission. ILCD Handbook, International reference Life Cycle System (2010)
ISO/TS 14067:2013 - Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification and communication
Product Enviromental Footprint (PEF) guide : 2012
PAS 2050 :2011 - Specification for the assessment of the life cycle greenhouse gas emissions of goods and services
Greenhouse Gas Protocol (GHG protocol): 2011

In addition, other more specific documents were analysed, such as the Product Category Rules (PCRs) and the Environmental Product Declarations (EPDs) related to the footwear sector. Table 2 lists the specific documentation analysed.

Table 2. Other documents analysed

Document
The international EPD® system. Product Category Rules. UN CPC 2933. Leather footwear. 2013:15. Version 1.0
Sustainable leather DANI. EPD® Product Environmental Declaration. Leather for clothing, upholstery, footwear, leather goods, accessories and interior design. 4/04/2012. Review: 0
The international EPD® system. Product Category Rules. CPC Class 2912. Finished bovine leather. Version 1.0 dated 2011-09-28
The international EPD® system. Product Category Rules. CPC Division 29. Leather and leather products; footwear. Version 1.0. 2010-11-30

System scope and objectives

As stated in the above-referenced standards, every CFP study shall start by defining the scope and objectives.

Since this is an iterative technique, a continuous reassessment of certain aspects is to be made as the system under study is more deeply known. This iterative approach also applies to the system scope, which can be redefined as the project progresses.

The ultimate aim of this study is not to compare the CFP of the products of different companies, but the internal applications within the same company in order to contribute to the reduction of its GHG emissions. Therefore, at a first stage, the CFP communication will only be used internally and will not be publicly available.

Among the communications options established in the standard ISO/TS 14067, the CO2Shoe project proposes the use of the (CFP performance tracking report). This report compares the CFP results of one specific product of the same organisation over time.

Assessment of the socio-economic impact of the project

An initial questionnaire was prepared and circulated among footwear companies in order to assess their level of knowledge and their general situation with regard to environmental issues and the carbon footprint.

According to the results obtained from the initial questionnaires, the data were statistically analysed. The analytical unit was comprised of 146 companies based in Spain, Italy, Portugal and Poland operating in the footwear manufacturing sector.

A second questionnaire is expected to be circulated at the end of the project. The results obtained will allow the assessment of the socio-economic impact of the project.

Results and discussion

The main results obtained so far are summarised below.

Among the documentation analysed, the documents listed below were followed in order to establish the system scope and objectives:

- Standard ISO/TS 14067:2013 - Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification and Communications.
- PCR UN CPC 2933. Leather footwear. 2013:15. Version 1.0.

<u>The product system and its functions:</u>

The product system under study is a pair of shoes, and its basic functions are to protect or cover feet and to provide passive support to human walking.

Table 3 shows the different stages of the product system. Apart from these, the distribution stage (9), relative to the transportation of materials between the different stages of the life cycle, and the energy generation stage (10) relative to the production of the necessary energy to perform each of the life cycle stages, shall also be taken into consideration.

Table 3. Stages of the footwear Life Cycle Assessment

	Stages
1	Raw material acquisition
2	Production of input materials
3	Production of footwear components
4	Footwear assembly
5	Production of packaging
6	Footwear distribution
7	Use of footwear
8	End of life

The functional unit:

One of the fundamentals of the standard ISO/TS 14067 is the definition of the functional unit for which the carbon footprint is to be quantified, since all results will relate to such functional unit.

For the CO2Shoe project, the functional unit is a pair of shoes (the final product and its packaging) size 42 for men's shoes, size 37 for women's shoes and size 32 for children's shoes (Note: European sizing system, based on the Paris Point).

Reference flow:

The reference flow uses a physical unit (mass) to measure the outputs from processes of the product system under study. For the CO2Shoe project, the reference flow is defined as the amount of material necessary to produce the functional unit (a pair of shoes and its packaging).

Table 4 shows the footwear components that have been considered for the CFP study. Obviously, the amount and type of material for each component will vary according to the footwear style being analysed.

Table 4. Footwear components considered in the CFP study.

	Components
Top part of the footwear	Upper
	Lining
	Tongue
	Toe puff
	Counter
	Laces
	Finishing materials
	Other (eyelets, zippers, etc.)
Lower part of the footwear	Footbed/Insole
	Midsole
	Outsole
	Others (shank, welt, etc.)
Other components	Packaging

System boundaries:

The system boundaries specify which unit processes are included in the CFP study, i.e. the processes that are part of the life cycle inventory for which input and output data are quantified.

In the CO2Shoe project, the LCA will have a 'cradle to gate' approach. The 'gate' is where the final product (a pair of shoes and its packaging) leaves the manufacturing site and is ready to be distributed for commercialisation. Therefore, the distribution (6), use (7) and end of life (8) stages listed in table 3 are excluded from the scope. The reason for the exclusion of such stages is related to the ultimate objective of the project, i.e. to improve the environmental situation of the footwear industry. Therefore, all stages that are out of the control of footwear manufacturers will not be considered.

Figure 1 shoes the footwear production flow chart. The stages encircled by the dotted line are within the system boundaries.

In the footwear sector, components are usually produced by third parties (for instance, leather). In this sense, the manufacturing processes covered by third parties and inputs and outputs of semi-finished materials will also be considered.

Leather production is a major process in the manufacture of footwear raw materials. Despite the extensive literature about this topic, there is currently no consensus on the establishment of the boundaries of the leather production system.

The European Commission has recently created a new working group aiming to reach an 'agreement among stakeholders in the cattle value chain regarding the system boundaries', and the way to share their environmental responsibilities. This working group is comprised of representatives of the leather, meat, dairy, livestock feed and pet food sectors.

The CO2Shoe project considers that most raw hides and skins originate from animals that have been mainly bred for human feeding purposes, such as meat and milk production (bovines, sheep, goats and some others). Therefore, the whole environmental impact will be allocated to the main products in the economic value chain (milk and meat). This implies that agriculture and animal farming shall be excluded from LCA studies on leather and the system boundaries should start at the exit of the slaughterhouse.

Note: Over 99% of the raw hides processed by tanneries around the world come from animals that have been raised to meet the needs of the world meat requirements (Source: FAO)

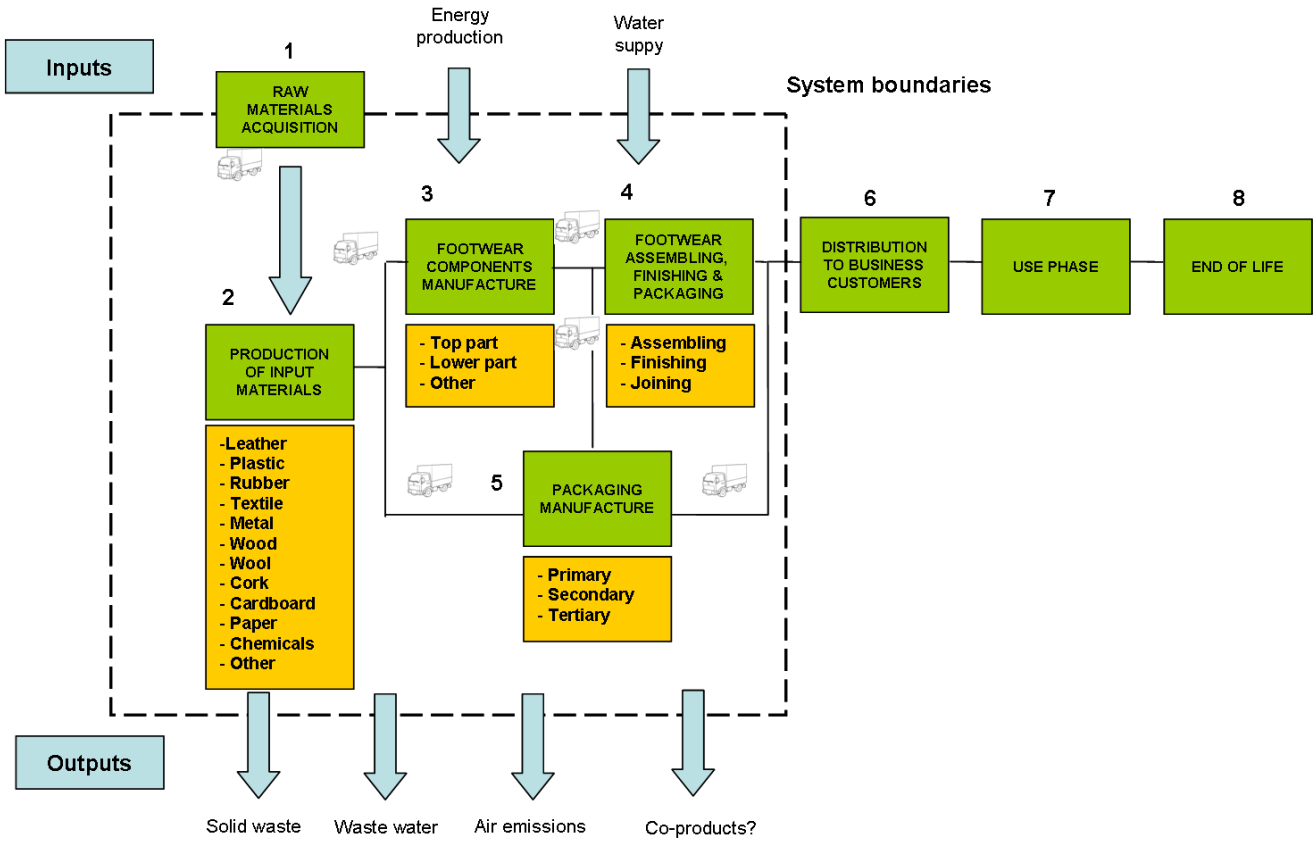

Figure 1. Footwear production flow chart and system boundaries

Cut-off rule:

A general rule of 1% weight/weight is established for materials, as defined in the PCR for leather footwear. This means that materials constituting less than 1% by weight of the functional unit can be excluded from the CFP study.

Data and data quality rules:

Primary (specific) data will be gathered for individual processes that are under the financial or operational control footwear manufacturers or suppliers, i.e. based on invoices, records, etc. To this end, a questionnaire will be prepared in order to gather input information for the tool to be developed.

Secondary (generic) data may be used when specific data are not available or for minor processes. These can be obtained from available data sources, such as commercial databases (Ecoinvent, mainly), free databases or other documents, such as:

- GaBi.
- Plastics Europe.
- PCR of the EPD system.
- EPD and scientific studies according to the corresponding PCR
- International Energy Agency (IEA).
- Ministry of Industry, Energy and Tourism (Spain).
- National Energy Commission (Spain).
- Institute for Diversification and Saving of Energy (IDAE) (Spain).

- The Catalan Office for Climate Change.

In the course of the project, a pilot test will be performed in order to check the operation of the developed tool. This test will end with a verification process by an external expert to ensure that all data used and calculations made are correct.

Once the tool development stage has been completed, the carbon footprint of 36 footwear models (4 countries, 3 companies per country, 3 models per company) will be calculated. For each model, the carbon footprint will be calculated at two different points in time. In the first one, the initial carbon footprint value will be obtained. Based on these results, some recommendations for improvement will be given and the companies will have some time allotted for their implementation. After the implementation of such improvements, the carbon footprint will be calculated again on the same footwear model.

In order to carry out each pilot application, a base year must be established, that is to say a reference period during which inventory data will be gathered for the calculation of the carbon footprint. Figure 2 shows the time frame for the completion of the pilot test and the 2 implementations.

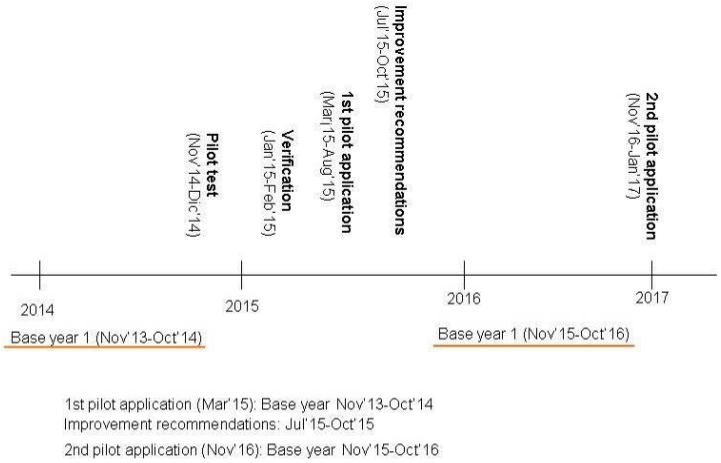

Figure 2. Time boundaries

Geographical scope:

With regard to the geographical scope of data, the study will have a worldwide scope. Data relative to the components supplied, as well as the distances travelled by components, will be accurately adapted to real life scenarios. For instance, transportation of components to the manufacturer shall be calculated with actual transportation and distance from the supplier.

For electricity used in the process, if the company buys the energy from the electricity mix on the current market, the national electricity mix shall be adopted. If the company buys energy from a specific supplier, a specific energy mix could be used, if the relevant information is available.

Allocation procedures:

For unifunctional processes, (systems generating one single product) 100% will be immediately allocated

For multifunctional processes, the % corresponding to the environmental burden of the product under study shall be allocated. The CO2Shoe project will use the attributional (allocation) model, which is used when one wants to know the environmental impact of a product and the hot spots in its life cycle, or when one wants to compare the impacts of 2 products with the same functional unit. Within this model, the most widely used option consists in establishing relationships between products according to their economic value.

Assessment of the socio-economic impacts of the project

Considering the results of the initial questionnaires, over 50% of the surveyed companies rated environmental issues as 'important. For almost 30% of them, environmental issues are 'fairly important'.

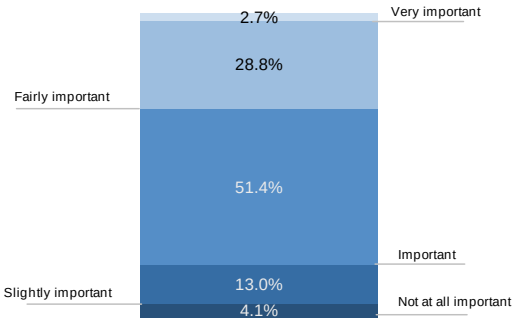

Figure 3. Percentage of companies according to how they rate the importance they assign to environmental issues

One of the possible applications of the carbon footprint calculation has to do with Eco-design. More than 70% of the surveyed companies had very little knowledge of Eco-design.

The main environmental criteria that companies take into consideration when a new product is designed are 'the absence of hazardous substances' and the 'durability', which were selected by over 60% of the surveyed companies.

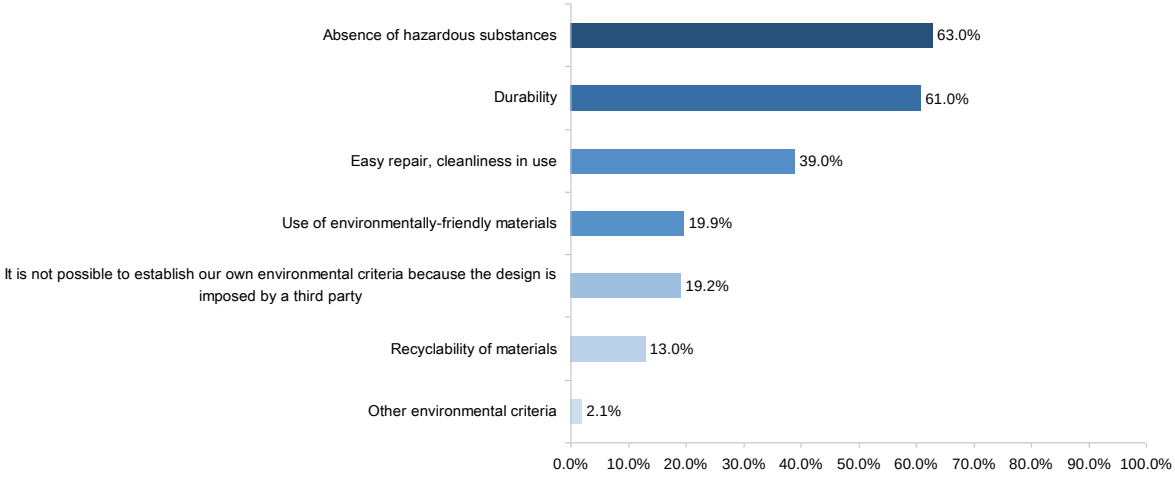

Figure 4. Percentage of companies according to the environmental criteria they take into consideration when a new product is designed

'Price' (85%) and 'quality' (82%) are the main aspects that the surveyed companies take into consideration when they purchase raw materials. For almost 34% of them, the 'absence of hazardous substances for human health and the environment' is also important for raw material acquisition.

Almost 90% of the surveyed companies have never quantified the environmental impacts associated with their production processes, but over 50% of them would be interested in doing so.

Most of the surveyed companies (93%) do not know any of the methodologies available for the identification and/or quantification of their environmental impacts. Among the methodologies they are familiar with, the carbon footprint (30%), the ecological footprint (21%) and the life cycle assessment (20%) stand out.

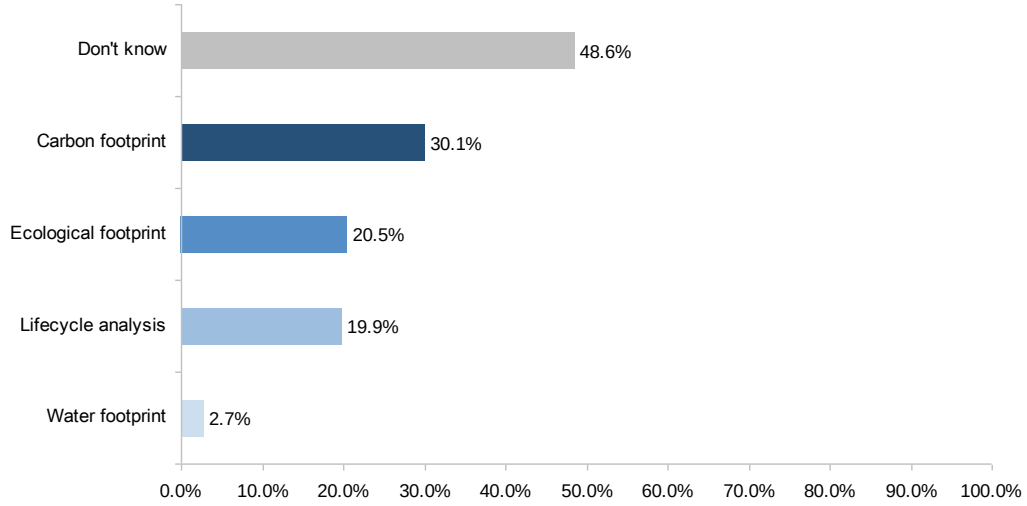

Figure 5. Percentage of companies according to the methodologies they would be able to use in order to quantify the environmental impacts

The environmental impact terms that the surveyed companies are most familiar with are 'ozone layer' (77%), 'climate change' (62%) and 'greenhouse gases' (53%).

In general, the vast majority of the surveyed companies (93%) do not know any of the existing standards for life cycle assessment or for the calculation of the carbon footprint. Besides, none of them has ever calculated their carbon footprint and only 1% has calculated the carbon footprint of some of their products.

However, despite their lack of knowledge, some 35% of the surveyed companies would be interested in calculating the carbon footprint of the new footwear styles to be placed on the market and more than 35% stated they would be interested in taking steps aiming at reducing the carbon footprint of their products. However, almost 96% of the surveyed companies would not know how to reduce the carbon footprint of their products.

For over 60% of the surveyed companies, 'improving the corporate image' and 'cost saving' are some of the benefits that the reduction of the carbon footprint of their products can bring about.

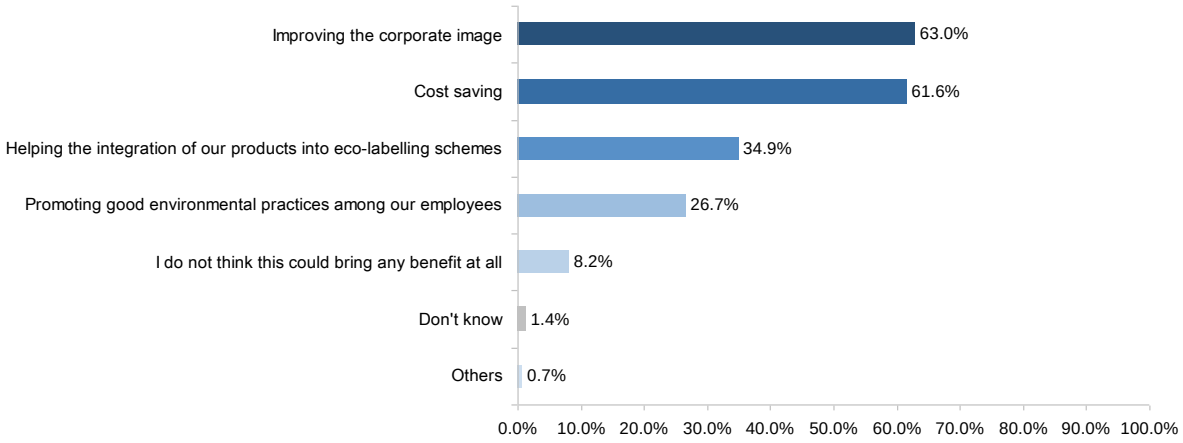

Figure 6. Percentage of companies according to the benefits they think that the reduction of the carbon footprint of their products can bring to them

Some 69% of the surveyed companies stated they were interested in disclosing environmental information about the footwear they produce.

Conclusions

Most footwear companies have never estimated the environmental impacts associated with their production processes. However, they are very interested in calculating it but they do not know the tools available to perform this task (Eco-design, Life Cycle Assessment, Carbon Footprint, etc.). In addition, there is currently a broad spectrum of methodologies for the calculation of the carbon footprint of products, which accounts for the large differences observed in the results obtained according to the methodology employed and the scope.

The work conducted in the framework of the CO2Shoe project will make it possible to develop a tool for the calculation of the carbon footprint specific for the footwear sector. The use of this tool will allow footwear companies to identify those footwear manufacturing stages, processes, materials, etc. employed in their production processes having the greatest impacts on climate change, so as to be able to minimize them.

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Abbreviated terms

LCA	Life Cycle Assessment
CO_2e	CO_2 equivalent
EPD	Environmental Product Declaration
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse Gas
CFP	Carbon Footprint of a Product
HFCs	Hydrofluorocarbons
ISO	International Organization for Standardization
PCR	Product Category Rules
PEF	Product Environmental Footprint
PFCs	Perfluorocarbons
TPU	Thermoplastic Polyurethane