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Use of Life Cycle Assessment by companies in the Basque region. Results of survey research

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ABSTRACT

The importance firms, public institutions, and, more recently, consumers give to environmental issues has led in recent years to a surge in the development, dissemination, and application of Life Cycle Assessment (LCA) methodology. Nevertheless, little is still known about this tool's effective deployment by companies, or about the level of knowledge they have of it in some specific geographical areas, as in the Basque Region in the north of Spain. This paper seeks to provide a starting point for subsequently addressing these unresolved issues.

Through the analysis and treatment of the data collected via the questionnaire, this work aims to provide a snapshot of the LCA situation in the Basque Country. In turn, the specific objectives are to discover who is carrying out LCA studies, why and how they are doing it, and to publicize the benefits provided by this type of study.

Among other things, the study reveals that the LCA is still a little-known tool used mainly by large companies in specific sectors. The LCA is perceived as a complicated methodology that reports few economic benefits, although its capacity to improve the environmental performance of the products and the image of the company is recognized. The companies also think that their use will be generalized in the future, although they complain about the lack of institutional support that is provided.

Keywords: Life Cycle Assessment (LCA); Life Cycle Management (LCM); Sustainability; Basque Country.

1. Introduction

1.1. The use of LCA by companies

It is obvious that in order to reduce the impact that a given product has on the environment the first step is to identify and evaluate this impact. It is equally obvious that it is not enough for companies to carry out this exercise focusing exclusively on their manufacturing process, but it is imperative to consider the impacts generated by the product throughout its entire life cycle. Life Cycle Assessment (LCA) pursues this precise purpose as it is deduced from the following definition proposed by Setac in 1993 which happens to be one of the first and most complete: "*LCA is a process to evaluate the environmental burdens associated with a product, process, or activity by identifying and quantifying energy and materials used and wastes released to the environment; to assess the impact of those energy and materials used and releases to the environment; and to identify and evaluate opportunities to affect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing, extracting and processing raw materials; manufacturing, transportation and distribution; use, re-use, maintenance; recycling, and final disposal"* (Consoli, 1993).

Although the first LCA analytical tools and methodologies were developed in the 1960s and 1970s (Spold, 1993), the importance firms, public institutions, and, more recently, consumers give to environmental issues has led over the last three decades to a surge in its development, dissemination, and application. At the end of the last century several authors identified the LCA as a tool to support the decision-making process for governments, companies, consumer organizations, and environmental groups (Wenzel et al., 1997; Krozer and Vis, 1998; Field and Ehrenfeld, 1999). The first comprehensive manuals for conducting LCA studies appeared in the 1990s, notably 'SETAC Guidelines for Life Cycle Assessment: A Code of Practice' (Consoli, 1993) and 'Nordic Guidelines for Life Cycle Assessments' (Lindfors, 1995). Finally, in June 1997 ISO published the first international standard on LCA under the name 'ISO 14040 Environmental Management. Life Cycle Assessment. Principles and Framework' (ISO 1997), which was undoubtedly an important milestone in the consolidation of the methodology. Shortly after, LCA received a further institutional boost when the European Union published its Green Paper on Integrated Product Policy (IPP) (EC, 2003), given that the European Commission itself singled out the life cycle approach as one of the pillars for the development of this policy (Guinée et al., 2002; Van Rossem et al., 2006).

Nevertheless, little is still known about this tool's effective deployment by companies, or about the level of knowledge they have of it in some specific geographical areas, as in the Basque Region. While acknowledging that the literature on LCA is extensive, the same is not true regarding its application by firms. Although there are some studies that actually address this

topic, the research that presents results on LCA studies and methodological developments, or deals with specific aspects of the methodology, such as the treatment of uncertainty, impact categories, communication of results, etc. predominate in the literature. To a lesser extent, there are also guides and manuals, sectoral studies and those works commissioned by public institutions to obtain information for the design and implementation of sustainable public policies.

The first works that address this issue go back to the beginning of the nineties. Sullivan and Ehrenfeld (1992) surveyed 26 large North American industrial companies about the different tools that were then emerging to help reduce environmental effects in the life cycle of products. Huang and Hunkeler (1995) focused exclusively on the use of LCA by Fortune 500 companies and presented the conclusions drawn from 56 responses. Some years later, with a similar purpose, Verschoor and Reijnders (1999) published an investigation on the use of LCA by large companies through a case study of 7 of these companies. At the same time, several similar studies were also published in Europe: Baumann (1996), in which more than 1,000 Swedish industrial companies participated; Grotz and Scholl (1996) which counted 77 industrial companies of Germany; Broberg and Christensen (1999) with the results of 26 Danish companies also from the industrial sector; or Hanssen (1999) whose scope included Norway, Sweden, Denmark, and Finland, and where in addition to companies, public institutions and research centres also participated. Sectoral studies also appear at this time, such as Olsen (1999) that analysed the use of the LCA by 23 companies in the chemical sector of several European countries. Other works focused on more specific aspects, to mention just one Vigon and Jensen (1995) asked 33 companies, universities, and public organizations in Europe and North America about their experience in relation to data quality and databases.

However, from this time, the following works deserve to be highlighted due to their wide geographical and sectoral scope, their high number of companies involved, and their alignment with the purposes of this research: The first one, Berkhout and Howes (1997), interviewed managers from 90 companies from different industrial sectors and different countries in Europe trying to know the degree and type of adoption of life cycle approaches. Meanwhile, Franckl and Rubik (1999) obtained 382 valid answers among companies from Germany, Italy, Sweden, and Switzerland to their questionnaire about the reasons for the use of the LCA and its applications among other aspects.

Closer in time, it is worth mentioning Lewandowska et al. (2013a) and Lewandowska et al. (2013b), which present the results of research on the LCA within the framework of the Environmental Management Systems (EMS) carried out through questionnaires among companies in Poland, Germany, and Sweden with 85 valid answers, and Green Research (2011),

which interviewed managers of 33 large multinationals in the US, Europe, and Japan on the reasons for the use of the LCA, its applications and the benefits obtained.

However the truth is that the differences among these studies in terms of methodology, chosen universe, specific topic addressed, etc. make it difficult to draw general conclusions. On the other hand, given that in most cases these studies start from criteria that define in advance the type of company chosen, it is very risky to draw clear conclusions about the exact type of companies using LCA. In the discussion section the results of this research are compared with those obtained by the aforementioned works.

1.2. Environmental Policies and LCA in the Basque Country

Turning the attention to the Basque Country it is worth saying in first place, that it is one of the most densely populated regions of Spain with an area of 7,234 km2 and some 2.2 million inhabitants (1.4% of the territory and 4.6% of the population of Spain). In 2016, its gross domestic product (GDP) reached 67,968 million euros, 6.12% of Spanish GDP, which in turn meant a GDP per capita of 311,294 euros, almost 30% higher than in Spain (INE, 2017). It also highlights the importance that the industrial sector has in its economic structure in comparison with other surrounding regions. In 2014, this sector accounted for 21.5% of GDP, above the 17.1% for EU-28 and the 15.5% of Spain, although still far from the 23.1% of Germany (Eustat, 2016a).

In terms of environmental aspects, Spain was the fifth country in the world with the highest number of ISO 14001 certificates in 2015, behind China, Japan, the United Kingdom, and Italy (ISO, 2016) and the Basque Country is precisely one of its regions with greater concentration of these certifications (Heras and Arana, 2010). Proof of this is that in 2014 47% of the ecodesign certificates and 65% of the environmental product declaration (EPD) in Spain were in the hands of Basque companies (Ihobe, 2014a). For its part, according to the Basque Government (as cited in Tamayo et al., 2017) the Basque Country ranked fourth in the Environmental Performance Index in 2014, only behind countries such as Norway, France, and Austria thanks to the implementation of advanced environmental policies and instruments.

The milestone that endowed the Basque environmental policy with a specific strategic and long-term strategic vision was, according to Heras et al. (2008), the approval in 2002 of the strategic environmental planning embodied in the document 'The Strategy Basque Environment for Sustainable Development 2002-2020' (Basque Government, 2002). This strategy was developed considering the particular situation of the Basque Country in environmental matters, and the EU's own strategy embodied in the communication of the EC Strategy of the European Union for Sustainable Development, presented during the Summit of Gothenburg (Sweden) in June 2001 (EC, 2001). The strategy is implemented through several environmental framework

programs of 4 or 5 years, of which the first three have already been carried out. `The IV Environmental Framework Program 2020´, currently in force while evaluating the previous program points out the need to promote ecodesign and eco-labelling as instruments for improving the competitiveness of the territory. The program is committed to the application of ecodesign methodologies to progress towards a competitive, innovative, low carbon, and efficient economy in the use of resources and includes a project called Green Manufacturing with this objective. It also encourages a more efficient building and construction, in relation to the use of resources throughout its life cycle, and especially to the use of waste at the end of it. (Ihobe, 2014b).

1.3. Objectives

As said before, despite the fact that there is a significant number of researchers working on improving the LCA methodology, the way in which companies are adopting it and using it in their strategies has not yet been studied in depth. (Frankl and Rubik, 2000, Nygren and Antikainen, 2010). The truth is that there are not many works that have approached this topic from an empirical point of view, either in other regions of the world or in specific economic sectors, and those that are circumscribed to the Basque Country are practically nonexistent.

This research aims to fill a small part of this gap by trying to know the characteristics of the companies that use LCA (although specifically in the Basque Region), the drivers for these companies to use it and the objectives pursued, the type of results obtained from these studies and the use that is made of them, the characteristics of the process to carry them out, and finally and most importantly, the benefits obtained through them.

The empirical nature of the research and its approach to the management aspects over the technical ones give this work an innovative character that aims to be useful in the following terms: Encourage companies that do not yet use the LCA to do so, making known the benefits it provides, and help them in this process by showing the information provided by the companies surveyed about to the methodology and its application. Finally, the results can serve as an additional input to make a diagnosis of the LCA situation in the Basque Country that helps policy makers to implement policies in favor of LCA in particular and sustainability in general.

2. Methods and Data

The criteria established for the definition of the research population were the following: Basque companies with more than ten workers belonging to the industrial, construction, and primary sectors and registered in the Register of Companies with Environmental Certificates run by the already mentioned Ihobe. These criteria gave rise to a group made up of 661 companies.

A questionnaire was sent by email to the environment department managers of all of them between the months of August and October 2015.

The questionnaire begins with 16 questions about the characteristics of the company and the person surveyed and it continues by asking about the use of the LCA in the company. The answer to this last question leads to the person surveyed by one of these three possible ways: If the person surveyed acknowledges not knowing the LCA, the questionnaire ends at that precise moment. If, despite knowing it, the LCA is not used in the company, five other questions are asked about the reasons for it, the opinion about the tool, or the intention to use it in the future, among others. Finally, if the respondent claims to use the LCA in his company, he faces the complete questionnaire formed by 32 other questions about the reasons for its use, the objectives pursued, the results obtained or the main obstacles.

Initially 164 responses were collected from which 11 of them had to be rejected as incomplete. Of the 153 companies that made up the final sample only 39 asserted to use the LCA (25.5%), at the opposite end, 67 acknowledged not even knowing the tool (43.8%), finally, 47 of them claimed to know it even though they do not use it in their company (30.7%).

3. Results

A first small group of results that facilitate the contextualization of the rest of the research is presented:

i. The first LCA studies in the Basque Country were carried out in 2001, increasing their number notably from 2010 onwards.
ii. Virtually half of the companies using LCA acknowledged having conducted just one or two estudies.
iii. As for the area of activity of the person surveyed, the environmental area, 35.95%, predominates in the sample over the quality area, at 20.92%, or the R&D, at 16.99%. However, when considering only the companies that claim to use the LCA, the R&D department greatly strengthens its presence by doubling its percentage of responses, although the environment department continues to be the most important one.

3.1. Who is conducting LCA studies?

i. Figure 1 clearly shows that the use of the LCA is more common as the number of employees increases. In fact half of the companies identified as LCA users have more than 250 employees despite being less than 30% in the raw sample.

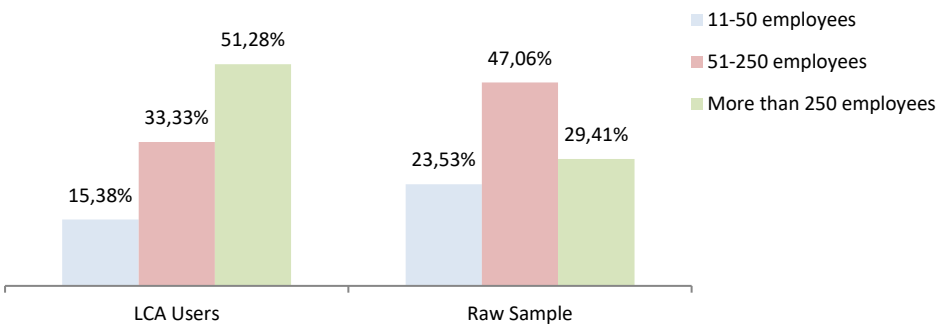

Fig. 1. Distribution by number of employees

In that same line, among large companies with more than 250 employees, over 4 out of 10 afirm they use LCA, while among smaller companies, that amount does not even reach 20% as shown in Figure 2. The 95% confidence interval (CI) for the proportion of companies that use the LCA among large companies is (29.93% - 58.96%).

In fact, the Pearson's chi-squared homogeneity test ($\chi 2$) for the proportion of companies using LCA in the three size ranges, yields a p-value of 0.0024, which indicates that its use is significantly influenced by the number of employees.

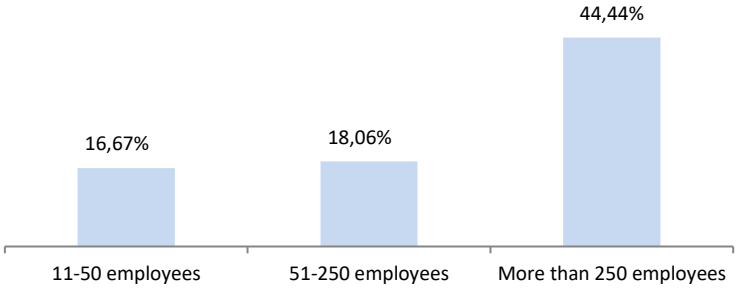

Fig. 2. Proportion of LCA users by size range

Something similar happens with billing; the proportion of companies with a turnover of more than 50 million Euros is significantly higher among the LCA users than in the raw sample, as shown in Figure 3.

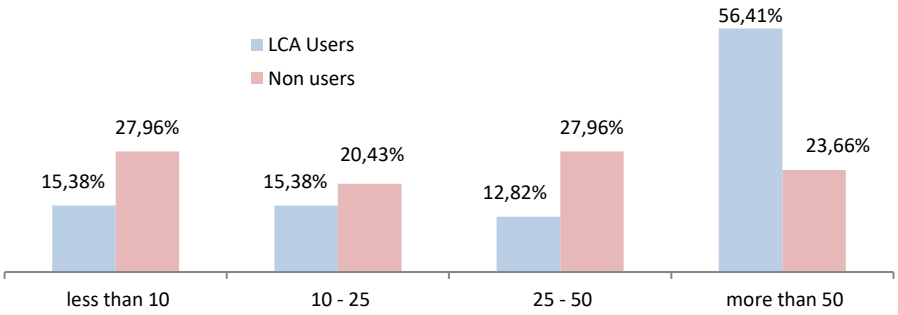

Fig. 3. Distribution by billing (Million €)

Besides, among companies that bill over 50 million euros, the rate of use of the LCA is much higher than that among companies with lower billings. In fact, one out of two among those companies carries out LCA studies as shown in Figure 4.

Pearson's chi-square independence analysis (χ2) for Use of the LCA and Billing shows a p-value of 0.0078, which indicates the existence of a statistically significant relationship between both factors.

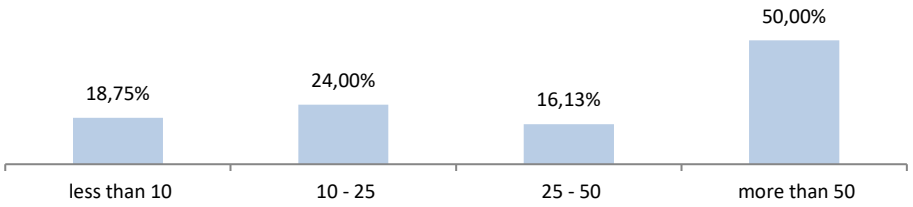

Fig. 4. Proportion **of** LCA users by Billing range (Million €)

The results of Figure 5 also indicate that companies using LCA have a greater implementation abroad than those that do not use it. Paricularly interesting is the 20% gap in productive plants.

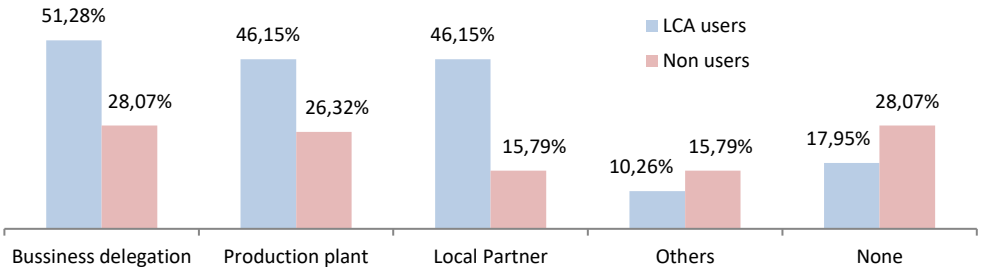

Fig. 5. Implementation Abroad

Finally, as shown in Figure 6, LCA users also have a higher level of exports, although the difference is not as significant as in the implementation abroad, probably because the export culture is deeply rooted among Basque companies.

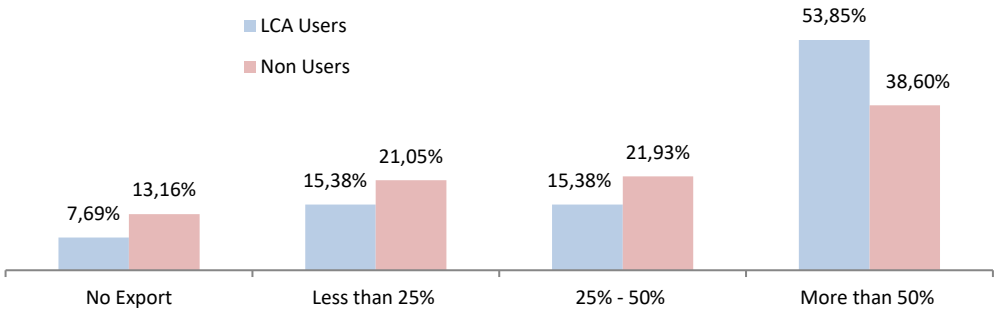

Fig. 6. Export level (% Billing)

ii. When analysing the level of activity in LCA the results allow the differentiation of three groups of sectors as shown in Table 1. A first group with high utilization and low ignorance, among which would be the aeronautics, the furniture, the machine tool, and the energy

sector, a second group with low utilization and average ignorance, where the steel industry and the metal transformation, the automotive or the construction appear among others, and a last group, with null use and high ignorance with sectors such as paper, waste managers, or the agri-food industry among others. In fact, when analyzing the existence of a relationship between the Sectorial Group and the Situation Regarding the LCA through the Pearson chi-square independence test ($\chi 2$), it is obtained that this relationship does exist and is statistically significant with a p-value of 0,00002.

Table 1.
Sectoral distribution of the sample according to the activity level in LCA

Activity Level	Sector	Use LCA	Know LCA but do not use it	Do not even know LCA
HIGH	Aeronautics Furniture Machine tool Energy	65.22%	13.04%	21.74%
MEDIUM	Steelworks and metal transformation Automotive Construction and construction materials Electrical equipment Electronics and telecommunications Naval Sector Chemical and petrochemical	21.18%	30.59%	48.24%
LOW	Paper industry Heat treatments and coatings Waste management Agri-food industry	0.00%	42.86%	57.14%

Finally, Table 2 shows the comparison between the sectoral distribution of the raw sample and that of the subgroup of companies using LCA. This analysis clearly points again the prevalence in the use of the LCA of the Machine Tool, Construction and Construction Materials and Furniture sectors, since its representation in the subgroup of users is much greater than that in the raw sample.

iii. Regarding the organization chosen for environmental management, six out of ten companies in the sample have opted for an integrated department for Quality, Environment and Occupational Health and Safety (OHS). However, this preponderance is not so pronounced among the companies using LCA, just one out of two. On the other hand, the specific Environment Department, although not very frequent in any case, is considerably more common among companies that use the LCA than among those that do not.

Table 2.
Sectoral distribution: LCA users vs Raw sample

Sector	LCA users	Sample
Machine tool	20.51%	7.84%
Construction and construction materials	17.95%	11.76%
Furniture	12.82%	3.92%
Electrical equipment	10.26%	9.15%
Automotive	10.26%	7.84%
Aeronautics	5.13%	1.96%
Chemical and petrochemical	5.13%	5.88%
Naval	5.13%	3.92%
Energy	5.13%	1.31%
Steelworks and metal transformation	5.13%	11.76%
Electronics and telecommunications	2.56%	5.23%
Other sectors with non LCA users	0%	29.41%

iv. The Ecodesign Certificate ISO 14006 is much more common among companies using the LCA than it is among non-users, while the ISO 14001 certificate is widespread in both cases, Figure 7. When considering other environmental certificates the results indicate that companies using LCA have a greater number of them than non-users, 1.74 on average to 1.16 (with variances of 1.14 and 0.21 respectively).

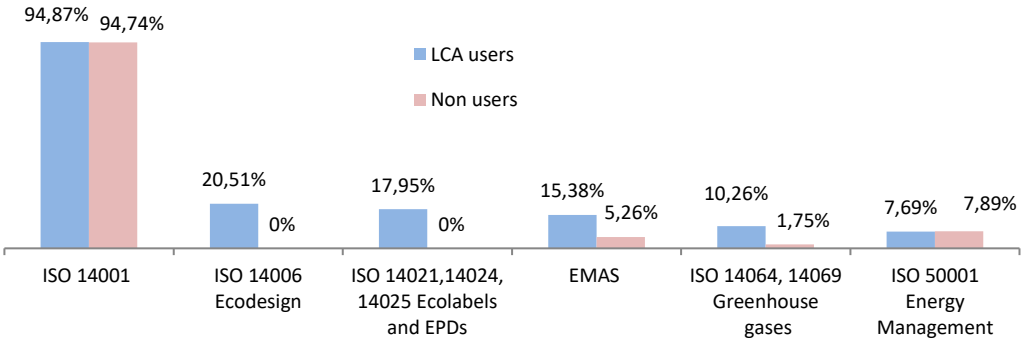

Fig. 7 Environmental Certificates

Pearson's chi-square independence tests (χ2) for Use of the LCA and Owning of each type of certificate (individually) show that there is no relationship between the use of LCA and ISO 14001 and ISO 50001 certificates, however, there is a relationship for the EMAS, Ecodesign, Ecolabels and DAPs and GHG Emission certificates, as shown in Table 3.

Table 3.
Relationship between the use of LCA and Environmental Certificates

Certificate	p-value	Significative relation α=0,05

ISO 14001	0.9739	No
ISO 50001 Energy management	0.9676	No
EMAS	0.0424	Yes
ISO 14006 Ecodesign	0.000001	Yes
ISO 14021, 14024, 14025 Ecolavels and EPDs	0.000004	Yes
ISO 14064, 14069 Greenhouse gases	0.0182	Yes

v. Finally, it should also be noted that every single LCA user company identified has a certificate in the field of quality management, and two out of three also in that of OHS.

3.2. Reasons for the use of LCA and the objectives pursued

Firstly, it must be said that the results surprisingly indicate that seven out of 10 companies conducting LCA studies apply them to their existing products, while just one out of three claims to apply it to their new ones.

Management's commitment to environmental issues is, as confirmed by half of the companies, the main driver to carry out LCA studies, well above legislative pressure, customer demand, or follow-up to the competition as shown in Figure 8.

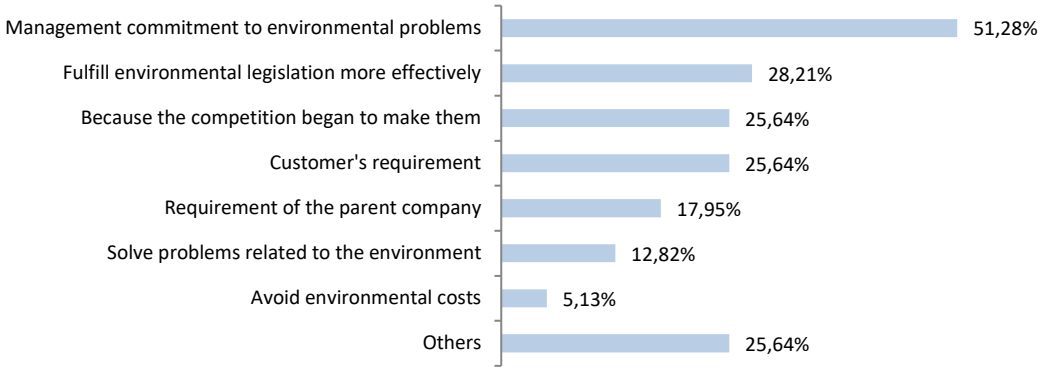

Fig. 8. Reasons for conducting LCA Studies

As for the objectives pursued, the improvement of the environmental performance of the products is the main one with about 80% of the companies pointing to it. Among the other objectives, support for ecodesign projects and the comparison of process or alternatives for proces phases are the only ones with percentages around 50%, with the rest being significantly below, as shown in Table 4.

Therefore, the motivations of these companies to carry out LCA studies seem to be mainly internal and not so much to respond to external pressures such as legislation, customers, or competitors. The studies are aimed at improving the environmental performance of the products and, to a lesser extent, at facilitating environmental communication and marketing.

Table 4.
Objectives pursued by LCA studies

Objectives	%
Identify and evaluate environmental impacts to improve the overall environmental performance of the product	79.49
Serve as support in the framework of Ecodesign	56.41
Comparative study of different process or process phases	48.72
Comparative study of existing products with new alternative products	38.46
Information and training for consumers and other interested parties	38.46
Obtaining some type of Ecolabel or Environmental Product Declaration	38.46
As part of the product redesign process	33.33
Serve as support in calculations of Carbon Footprint	33.33
Comparative study between different raw materials	28.21
Collaborate with advertising and marketing policies	28.21
Identify energy saving opportunities	28.21
Comparative study of their products with those of the competition	20.51
Allocation of environmental costs	10.26
Comply with the criteria of Green Public Purchase to participate in public tenders	2.56
Determine purchase specifications and criteria for selection of suppliers	0
Others	2.56

3.3. Type of results obtained and the use made of them

First it must be said, that only one fifth of the respondents describe the results of the studies as conclusive and very useful. On the opposite end, one in ten companies considers them inconclusive, and therefore, little useful. In any case, most companies classify them as reasonably useful, although they recognize that complementary studies are necessary, Figure 9. Moreover, regarding the predictability of the results, eight out of ten respondents acknowledge that they have confirmed, in part or totally, the initial suspicions and highlight the fact that not even one of the respondents has described them as surprising.

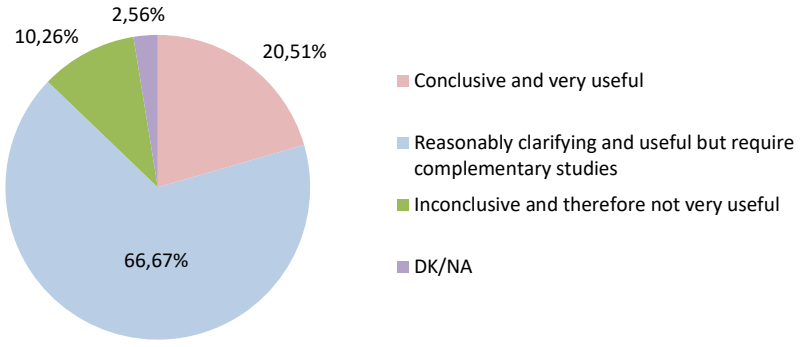

Fig. 9. Opinion on how conclusive are the results and their usefulness

Other results show that although more than half of the companies make an exclusively internal use of the results, the proportion of companies that use them also involving suppliers,

customers, etc. nearly reaches 40%. However, it should be noted quite paradoxically, that seven out of ten companies claim to publish all or part of the results, while only one in four directly admits not doing so.

3.4. Benefits provided by LCA studies

In relation to the benefits of LCA studies, respondents were asked to rate, according to a Likert-type scale from 1 to 5 (1 very scarce, 2 scanty, 3 moderate, 4 important, 5 very important), the positive impact that LCA studies have on different aspects of the company. The results are shown in Table 5.

Table 5.
Positive impact of LCA studies on the company

Impact	Mean Value	Variance	95% Confidence interval for the Mean Value
Perception of the company by public institutions	3.97	2.13	3.50 – 4.42
Improvement in the environmental impact of the company	3.74	1.22	3.40 – 4.10
Perception of the company by customers	3.49	1.95	306 – 3.94
Decrease in costs	2.82	1.34	2.44 – 3.16
Improvement in employee satisfaction	2.51	1.41	2.13 – 2.87
Increase in economic benefit	2.33	1.75	1.92 – 2.75
Increase in billing	1.90	1.09	1.55 – 2.20

The impact that LCA studies have on those economic magnitudes linked to profitability such as cost savings, increased sales, and increased profits, is rated by respondents as scanty with average ratings below three in all cases. In the view of the respondents, however, LCA studies moderately improve the perception that both clients and public administrations have of the company, although to a lesser extent in the case of the former. Finally, the improvement of the environmental performance of the products is the best valued impact, bordering on the qualification of Important.

Companies are therefore, quite cautious regarding the benefits provided by LCA studies, and generally admit the improvement of the environmental performance of their products and the improvement of the image of the company. However, they hardly perceive an increase in the economic benefits due to LCA studies.

3.5 Characteristics of the Studies

i. Table 6 shows how Complete studies are the most common type of study well above Simplified ones. Quite surprisingly, it also highlights the fact that no company has selected the Screening studies option.

Table 6.
Type of LCA study conducted

Type	%
Complete	61.54
Simplified	38.46
Screening	0.00

ii. Probably one of the most important results, although quite predictable at the same time, is that just one out of three companies claims to include all the stages of the life cycle in their studies. Regarding the stages considered however, it is only worth noting that the recycling has a somewhat higher consideration than the rest of the stages except logically the manufacture of the product that is considered by all companies, Figure 10.

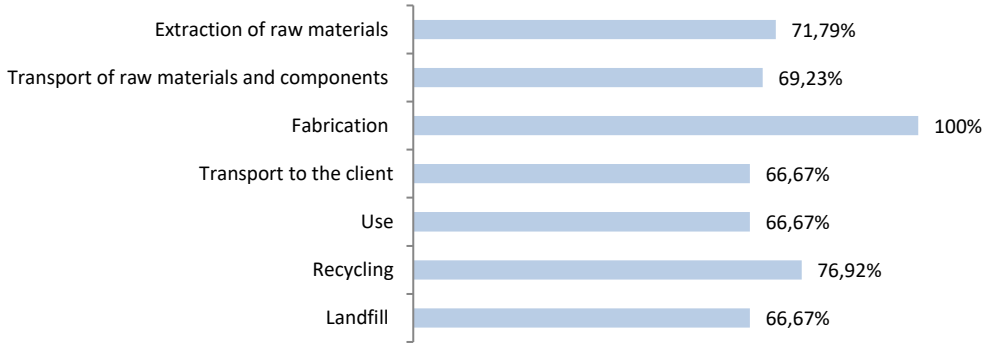

Fig. 10 Life cycle stages considered in the studies

iii. Impact categories are not all considered with the same frequency, the most common being the greenhouse effect, acidification, and eutrophication with the percentages shown in Table 7.

Table 7.
Impact categories considered in the studies

Impact category	%
Global warming or greenhouse effect	69.23
Acidification	61.54
Eutrophication	61.54
Depletion of stratospheric ozone	51.28
Resource consumption	48.72
Formation of photochemical oxidants	48.72
Waste	46.15
Human toxicity	33.33
Ecotoxicity	30.77

iv. As Figure 11 shows, just over half of the companies acknowledge never carrying out the critical review which is a quite worrying result. Moreover, there is also a high level of respondents that marked the Don´t Know/No Answer (DK/NA) option. On the other hand, only 15% of them claim to have applied the Critical Review to all their studies, although a few more affirm that they have applied it, even if only to some of them.

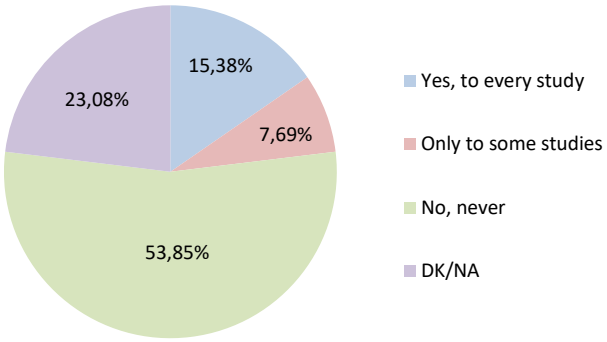

Fig. 11. Use of Critical Review

v. Interestingly the results confirm the usefulness of the existing international standards on LCA. In fact, companies that confirm the use of this type of standards exceed 80%. More specifically, almost 6 out of 10 companies recognize using ISO 14040, while other standards also indicated by the respondents, although to a lesser extent, are ISO 14006 for ecodesign, and those that regulate ecolabels and EPDs ISO 14021, 14024 and 14025.

vi. Regarding computer support, Ecoinvent Data, Eco-it and PE International are the main databases while Simapro, LCA Manager, Ecoscan and GaBi seem to be the most popular LCA software. Finally, Eco Indicator-99, CML 2001, Recipe and IPCC are amogst the most common impact assessment methodologies according to the respondents.

vii. A very interesting result in terms of the importance that companies give to the LCA is shown in Figure 12. Companies do not seem to perceive LCA as a mere tool for environmental improvement but they also see it as a support instrument for strategic decision making as in almost two out of every three companies the studies are coordinated by the Product Research and Development department. The Environment department does it in only one third of the cases and also interesting is the fact that neither the Production Department nor the Top Management have been appointed by any company.

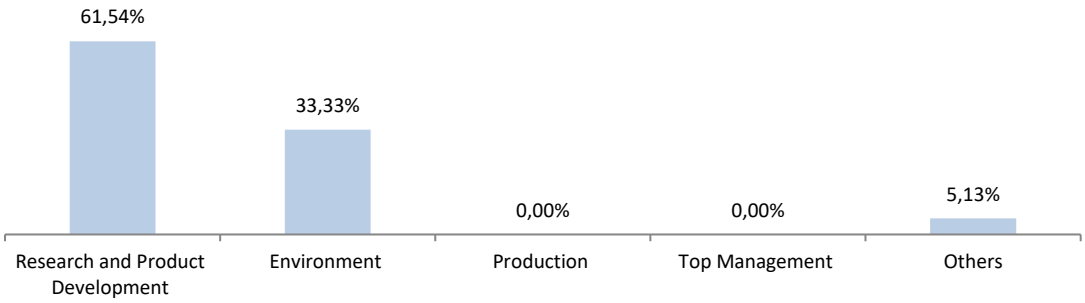

Fig. 12. Responsible for the studies

3.6. Needs and obstacles

As with the benefits, the respondents were asked to rate the importance, according to a Likert-type scale from 1 to 5 (1 very scarce, 2 scarce, 3 moderate, 4 important and 5 very important), of a series of obstacles.

The results of Table 8 show that the drawbacks related to data and methodology are perceived as more important than those related to the need for resources. The difficulty of collecting data is considered the main difficulty with a mid-way assessment between important and very important. Actually, everything concerning the obtaining and the reliability of the data is seen as a source of difficulties of moderate importance in the best of cases. On the other hand, the training of personnel, the cost of labour and the cost of software, although all fall within the range of moderate obstacles, receive lower valuations. Thus, the main barriers identified by Basque companies refer to the quality and availability of the data, as well as to the complexity of the methodology itself above the need for resources.

Table 8.
Degree of importance of obstacles

Obstacle	Mean Value	Variance
The difficulty of collecting the data	4.56	0.49
The difficulty to include all stages of the life cycle	4.13	0.82
The difficulty to include all environmental impacts	4.10	0.79
The quality of the data	4.08	0.91
The excessive time needed	4.08	0.79
The lack of databases and the updating of existing ones	3.95	0.84
The complexity of the methodology itself	3.85	1.03
The difficulty in defining the limits of the system	3.74	1.00
The difficulty to evaluate and interpret the results	3.62	1.12
The lack of experts	3.62	1.96
The lack of trained personnel	3.33	1.44
The high cost of labour	3.15	1.58
The high cost of the software	3.13	2.19

There are also some other results that seem to reinforce the idea that LCA is a complex methodology that requires significant efforts. Thus, the vast majority of companies, 87.18%, acknowledge having needed training to carry out the studies, most of them on the methodology, and one out of three on the use of the software. Moreover, it is also an almost unanimous phenomenon in the Basque Country to hire external consultants to carry out these studies as 4 out of every 5 companies acknowledged having done so.

However, somehow paradoxically, the time needed to carry out a study is apparently short, since a quarter of companies say it takes less than three months, while only one in ten points it takes more than a year, Figure 13.

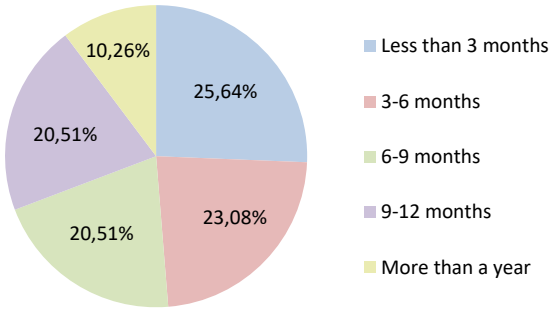

Fig. 13. Time needed to conduct a study

Finally, despite the fact that the need for resources is not among the main obstacles identified by the companies themselves, seven out of ten acknowledge having obtained external financial assistance to carry out the studies, mostly from autonomous, provincial, or local institutions, with just a few getting funds from national or European Union agencies. Among the affiliates, about 40% also admit having received funds from their parent companies.

3.7. Perspectives

i. The majority of respondents consider that LCA is still very little known among companies, although those who already use it are somewhat less pessimistic about it, as can be seen in Figure 14.

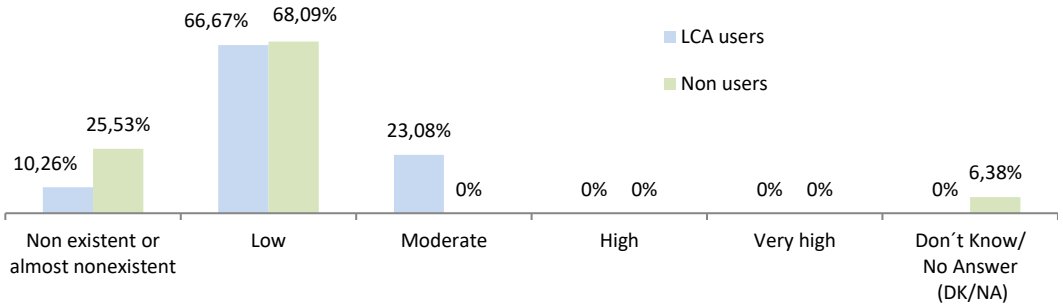

Fig. 14. Opinion on the knowledge of the LCA among the surrounding companies

ii. Very few companies that have already used the LCA openly acknowledge that they will stop doing so, in fact, most of them confirm their intention to continue using it. Regarding the intensity of this use, slightly more than half of the companies state that they will maintain their current level and only one in five intends to increase it. On the contrary, one out of ten will decrease their efforts, as shown in the Figure 15.

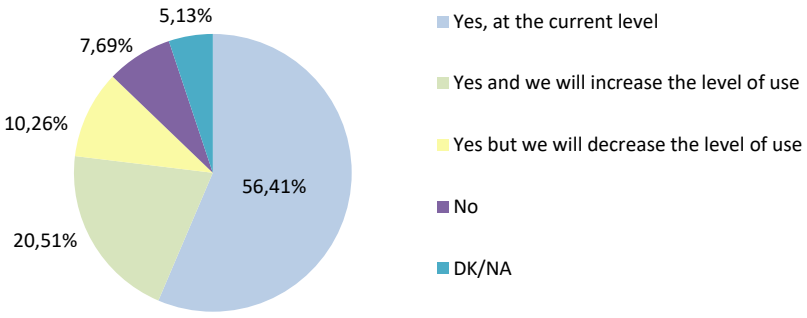

Fig. 15. Intention to conduct LCA studies in the future

On the other hand, when asking companies that do not still use LCA about their intention to start doing so, the results are not as positive, as shown in Figure 16. Only one in four companies confirm their intention to perform this type of study in the future while slightly more than half directly admit that they will not.

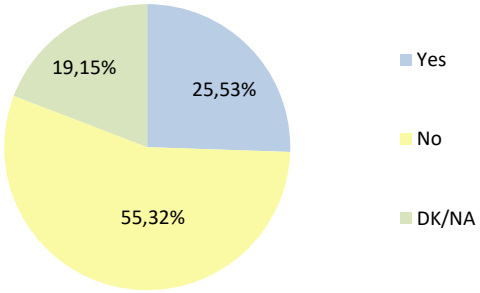

Fig. 16. Intention to start using LCA

iii. A quite negative feeling is perceived among the companies about the help they receive from public institutions in this area, as shown in Figure 1. Worryingly more than one out of every three companies in the sample qualifies the effort that public institutions make to promote the use of LCA as little or null, and another third consider it to be just moderate. Those companies that consider it important hardly reach 25%, and not even one describes it as very important.

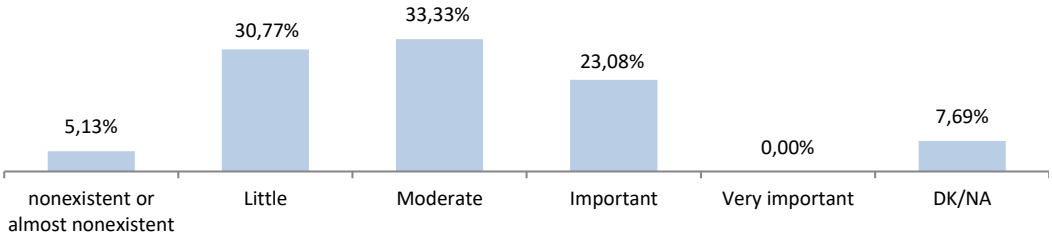

Fig. 17. Opinion on the effort of public institutions

However the results actually suggest that companies are generally optimistic about the future of the LCA. Optimism that is clearly confirmed when they are directly asked about it, as shown in Figure 18. Among users the majority believe that LCA will be a tool of widespread use in the future. Among non-users however, the opinion is not as positive, although those who say that it will be generalized are still more. It is also worth mentioning the high percentage of DK/NA type answers which reveals a high degree of uncertainty over this matter.

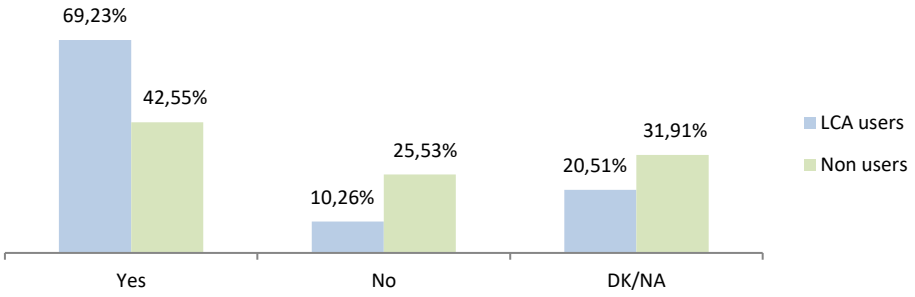

Fig. 18. View on the generalization of the use of the LCA

4. Discussion and limitations of the study

In view of these results, it can be concluded that in most cases the companies that use LCA in the Basque Country are large both in terms of number of employees and billing. This conclusion coincides to a large extent with those contributed by several authors already mentioned in this paper (Huang and Hunkeler, 1995; Green Research, 2011; Lewandowska, 2013b).

As shown in the results section the main drivers of the companies to use the LCA are internal and not so much to respond to external factors such as legislation or customers to name a few. In this case there is a certain level of discrepancy with the conclusions drawn by (Huang and Hunkeler, 1995, Berkhout and Howes, 1997, Green Research, 2011) (Franckl and Rubik, 1999) who, as seen in section 2, concluded, although with different nuances, that the market is the main motivation to develop LCA studies.

On the other hand, in line with previous studies such as (Berkhout and Howes, 1997; Cooper and Fava, 1999; Green Research, 2011; Lewandowska et al., 2013b), the main barriers identified by Basque companies are those related to data and the methodology itself and not so much to the necessary resources.

Basque companies, also admit the improvement of the environmental performance of their products and the improvement of the image of the company due to their efforts in LCA, in line with what was pointed out by Green Research (2011) and Cooper and Fava (2006). However, unfortunately they do not believe that LCA studies provide better economic results as it was also pointed out by Green Research (2011).

Regarding the process and the methodology, comparisons with other works have been more complicated, although some similarities and discrepancies have also been identified:

Basque companies have mostly carried out their LCA studies based on the ISO 14040 standard, which coincides with the results obtained by Cooper and Fava (2006). However, while they generally carry out complete LCA studies and not even one claimed to have carried out exploratory studies, the latter appeared as the most frequent in Green Research (2006). They also mostly apply their studies to some of their existing products and not so much to new products while Franckl and Rubik (1999) pronounced themselves in a similar way, affirming literally *"(...) LCA is mostly used for a few existing products, and is clearly not used for green products only".*

There is also a notable consensus that impact categories are not considered with the same frequency. As in the present work, Huang and Hunkeler (1995), Lewandowska et al. (2013b), and Broberg and Christensen (1999) also appreciated significant differences in the impact categories considered by the studies. There is even a certain similarity between the impact categories most frequently used by Basque companies and those identified as the most common by Broberg and Christensen (1999), the greenhouse effect, acidification, and eutrophication in the former case, and, depletion of resources, acidification, and greenhouse effect in the latter.

Basque LCA users recognize that critical review is unusualt against what Cooper and Fava (2006) affirmed in their work carried out among LCA practitioners. It is true, however, that the latter offered somewhat contradictory results; although all the respondents claim to have participated in critical review processes, 45% of them also acknowledged having taken part in LCA studies where this phase was not carried out.

Regarding the widespread use of external consultants by Basque companies to carry out LCA studies it should be mentioned that Broberg and Christensen (1999) observed this same pattern among Danish companies. However, given that Baumann (1996) and Grotz and Scholl (1996) in their investigations with Swedish and German companies had obtained the opposite

results, they concluded that Danish companies were probably still in the adoption and learning phase of the LCA, and that probably, their smaller size (in relation to the German and Swedish companies) and their consequent limitation of resources were the cause of it. Perhaps the same can be deduced from Basque companies regarding the learning phase but not in terms of the size of the companies given that, as already indicated, in the Basque Country LCA is mainly used by large companies with great resources.

To conclude with the discussion of the results and to facilitate a better understanding of them, the main limitations of this research are listed below:

- Limitations due to the quantitative nature of the methodology that do not allow a deep understanding of the phenomena discovered by the methodology itself. Therefore, it would be interesting to complement this study with others that sharing the same objectives would use qualitative techniques. It would also be advisable to extend the scope to other agents involved, such as consulting firms and public institutions.
- Although the sectoral distribution of the sample shows similarity with the population, it is true that there are some significant differences. The Machine Tool sector for instance is overrepresented in the sample while Building and Petrochemical sectors are underrepresented.
- Finally, it is likely that the difficult economic situation during the responses collection period has avoided a greater number of them. Probably, it has also negatively influenced the responses on the benefits provided by the studies or the difficulties they pose.

5. Conclusions

A first aspect that deserves to be highlighted is the existence of a delay of ten years in the beginning of the use of LCA by Basque companies in comparison to those of the leading countries in LCA. While (Guinée et al., 2011) called the first decade of the present century the "Decade of Elaboration", in the Basque Country the first studies appear in this period and it is in the following decade when their number increases considerably.

The picture of the situation in the Basque Country shows that LCA is still a little-known tool used in most cases only by large firms which mostly belong to the machine tool, construction, furniture, electrical equipment, and automotive sectors. In fact, LCA is still perceived as a complicated methodology that provides quite predictable results, that are used mainly internally without involving external agents such as suppliers or clients, and which generally requires complementary studies. It is also worrisome to see how in the opinion of the companies it provides few economic benefits, although its capacity to improve the environmental behaviour

of the products and the image of the company is recognized. Anyway, companies think that its use will become widespread in the future and claim they will continue using it at least as intensely as they currently do although they complain about the scarce institutional support for its use.

The fundamental challenge therefore is to increase the general knowledge of the methodology, so that its use can expand to those sectors that are now more delayed, and SMEs can be incorporated into the LCA community, something essential if you take into account that 98.7% of the companies in the Basque Country have less than 50 employees (Eustat, 2016b). For this, it is not necessary in the opinion of the authors, the definition of new instruments; these mechanisms already exist and are perfectly described in the already mentioned IPP of the EU (EC, 2003). The key is a real and honest commitment by companies and public institutions to implement these mechanisms or reinforce those that are already being used. Basque institutions must become main actors in this process, acting in two fronts, as buyers, through programs of green public purchases, and as facilitators offering financial aid, tax incentives, training programs, marketing campaigns, consumer awareness programs etc. As for the private initiative, it is necessary to make greater use of the influence that large companies, users of the LCA and with great traction power over the supply chain, have on the whole business network. These companies should encourage their suppliers to incorporate the LCA into their dynamics. To this end, a greater number of collaborative projects and benchmarking processes would undoubtedly be desirable, but also, in a similar vein to the green public purchase programs, by requiring their suppliers to use the LCA as they have already done in other fields, such as quality or OHS.

Hopefully this work can help in the preparation of a diagnosis on the situation of the LCA in the Basque Country which in turn, would be useful in the design of public policies in favor of sustainability. On the other hand, once the most advanced sectors have been identified, using their experiences and through benchmarking strategies, the use of LCA can be promoted among those other sectors pointed as lagging behind. The machine tool sector can play, in the opinion of the authors, a particularly important role in this sense due to its enormous relevance both in the Basque economy and in the industry. This sector, deeply rooted in the region, has numerous leading international companies which, as already mentioned, have adopted this tool with enthusiasm.

Finally, there are also in the opinion of the authors, some considerations worthy of attention by the international community of LCA.

The realization of the Critical Review is undoubtedly well below the desirable levels, so it is imperative, for the credibility of the methodology itself, to strengthen this aspect. For this purpose it would be advisable for the entire LCA community to demand its realization beyond the cases established as mandatory in the ISO 14040 and ISO 14044 standards. However, the process should probably also be simplified and the number of professionals trained to carry it out increased. On the other hand, given the poor opinion of the companies about the economic benefits reported by LCA, it is vital for its popularization to undertake new studies that address this specific aspect and that provide more detailed and accurate information in this regard.

Fnally, some kind of certificate on LCA could also help broaden its knowledge. Concepts such as Carbon Footprint, Ecodesign or EPD are all well known due in part to the success of certifiable schemes in the Basque Country. However, although the LCA is intrinsic to some of them and even mandatory in the case of some EPDs, the LCA is known mainly by specialists and even many environmental professionals have limited knowledge of it.

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