Chapter 1

A New Perspective for Labeling the Carbon Footprint Against Climate Change

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Additional information is available at the end of the chapter

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1. Introduction

Irrespective of the current social and economic problems, the fact is that hurricane-force winds hover over our current way of life, and ultimately over our very civilization. Progressive deforestation, water shortages, loss of biodiversity, the scarcity of natural resources exposed to their own ecological limits. The result of all of this is the relentless generation of waste, emissions and discharges into an increasingly limited absorptive capacity of the planet.

The economic debt, in any form, whether it is consumer-related, national or foreign, which we hear about every day on the news, is insignificant compared to the ecological debt we are acquiring. In 1997 a study by the team of Robert Costanza, specialist in environmental economics, estimated the average value of the global ecosystem services to be around the 33 billion dollars annually. That same year the global GDP was only 18 billion. For example, the Global Footprint Network (GFN) calculations of April 2011 showed that Spain entered an "ecological debt" situation, having consumed by that time the total annual budget in terms of natural resources.

It is possible to adapt an economic model, to fix it, and replace it, but trying to expand the planet is simply utopian. Like it or not, our planet is finite and a finite system is incompatible with a subsystem (economic) whose paradigm is based on continuous and unlimited growth. Somehow we have to reconcile growth and sustainability, and to do so, our companies need to access transparent and comparable information to be able to make the best decisions so as not to compromise either their growth or the impact on the planetary ecosystem.

Obviously, growth and better living conditions have to reach developing countries where per capita income is less than a dollar a month, but it doesn´t seem consistent to raise growth based on production patterns that are supported by 'dirty' technologies in developed countries. Identifying sinks in a critical absorption situation and ecosystems with a falling supply in natural resources, on which we base our economy, are critical to our survival.

One of the most critical impacts identified during the last century was the likely failure of the absorption capacity of our atmosphere to operate as a sink for so-called greenhouse gases (GHGs) without producing drastic changes in climatic conditions. These gases are named for their characteristic ability to pass short wavelength radiation from the sun and retain heat from the earth in the form of long wavelength radiation, which leads to the greenhouse effect.

Reports issued by the Intergovernmental Panel on Climate Change (IPCC), which includes the largest community of experts, are warning us that, like everything in life, a little bit of everything is good but too much of one thing can be lethal.

One of the main problems is the extraordinarily high rate of GHG emissions which our society has been generating for more than 100 years. This inhibits any reaction from the flora and fauna as well as the human race, which is encountering an increasingly unpredictable system from a climatic point of view. The planet will absorb these greenhouse gases without any problem, but the species that inhabit it will have enormous difficulties in adapting to new conditions. The scenario painted by the experts could not be more daunting, and urgent warnings for action must be sent out to the general public, businesses and individuals.

In answer to this impending scenario, Carbonfeel has been designed with a core mission: to organize information and knowledge on the carbon footprint, making it universally useful and accessible to all society. In short, the point is to provide companies with the best available techniques for calculation and exchange of information within the processes of inventory, management, reduction and offsetting of GHG emissions generated by their own activities.

This information will allow companies to participate actively in improving their behavior, without having any effect on their business. Quite the contrary; their activities will start to focus on production patterns based on eco-efficiency and eco-design, and therefore lead to a reduction in costs. Moreover, customers will recognize a continuous improvement effort based on a credible label supported by many different certifiers, consultants, companies, associations, universities and others.

The message is very clear to society. Various organizations have joined together to facilitate the expansion of a responsible economy to help businesses generate goods and services in a friendly environment, avoiding the wide variety of labels and certificates with a commercial purpose only. We understand from Carbonfeel that making business compatible with and respectful of the environment is not an option, rather it is the only valid way for modern business. Whether we recognize this or simply look away depends on the conscience of each and every individual.

Carbonfeel provides the public and private world a true environmental accounting system based on the universal indicator, the carbon footprint (CF), a scorecard that will help them choose the best practices in their processes and procure less intensive goods and services, all tending towards a low carbon culture.

2. The Carbonfeel project

2.1. Why Carbonfeel? The initiative

Carbonfeel (http://www.carbonfeel.org) is a collaborative initiative promoted by the Environmental Forum Foundation (http://www.forumambiental.org), the Interdisciplinary University Group Carbon Footprint and the technology company Atos (http://atos.net). The project provides procedural solutions, methodological and technological processes of calculation, verification, certification and labeling of the carbon footprint both at the corporate level and in terms of products and services.

Any organization that has in its principles of corporate social responsibility the fight against climate change as a priority, is invited to participate within the profile appropriate to their interests, either actively collaborating in the dissemination of calculation and verification projects, or simply calculating their footprint. Through this network of collaboration we have a carbon footprint that is truly accessible, transparent and comparable.

Carbonfeel starts out from a methodological basis proposed by the Compound Method based on Financial Accounts (MC3), inherited from the ecological footprint concept that has been extended worldwide by its creators William Rees and Mathis Wackernagel (http://www.footprintnetwork.org). The project takes advantage of other emerging methodological trends such as GHG Protocol, PAS 2050 or ISO 14064 standards and the future ISO 14067 and 14069, in order to get an approximation of the real calculation.

Supporting an integrated approach, the incorporation of information technologies makes Carbonfeel an innovative project that has burst into the market to completely change the focus of the classic studies of life cycle analysis, whose drawbacks in cost and study time had already been reported by different analysts. This also became evident after the announcement in January 2012 of the multinational company Tesco (a pioneer in carbon footprint labeling), which, after five years of activities in projects of calculation, abandoned its initial plan to label all their products with their carbon footprint, blaming the fact that "a minimum of several months of work" would be necessary to calculate the footprint of each product and the lack of collaboration and monitoring of suppliers and other retailers.

The Guardian previously reported that Tesco would take centuries to fulfill his promise, as the supermarket adds labels at speeds of 125 products a year. A Tesco spokesman expressed their expectations to new ways of undertaking the calculations "We are fully committed to the carbon footprint and to helping our customers make greener choices. No final decision has been taken and we are always on the lookout to find ways to better communicate the carbon footprint of products in a way that informs and enriches our clients".

Other corporations that have undertaken calculation at the corporate level express their disappointment at not being able to assume scope 3 (the footprint inherited from their suppliers) because of the lack of standardization and collaboration in the supply chain, which makes the inclusion of the suppliers' footprints in this puzzle completely unreliable.

The great paradox of the Carbonfeel method is that companies get a carbon footprint at the corporate level and the life cycle of all products and services without any restriction on the scopes, with the information provided in great detail. Moreover this information is more extensive and of a higher quality as it is based on primary data (real footprint of its suppliers), and all at a cost and a time frame fully accessible to any corporation.

The telematic assembly technique provides an entire life cycle, where each corporation analyzes its own emissions (scope 1 and land use) on an autonomous basis for calculating the indirect footprint or inherited from its suppliers by the telematic assembly.

This report shows step by step how it is possible to have more and better quality information to help companies transform their patterns of production and consumption habits towards a low carbon culture, and all this in a way that is totally accessible to the entire business community, from micro-businesses to SMEs and large corporations.

2.2. Mission and objectives

The network of actors involved in the initiative offers our society a way of working with a clearly defined mission and objectives:

Mission

- Organize information and knowledge about the carbon footprint, making it universally useful and accessible to all society.
- Promote new patterns of production in organizations and a real transformation of consumer habits in society, both directed towards a low carbon culture.

Objectives

- Standardization of a methodology for the calculation of the carbon footprint based on an integrated approach (organization and product/service), always in strict compliance with the existing international standards in use, both at the corporate level (ISO 14064, GHG Protocol and future ISO 14069) and product level (PAS 2050 and future ISO 14067).
- Standardization and automation of the verification and certification processes of the carbon footprint.
- Make available to the general public an accesible, transparent and comparable labeling process of the carbon footprint.
- Incorporation of all the above points in the information society through the use of the new technologies required in the initiative.

As mentioned previously, countless labels and certifications are saturating the market. Some of these are based on calculation methods that have been accommodated to certain interests of the contracting company, a fact which only serves to undermine the credibility of the different studies. This type of dynamics is being used by companies interested in 'greenwashing' their products and actions. This sometimes leads to an unfair scenario in which companies that are truly committed to the environmental improvement of their products are put in a situation where their clients can not appreciate the goodness of their acts.

Carbonfeel emerged as a proposal that incorporates a common language based on consensus to the vast network of actors involved in the calculation of the carbon footprint. It is based on information technologies which allow data exchange to flow quickly and reliably, providing accounting and labeling processes that are renewed annually.

Carbonfeel seeks the incorporation of all types of businesses into the process of calculation and certification. It is no longer a marketing tool only affordable to large corporations, but has become a basic environmental accounting tool for the future assessment and analysis of improvement actions. Thus, even the smallest company will be eligible for certification. Moreover transparency is ensured under the rules and calculation methods accepted by all, without any problems related to subjectivities or cut-off criteria in the delimitation of the calculation, and thereby obtaining comparability as a source of competitiveness.

The reasons why a project like Carbonfeel has arisen and keeps on growing daily, fall under four different perspectives: social, economic, environmental and institutional.

- **Social perspective**: introducing concepts such as the carbon footprint and eco-labeling, which today are still unknown (in 2010, only 23% of Spanish consumers, compared to 94% of British or 97% of Japanese, had heard about the carbon footprint, according to studies conducted by TNS).
- **Economic outlook**: making it easier for companies that actually opt for an alternative "green" production style so that they can have a favorable commercial scenario and, thereby, facilitating their growth.
- **Environmental perspective**: promoting a real change in production patterns in organizations and a real transformation of consumer habits towards a low carbon culture.
- **Institutional perspective**: providing consensual solutions that may allow the homogenization of the many initiatives of institutions at national, regional and even local levels, who want to inventory, monitor and promote attitudes and sustainable practises in businesses and citizens.

2.3. Holding the roof

If we ask ourselves what kind of results a carbon accounting method should provide, the most appropriate answer is to help reduce emissions of greenhouse gases. Any other purpose would seem banal. Isn't the carbon accounting technique supposed to combat climate change? Because if the idea is to use it as a tool for promoting green products and the corporate image, then there are better marketing tools without having to pervert a method that was created for a very clear purpose.

Therefore, disregarding other objectives related to the current economic situation, we must pay attention to an overview of the results in the attempt to find a working method for calculation, verification and labeling which will be truly useful in the fight against global climate change. Indeed, there is nothing more useful for companies than to provide information that facilitates the reduction of emissions in relative terms (per unit of production of a product or service, and emissive intensity), but also in absolute terms (for the whole corporation). It's of little use if we lower emissions relatively while, on the other hand, corporate emissions grow due to other actions that are not within the scope of the current study.

The roof

Imagine that what we want to do is build a house with a roof called "to lower emissions" and the aim is that the roof should be as large as possible, so that the larger the size of the roof, the greater our success in fighting climate change.

But we cannot put a roof over nothing; we need a structure that supports it. What are the requirements, given that the greater the support, the greater the roof "to lower emissions" will be?

The beams

To lower carbon emissions there are few roads to choose from. A simple but subtly devastating vision of the problem indicates that we can do basically three things:

- Change our patterns of production, either by identifying processes for improvement, identifying good product design that is more environmentally friendly in the vector of climate change.
- Identify measures of eco-efficiency in the consumption of energy and materials in our business and production processes.
- Change our habits, both from the standpoint of providing information to the final consumer (B2C) of our products and services, and to provide ourselves with information from our network of suppliers (B2B) in order to help us to inherit the smallest footprint possible of products and services that feed our production system.

These are the three basic and essential beams required to sustain our roof, and if they are well-managed they will allow us to reduce emissions from our corporate activities.

Note that all three require the processing of data quickly and reliably. Let's explore this point that will lead us to the following levels of support for our house.

The columns

How can we change our production and consumption patterns, and at the same time identify eco-efficient measures in our activities to help us cut emissions?

There is a clear answer to this question ... we must have reliable and quality data, and this information must have three properties that ensure the stability of our house:

- Accessibility
- Transparency
- Comparability

Let's consider each of these three points together because all three are intimately intertwined.

We refer to **accessibility** as the option for all businesses, from the smallest company to the large corporations, to make a claim for a carbon footprint certificate for their products, according to the prices and time frames of the projects adapted to the size of the contracting company, without omitting, in any case, the other two pillars: transparency and comparability. The incorporation process of calculating all the business is necessary; a global problem requires the involvement of all.

At present, the size of projects based on calculation techniques using the classic life cycle analysis, in which a link in the chain (the company who wants to calculate the footprint of its product) bears the burden of the whole calculation effort by drawing up complete process maps for the product and its life cycle. However, owing to the sheer size of these projects, both financially and operationally, they cannot be assumed by the majority of small and medium-sized enterprises.

Negotiating the scope of the studies, a common practice adopted by many companies to reduce costs, isn't the solution because it prevents reliable management and threatens the basic column of the home we propose to build: the **comparability** of results.

Therefore, the method needs to be accessible to all companies so that they will have a chance to show their carbon intensity, and thus, to improve themselves using benchmarking techniques supported by the comparability of results.

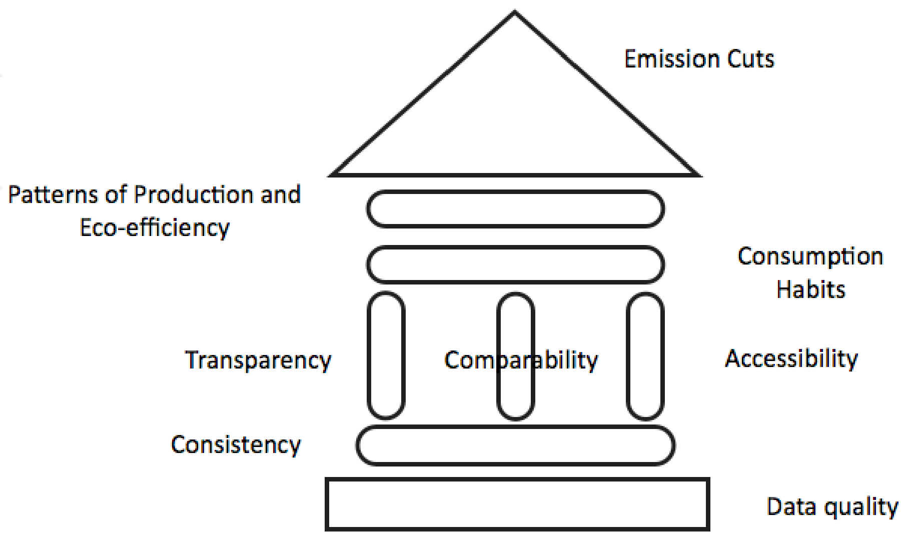

Figure 1. Requirements for a useful carbon accounting method in the fight against climate change

The existence of a spreadsheet calculation scheme that ensures the same scope for any project provides credibility and confidence to companies who want to 'play' on a scenario with identical rules and conditions. Thus, each company will be sure that their calculations have been carried out in the same way as their competitors.

This assumption is necessary to obtain an exemplary and transparent certificate, and the only way to do this is by a reporting method in line with a clear and objective scheme of calculation. How many times have we read about the total emission compensation for a given organization, where it is impossible to compare the study limits, calculation schemes and data sources that underlie the study?

Indeed, many of them are just "green-washing" strategies that confuse consumers and prolong a scene truly unfair to companies that are committed to an environmental strategy for its activities.

Transparency will provide confidence to all stakeholders and will eliminate from the carbon footprint market opportunistic corporations with marketing labels that try to displace corporations that are truly committed to sustainability and fighting climate change. Under these conditions of non-transparency, the proposed house will have little chance of supporting the roof that today's world demands of us.

Finally we will describe below the column that will provide definitive support to the structure.

Comparability is one of the most wanted features in a carbon footprint labeling process. It is essential to boost competitiveness in favor of corporate environmental improvement. Without comparability, the carbon footprint has no meaning and becomes just another environmental label.

A green purchasing policy, public or private, means including the carbon footprint as a standard for the environmental certification of products and services. The lack of comparability is one of the main excuses given by certain business sectors not to accept or promote green purchasing policies based on the concept of the carbon footprint.

Corporations seeking solutions that may allow them to flood the market with products and services with a lower carbon load need to identify improvements. Without comparable references in the market, these companies cannot carry out their mission; they cannot buy less carbon intensive goods in the market.

The foundation

These columns, representing accessible, transparent and comparable information, require a foundation to support them. This is what gives strength to the structure:

- Data consistency
- Data quality

To understand what consistency means in this context, it is necessary to explain the great paradox of the carbon footprint, which, in the words of Juan Luis Doménech, chief ideologue of the MC3 methodology, clearly shows how inefficient it is to maintain separate approaches to the corporation and products.

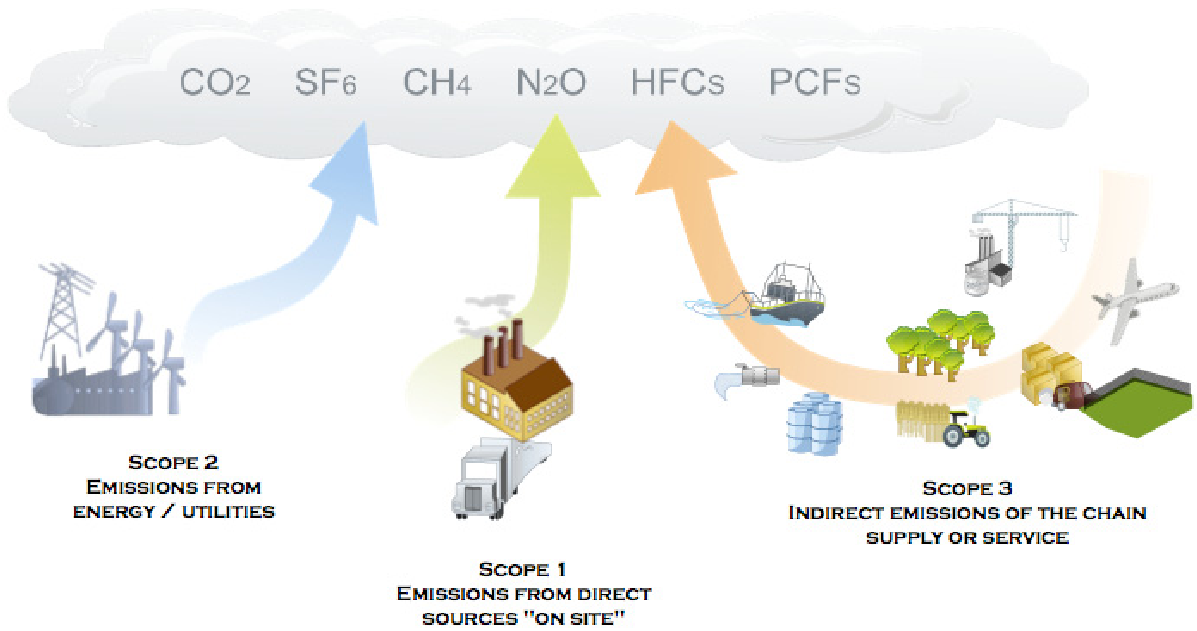

Figure 2. Classification of activities subject to emission rights (scope 1 and 2 are adopted)

"The methods of the classic life cycle analysis or methods focused on processes (ACV-P, PAS 2050) are not easy to implement as they require the participation of several companies on the value chain. Data acquisition based on the "most relevant processes" varies according to the analyst, and the "cutoff criteria" (as the value chain could be infinite) seriously compromise the comparability between products.

On the other hand, methods focused on the organization (such as ISO 14064 and GHG Protocol) are partial; they allow emissions called "scope 3" (materials, services, contracts, travel, construction, waste, etc.) to be voluntary and may vary from company to company. This also undermines comparability, at least for now, unless future editions correct this situation. On top of this, they are free to choose the calculation method of the actual carbon footprint and the emission factors. The latter should only come from reliable sources."

Carbonfeel is committed to an integrated approach, in which, as in any cost accounting method, partial studies are abandoned and a global vision of the company as a GHG emitter is undertaken in order to enter the gases emitted into the company's accountability in all the products and services generated.

This is the consistency which we are referring to. In the economic sphere, any accountant generally applies an integrated approach. Any other alternative with a partial character would not be accepted by a financial department. The corporate carbon footprint and the footprint of products and services that have no consistency will never be able to offer a scenario based on comparability, and therefore we will be seriously damaging a fundamental column of our building.

Finally, there is a basic foundation that supports the entire building: the quality of the survey data. To address this point, we must first distinguish the subtle difference between primary data and secondary data.

Primary data are obtained from a source through direct measurements, or provided by the same supplier that certifies that measurement to us in the case of an inherited footprint. In some ways it is a fact that closely reflects the local situation under study.

When primary data are not accessible due to the high cost in obtaining this information or simply because the provider does not provide it, we turn to what is called secondary data, provided by reliable sources. Conversion factors, databases or simulation tools give us a valid approximation to the data.

Logically, it is desirable that the calculations are supported by primary data to have a better approach to the real data. However, in the current state of the art, this is not true, and there is a lucrative business to be had in providing companies with secondary data to support their calculations.

Somehow these secondary sources, which are needed in the current state of the art, indicate, for example, that 100 gr. of sugar has a given carbon footprint load based on a life cycle study carried out under certain conditions. This figure is only a simplification that causes almost all companies to end up giving the same results for their studies due to the fact that all of them are based on the same reference data, rather than relying on the myriad scenarios that make up the current sugar production situation. It is not the same to have a local supplier, in this sugar production process case, than one that is 10,000 km away.

Thus, when discussing data quality, we refer to the fact that the proposed working method should be oriented towards the development and distribution of raw data (actual data derived from measurements provided by the supplier), and not to the business of secondary data. The role of secondary data in a calculation methodology is necessary, but as an alternative, not as an end.

2.4. State of the art

Before getting into the working method of Carbonfeel, we must make some comments on the state of the art which will help provide some insight into the advantages offered by the proposed method.

In a study commissioned by the European Commission in 2010, a total of 80 corporate CF calculation methodologies were identified, and 62 in the approach to products or services, each with countless variations and sectorial "sensitivities".

It could be said that once the calculation has been made, even within the same methodology, the results can be quite different depending on the analyst conducting the study, the collaboration of the chain and data sources used.

Obviously, there are a wide variety of reasons why companies choose to use a corporate approach or a product approach. Corporate carbon footprint studies are mainly undertaken when the company's activity is subject to emission permits and therefore it is mandatory to do so. In addition to this, a company may undertake these studies to communicate a green image to third parties and finally, these studies are undertaken to identify possible sources of inefficiencies that result in cost savings in energy and resources.

In the product approach, interests have nothing to do with the emission permits, but lie closer to the promotion of products by associating them with a green image, to meet the requirements of international customers, and even to identify improvements in the eco-efficiency of the production process and the use and disposal of the products and services under study.

As shown, they are all partial interests. If a company undertakes annual corporate carbon footprint studies in order to contribute to the fight against climate change, these partial interests will automatically be fullfilled as they will have a real environmental accounting method with relevant information to manage and communicate as they see fit.

Carbonfeel proposes a method that gets more and better information at a lower cost, which favors the annual monitoring of this type of accounting, as in the field of economics.

We cannot imagine a company doing accounting processes only every two or three years, so why is it acceptable in the environmental field?

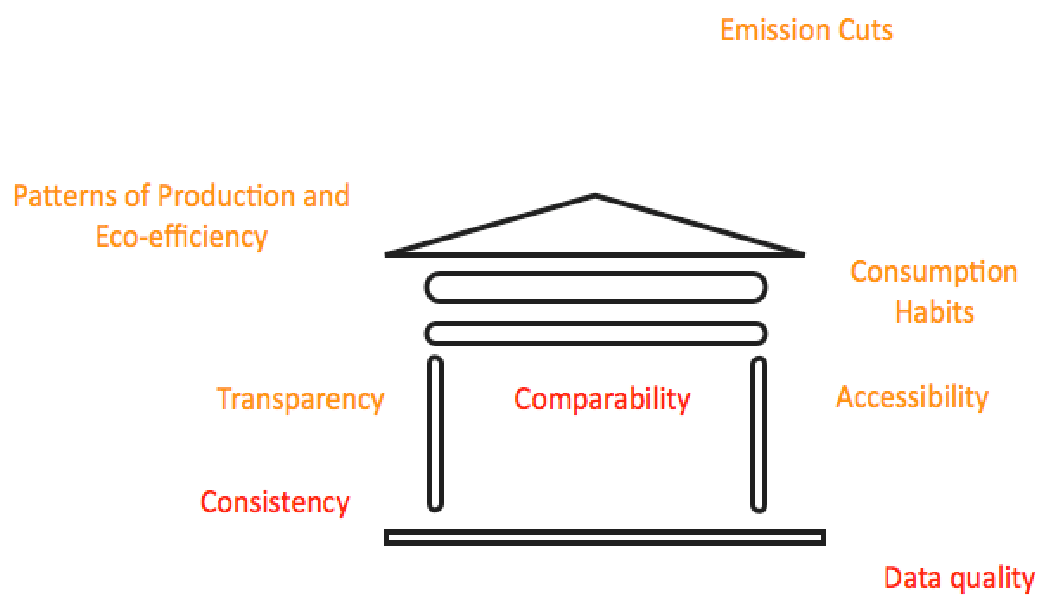

Figure 3. What does the state of art tell us?

The answer is obvious, because there are no available data to avoid the great effort in terms of time and economics that a company must exert if it wants to undertake this type of environmental accounting.

While we have outlined the difficulties of conducting studies with partial approaches (corporate vs product/service level), let us do a brief inventory of the current situation and its impact on the construction of this building whose roof we call “emission cuts".

The calculation process at a corporate level faces the following obstacles:

- Great difficulty reaching scope 3. Collecting the supplier’s indirect footprint is an impossible mission for many corporations. In addition to the procedural difficulty involved in "forcing" providers to do the calculation, it is based on a totally non-standard assembly process in which each provider chooses the method to calculate the footprint of their products. This creates great distortion and the results lack credibility.
- Voluntary choice of the calculation method, and the scope and the emission factors as long as they come from 'reliable sources'. This leaves the spreadsheet open.
- Inconsistency with the footprint of products or services when these are calculated.
- Legislation compliance (CO_2 emission rights) rather than searching for scenarios of competitiveness among enterprises.
- Risk of outsourcing scope 3. Indeed, if it is decided not to calculate the footprint, then all that is needed is to outsource the activities (eg. transportation) so as not to include the footprint in the studies as they are not part of scopes 1 and 2.
- Risk of dispersion of the network. This is perhaps the most serious drawback. The corporate carbon footprint, despite all the potential it has to do a complete analysis of the corporation’s resource consumption, may become a mere bureaucratic procedure.
- It is not possible to compare emission intensity. The basic indicator that informs us about CO_2 emissions per monetary income of a corporation is disabled by not including all ranges in the calculation studies.

Regarding the approach to products based on a life cycle analysis, the following are identified:

- Great difficulty in project development since the participation of many companies is required. Projects become a repetitive search for information within a company network usually with little willingness to cooperate, either because they are not interested, or because it is hard work getting the required information. This causes unaffordable time and costs for many corporations.
- Accessibility based on the negotiation of the scope of studies. As it is virtually impossible to face the whole cycle with all its ramifications, the cutoff criteria may be capable of being negotiated subjectively, simply according to economic criteria.
- It calculates potential impacts, not real impacts. By eliminating corporate carbon accounting, LCA studies face process maps with theoretical material, according to data provided by companies on inputs and outputs, data which are based on patterns of behavior often very far from the business reality under study.
- Risk of “tailor made” labeling. One of the biggest risks is the profusion of non-transparent product labeling, based on studies whose sole purpose is to bring carbon footprint labeled products to the market but with hardly any verifiable indications.

- No application criteria of secondary sources. The method is mostly based on secondary data support, on which there is no consensus either locally based or sectorial, causing distortion in the calculations and avoiding possible scenarios for comparison.
- High subjectivity of the analyst and the contracting firm on the calculation specifications.
- Comparability is ruled out due to problems arising from the above points. Comparability can not be assumed.
- Indirect carbon charges are dismissed. Studies based on process maps rule out carbon loads from 'non relevant' processes for the corporate character. The relevance or non relevance of these processes is not regulated or is difficult to verify.
- Focused on the business of secondary data. In order to rule out the primary character of the data due problems with availability, secondary data bases, which are hard to upgrade, are promoted. These data provide estimations, but in no case can they calculate a carbon load close to the real business performance.
- Inconsistency of product-level calculations from the corporate perspective. Life cycle assessments lose business perspectives. They focus on the product in search of patterns of behavior, leaving aside the real carbon loads of the corporations which belong to the chain under study.

2.5. The integrated approach: The key question

Once the open points of the approaches are detected, we shall see in this section the calculation of both the corporate and products/services footprint. The method not only closes many of these points, but reinforces consistency, transparency and finally ensures the comparability of results opening up a spectrum of possibilities for action in the business world to encourage changes in production patterns, eco-efficiency and consumption habits.

Paradoxically, a calculation based on an integrated approach is both more economical and more complete. It includes all ranges. The company stops worrying about the tracking of emissions that are out of view (scope 3 in the approach to corporate and upstream approach to product based on LCAs) and focuses exclusively on the part of their responsibility, the direct emissions and the organization’s land use. Therefore, time of calculation is drastically reduced, making it assumable to all the business.

There is no doubt that if a corporation is seriously facing a study of carbon footprint with high quality information in order to improve emissions intensity of their activities (Kg of CO_2 emitted by € of income), an integrated approach has to be undertaken.

If we talk about accounting, there is no general manager that takes more seriously into consideration the importance of data quality and consistency than a CFO. This CFO, when performing cost accounting, never conducts an 'upstream' research on costs which has impacted the income statement of its products in the life cycle. Obviously it is impossible to assume such studies because no longer are they economically sustainable and results are useless due to the uncertainty that they cause. He simply counts the costs of the organization and then splits them between the actual production, which gives a true picture of the corporate cost accounting of each of their products and services.

So, why does a Director of Environment face ACVs projects with a high level of economic demand for accounting the carbon footprint of its products, when it only provides potential emission values as it misses the whole business perspective? We can list many reasons, but, from the technical point of view, we would say that it is impossible to assess the actual cost or carbon footprint per functional unit of each good or service purchased by the organization. This is the key difference between why a CFO carries out an integrated accounting and why a Director of Environment cannot perform it.

But, if this should be solved, if somehow someone had a method that moved all purchases, usually in monetary value, to carbon footprint, the problem would be solved, at least in part.

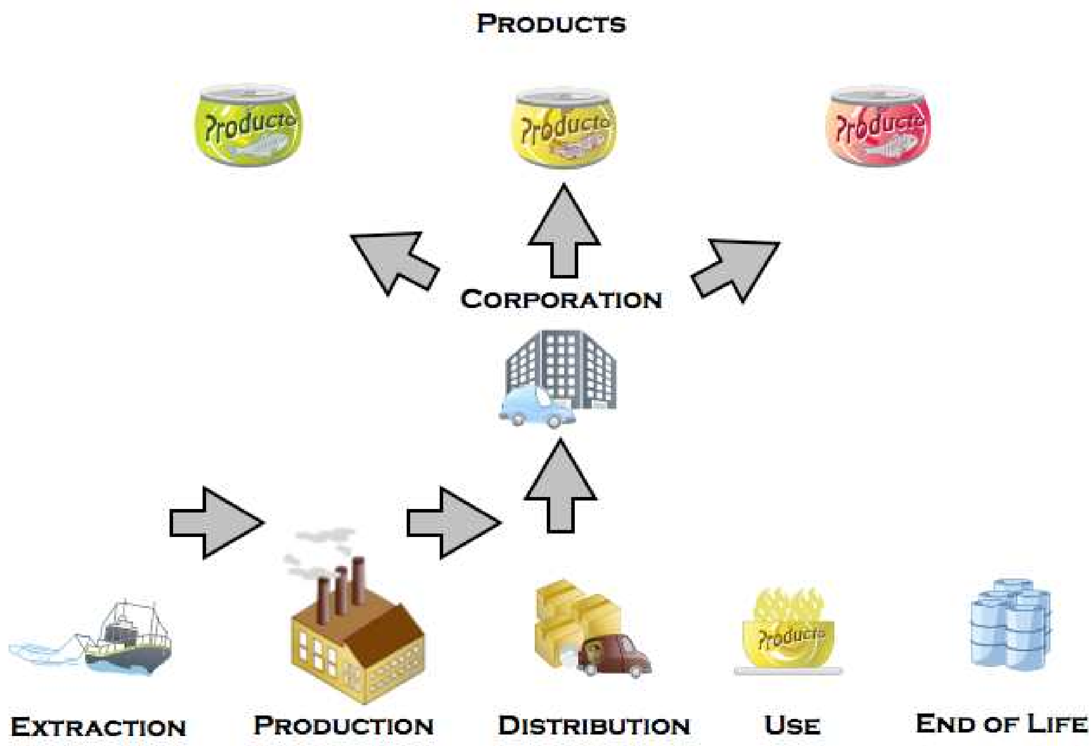

Figure 4. The integrated approach

2.6. The Compound method based on Financial Accounts (MC3)

The Compound Method based on Financial Accounts (MC3) has two different uses. Firstly, the MC3 provides an inventory of materials, goods, services and generated wastes transformed into a common unit, $EqtCO_2$. This information is useful to elaborate environmental policies and corrective measures based on the CF at an organizational level.

Secondly, the footprint of a company can be assigned to the produced goods. In this case, the organizational footprints assess the product's CF across the supply chain, identifying the footprint at every phase of the life cycle. The distribution of the footprint of every organization among the produced goods requires unitary footprints expressed in Gha/t and/or tCO_2/t. When a firm purchases a good, the acquiring company will use unitary footprints to estimate his organizational footprint.

Organisation level

The MC3 was developed by Doménech [1,2]. Initially the method assessed the CF of companies and organizations. Nowadays, the method also estimates the CF of goods and services throughout the supply chain.

In both cases, the starting point of the MC3 is the estimation of the CF of organizations. This chapter briefly describes the method at this level. A more detailed explanation can be found in [1-4].

The origin of MC3 can be found in the concept of household footprint [5]. In this way, based on the matrix of consumptions versus land present in the spreadsheet for the calculation of households' footprint [5], Doménech [1] prepares a similar consumption land-use matrix (CLUM) (see table 2), which contains the consumptions of the main categories of products needed by a company. The land-use matrix also includes sections for the wastes generated and the use of land. These consumptions/wastes will be transformed into land units and greenhouse emissions [6]. Carbonfeel initiative has improved this CLUM matrix, including new categories of products, emissions and conversion factors (MC3.V.2).

The needed information to estimate CF using MC3 is mainly obtained from accounting documents such as the balance sheet and the income statement, which clearly state the activities that are associated with every entity: MC3 estimates the footprint of all the goods and services considering information from financial accounts. Wastes generated and built-up surface by all the facilities of the company are also included. Further information from other company departments with specific data about certain sections (waste generation, use of land by the organization's facilities, among others) may also be necessary in case this information is excluded from the financial accounts. The footprint is calculated in a spreadsheet, which also works as the CLUM matrix.

The rows of this CLUM matrix show the footprint of each category of product/service consumed. The columns present, among other elements, different land-use categories for CF, into which the footprint is divided. Columns are divided into five groups. The first one (see column 1) corresponds to the description of the different categories of consumable products. These are classified into 9 major categories showed in Table 1. One can include as many products as desired within each category.

The second group (columns 2–6) shows each product's consumption, expressed in specific units. The units in the first column of the group are related to product's characteristics (e.g., electricity consumption, in kWh). The second column indicates the value of the consumptions in monetary units, while the third shows consumptions in tonnes. The fifth column reveals energy corresponding to each consumption expressed in gigajoules (GJ), obtained by multiplying tonnes of product (third column) by the quantity of energy used by tonne in its production (GJ/t) (fourth column) [7].

Consumption sections	Consumption categories
1. Direct emissions	1.1. Fuels 1.2. Other direct emissions
2. Indirect emissions	2.1. Electricity 2.2. "Other indirect emissions"
3. Materials	3.1. Flow materials (merchandise) 3.2. Non-redeemable materials 3.3. Redeemable materials (generic) 3.4. Redeemable materials (construction) 3.5. Use of public infrastructures
4. Services and contracts	4.1. Low mobility services 4.2. High mobility services 4.3. Passenger transport services 4.4. Merchandise transport service 4.5. Use of public infrastructures
5. Agricultural and fishing resources	5.1. Clothing and manufactured products 5.2. Agricultural products 5.3. Restaurant services
6. Forestry resources	
7. Water footprint	7.1. Consumption of drinking water 7.2. Consumption of non-potable water
8. Land use	8.1. On land 8.2. On water
9. Waste, discharges and emissions	9.1. Non-hazardous waste 9.2. Hazardous waste 9.3. Radioactive waste 9.4. Discharges in effluents 9.5. Emissions 9.5.1. GEG Gases Kyoto Protocol 9.5.2. Other GEG or precursors 9.5.3. Other atmospheric emissions

Table 1. Sources of emissions considered in the carbon footprint (MC3.V.2)

Energy intensity factors comprise the amount of energy used in the production of every product included in the CLUM matrix, considering an average supply chain. At this moment, they are mainly obtained from the European Commission [8-10], Simmons [11], Wackernagel [5,12] and different public institutions such as Spanish Office for Climate Change (OECC) and The Institute for Energy Diversification and Saving (IDAE) and Intergovernmental Panel on Climate Change IPCC [13]. The third group of columns

(columns 7 and 8) show emission factors for every category of product. Emission factors are mainly obtained from the European Commission [8-10,14,15], IPCC [13], OECC and IDAE.

The fourth group contains six columns (9–14) showing the distribution of the footprint among different categories of land. These are the same as that used for the countries' ecological footprint (CO_2 absorption, cropland, pastures, forests, built-up land, and fishing grounds).

Finally, MC3 estimates the organizations' counter footprint. The counter footprint concept starts from the positive regard for the companies' availability of natural capital, despite the desirable reduction of their footprint by being more efficient and by curbing consumption. Therefore, investments in this kind of productive space reduce their footprint. In this way, this indicator could encourage the private sector's involvement in the preservation of natural spaces [2], as which is positive in terms of sustainability [6].

Product level

Since the year 2005 a team of researchers from the Universities of Oviedo, Cantabria, Valencia, Cádiz, Santiago de Compostela and La Coruña, coordinated by Juan Luís Domenech, have been developing MC3 at an organisation level. A member of this group, Adolfo Carballo-Penela, of the University of Santiago de Compostela, has broadened the scope of the method to products, and has developed the theoretical and practical knowledge needed to determine how they should be ecolabelled [3].

Information from products considering supply chains is useful for both, companies and final consumers. Companies can reorganize their existing processes, obtaining environmental improvements and reductions of costs. Ecolabelling processes based on CF allow consumer's purchase decisions to have a positive influence in achieving a more sustainable world.

From the MC3's perspective, CF throughout the life of a good or service considers those land and emissions required/generated by each of the companies involved in its production, from the phase of raw materials up to the retail point. Every company itself is a phase of the supply chain.

Figure 5 shows an example of this way of proceeding. In this case, the supply chain is composed by four companies which produce canned tuna fish: a fishing company, a preserves company, a carrier and a restaurant. If the customer of the restaurant applies for lower CF products, the restaurant must reduce its footprint to meet this demand. Actions like reducing consumption of goods and waste generation, recycling activities, or technologies that are more efficient would be effective in this case. The purchase of goods with a lower footprint is also a valid option, replacing present suppliers for other lower-footprint providers. Asking present suppliers to reduce their CF and, therefore, their product's footprint is a possible recommendation as well. The demand for lower footprint products can be extended to all the participants of the considered lifecycle and to all the goods of the economy.

Product category	Annual consumption					Emission factor		Footprint by productive space						CF	Counter footprint
	Consumption units	€, $, …. without VAT	Tones	Energy intensity	GJ	[eqt CO_2/t]	[t CO_2/GJ]	CO2 absorption land	Cropland	Pastures	Forests	Built-up land	Fisheries ground		
	[unit/year]	[€/year]	[t/year]	[GJ/t]	[GJ/year]										
1.- Direct emissions															
2.- Indirect emissions															
3.- Materials															
4.- Services and contracts															
5.- Agriculture and fishing resources															
6.- Forestry resources															
7.- Water footprint															
8.- Soil use															
9.- Waste, discharges and emissions															

Table 2. Structure of the spreadsheet showing the CF CLUM matrix.
t: tonnes; VAT (value added tax)

The adoption of MC3's supply chain approach requires establishing links among the CF of the different companies of the supply chain. When each of the participants in the lifecycle of a product acquires different goods from the company situated in the previous phase, they are also acquiring the CF incorporated in that good. If every participant communicates the unitary footprints of the goods and services that produces (e.g. eqtCO2/t of product) to the following phase of the supply chain, the needed connection is made. Footprints per tonne of product (unitary footprints) are obtained dividing the total footprint of every company by its production. Table 3 collects an example of this way of proceeding.

This case is similar to that shown in Figure 5. In this case, a retailer replaces the carrier. This example assumes that each participating company produces only one tonne of one product, the canned tuna fish, which is purchased by the next company in the supply. Every company also acquires 1 ton of the rest of the used products. Information of the CF is shown in Table 3.

Company	CF
Fishing company (EqtCO_2/t of product)	8.0
Fuel (EqtCO_2/t of product)	2.0
Bait fish (eqtCO_2/t of product)	6.0
…	
Preserves company	15.0
Tuna fish (EqtCO_2/t of product)	8.0
Machinery (EqtCO_2/t of product)	7.0
…	
Retailer	17.5
Tuna fish (EqtCO_2/t of product)	15.0
Fuel (EqtCO_2/t of product)	2.5
…	
Restaurant	21.0
Tuna fish (EqtCO_2/t of product)	17.5
Electricity (EqtCO_2/t of product)	3.5

Table 3. An example of unitary footprints application in the lifecycle of canned tuna fish

The fishing company would estimate its footprint using the unitary footprints of the acquired goods, in this example, fuels (2.0 EqtCO_2/t of product) and bait fish (6.0 EqtCO_2/t of product). Considering these values, the CF of one tonne of tuna fish at this phase of the supply chain is 8.0 EqtCO_2/t of product. The preserves company acquires a tonne of tuna fish, which means, 8.0 EqtCO_2/t of product. This company adds footprint from the consumption of one ton of machinery (7.0 EqtCO_2/t of product), being its total footprint of 15.0 EqtCO_2/t of product, the only commercialized product of the preserves company.

In this example, the retailer's purchase of fuel generates 2.5 EqtCO_2/t of product. In addition, this firm acquires 1 tonne of tuna fish (15 EqtCO_2/t of product) from the preserves company.

This means a total footprint of 17.5 EqtCO_2/t of product of tuna fish, sold to the restaurant. This company also adds 3.5 EqtCO_2/t of product, from the electricity used in its activities, which implies a CF of 21.0 EqtCO_2/t of product of tuna fish at the end of the supply chain. This value would be showed in an ecolabel that collects the CF of this preserved fish tuna.

We want to remark that the total footprint of the tuna fish is not estimated as the sum of the footprint of all the companies involved in the supply chain (61.5 EqtCO_2/t of product). By doing this, the footprint of tuna is multiple-counted since every company includes the fish's footprint of the previous phase. The tuna fish's CF is estimated considering the added footprint in every stage of the supply chain.

Starting of the method

The use of MC3 to estimate the CF of products needs of unitary footprints for each of the categories of products collected in the CLUM matrix. These unitary footprints come from secondary data from pilot studies. The pilot studies are based on the energy intensities and emission factors usually used by the MC3, besides results from other supply chain studies that estimate the emissions from primary data.

The transmission of CF across the supply chain and its use as an ecolabel will depend on the will of the participants in the supply chain to estimate their footprint. The success of the adopted approach depends on the organizations' awareness of the advantages of estimating the footprint of their products. Environmental marketing differentiation and savings related to a more efficient use of materials and energy along the supply chain are relevant questions that should be considered [16]. However, Carbonfeel initiative will provide involved companies with enough information to estimate the footprint of the products they purchase.

The support of national or regional governments seems to encourage companies' participation in countries like the United Kingdom, where DEFRA and the Carbon Trust have developed a key role to accelerate the process. In the absence of public sector participation, interested companies should encourage customers and providers to estimate their CF and communicate them along the supply chain.

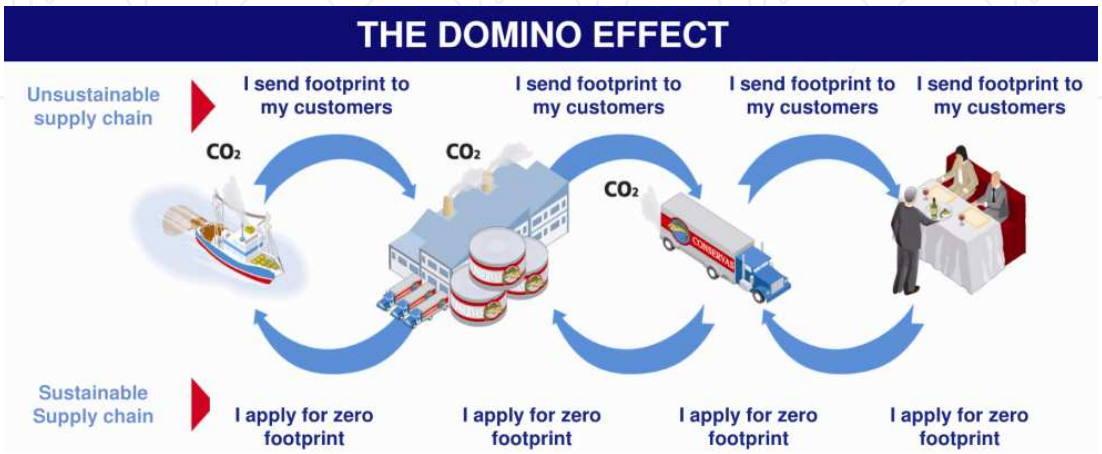

Figure 5. An example of supply chain according to MC3: tuna fish in preserve [2]

Boundaries of the analysis

MC3 is based on the cradle-to-gate life cycles. This means that MC3 assesses CF from the raw materials phase to the retailing phase, by including all the activities required to extract the raw materials for the product, manufacture the product, and ship the product to the point of purchase. MC3 does not consider footprints from the use and disposal of goods. MC3's footprints collect the demand of land/emissions of CO_2 of all the goods and services acquired by every company, the generated wastes, and the built-up land in each of the phases of the lifecycle.

Transmission of the information across the supply chain and ecolabelling process

In case of goods for final consumption and services, the information about unitary footprints (tCO_2/t) should be incorporated in the common price labels, tickets and similar documents. Invoices, delivery notes, contracts, budgets or any other documents containing prices should add CF information at the intermediate phases of the lifecycle. This is the way that the CF information is available during the entire life cycle and transmitted. Once Carbonfeel begins to work, information technologies will simplify the process of communicating footprints among companies.

When a company acquires a product, the purchase documents should include the unitary footprint accumulated until that moment and making possible to use that information for estimating its organizational footprint. If a supplier does not provide information on a product, Carbonfeel database will supply this information. This database includes the unitary footprints on standard lifecycles for the main categories of products included in the CLUM matrix. They are obtained from pilot studies. These unitary footprints show information from the different stages of the supply chain. Considering the case of the tuna fish (Table 3) different unitary footprints for "Tuna fish", "Preserved tuna fish", "Preserved tuna fish: retailer" and Preserved tuna fish: restaurant" should be available for the MC3 users. At this moment, the Carbonfeel database is under development. Obtaining detailed information about more goods and services requires an increase in the number of pilot studies.

Assessment of the exposed method

Similar to the other methodological approaches, the MC3 has some strengths and limitations, summarized in the following sections.

In previous articles, authors have stated that the MC3 is a complete, transparent and technically feasible method based on Wackernagel and Rees compound method. Working with MC3 does not require extensive expert staff inputs and everybody working with spreadsheets will be able to calculate CF. MC3 is also a flexible and complete method. MC3 can be adapted to the characteristics of different types of companies, collecting the footprint from all the products consumed and wastes generated by a company [7].

The fact that the information comes from accessible financial documents, and that every company covers a complete phase of the lifecycle implies lower economic and time costs, besides delimiting clearly the products and activities that are under analysis. This ensures comparability among products.

The theoretical presentation of the method requires determining participants in the supply chain. In practice, every company gets the environmental information of the purchased products from their suppliers or from the Carbonfeel database. According to the European Commission [17], the market could become a powerful force for delivering environmental improvement. The role of markets as the main source of environmental information on products, thereby absorbing environmental performance as a competitive issue, is an important strength of the method. The identification between a corporation and the supply chain phase also favours the collection of information, obtained from every company [6].

The way of estimating the CF avoids double counting problems with some intermediate inputs, a relevant question in this context [18,19]. Organisational footprints are useful in terms of making decisions on improving environmental performance of organizations but never in terms of aggregating environmental impacts. This aggregation is only possible in terms of the products.

This analysis is less detailed than conventional process-based life cycle assessment. The organization's activities are not divided into detailed simple processes that show the amount of energy, and materials consumed in every stage of the production. Instead of doing this, MC3 includes all the goods, services and wastes consumed/generated for the organizations in a period. The use of unitary footprints or energy intensities and other aggregated information allow MC3 to estimate CF.

Benefits of the integrated approach

Recalling the three basic pillars necessary for a carbon accounting method to be useful to the company in its fight against climate change, we note that an integrated approach, like MC3, provides a number of benefits that can solve many of the open issues identified in the approaches focused on the organization and on an individual product.

Transparency

- All calculations are based on reliable sources of recognized standing and free access.
- There are neither subjective criteria of the study design limits nor cutoff criteria, since the scope is complete.
- As a result, customers and consumers are well aware that the Carbonfeel label guarantees studies that have been conducted on an equal basis in all participating organizations. A company facing a Carbonfeel project can communicate this to the interested parties, who will accept and trust in these studies.
- The information is not just potential, it closely reflects the true business reality of the organization and provides critical indicators of emission intensity which, with the inclusion of all scopes, provides an idea of the company's situation in terms of carbon accounting.

Accessibility

- The information is found within the company; it isn't necessary to to get it from the network of suppliers. The calculation is completely autonomous and does not depend on other organizations.
- As a result, the study times are speeded up exponentially. This process will be optimized over time once the elements involved in automating the calculation, exchange and assembly of information have been identified.
- Moreover, the project cost drops dramatically by not requiring mapping processes and the subsequent investigation in the whole supply chain.

Comparability

- By not having to develop cut off criteria, studies ensure full comparability.
- In the near future it will be possible to design carbon footprint labels type III of sectorial goods and services as long as comparability of results is guaranteed.

Added to these benefits, the integrated approach provides a foundation which ensures that the three columns will support the building. The consistency of the results, defined as the consistency between the Corporate Carbon Footprint and the Carbon Footprint of products and services.

2.7. The pending issue

Note that an integrated approach can be improved by adding a foundation to provide greater stability to the building to be constructed, which results in more transparency, comparability and accessibility. It is therefore more likely to transform our patterns of production and consumption.

As mentioned, virtually all methods of calculation are oriented towards the use of secondary data when incorporating emissions from the lifecycle or footprint of our suppliers. Multiple databases with commercial or free access grow asynchronously, which adds a new point of controversy to the calculations, leading to a lack of comparability of the results.

MC3 provides the factors to estimate the carbon footprint based on sources and conversion factors that continue to be a secondary database such as, for example, used energy intensities.

We understand that a working method of carbon accounting should be aimed at facilitating the integration of primary data, i.e. the actual footprint of goods or services which are acquired or participate in a given life cycle.

The integrated approach favors this. If somehow we could operate like a CFO and get the cost of what you buy on each bill, i.e. the actual carbon footprint per functional unit that a Director of Environment has to charge to their accounts and then multiply it by the real consumption, we will be laying a vital foundation: data quality.

The 'green coin' can become a reality if we pay attention to the technological factor faced by the carbon footprint as a problem of information exchange.

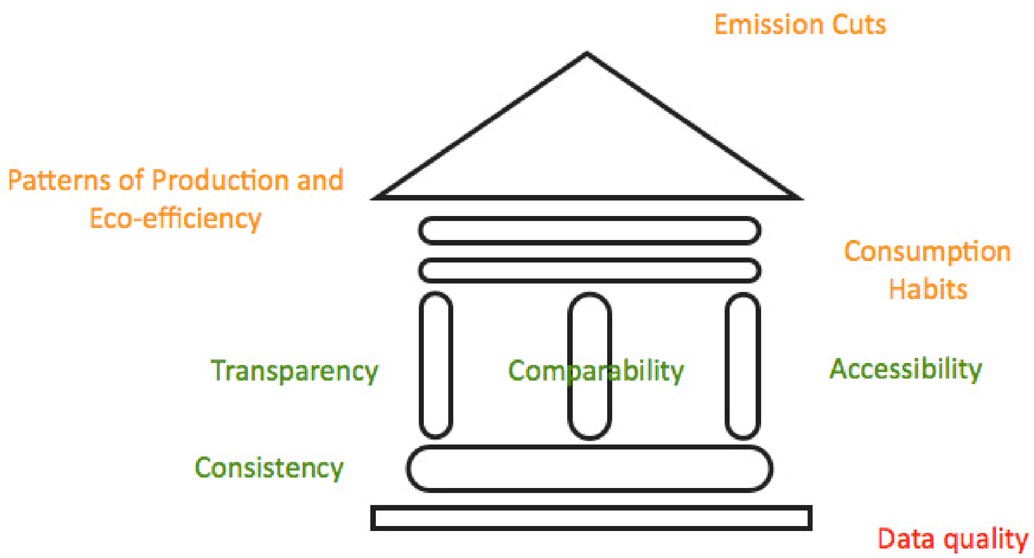

Figure 6. What does the integrated approach report?

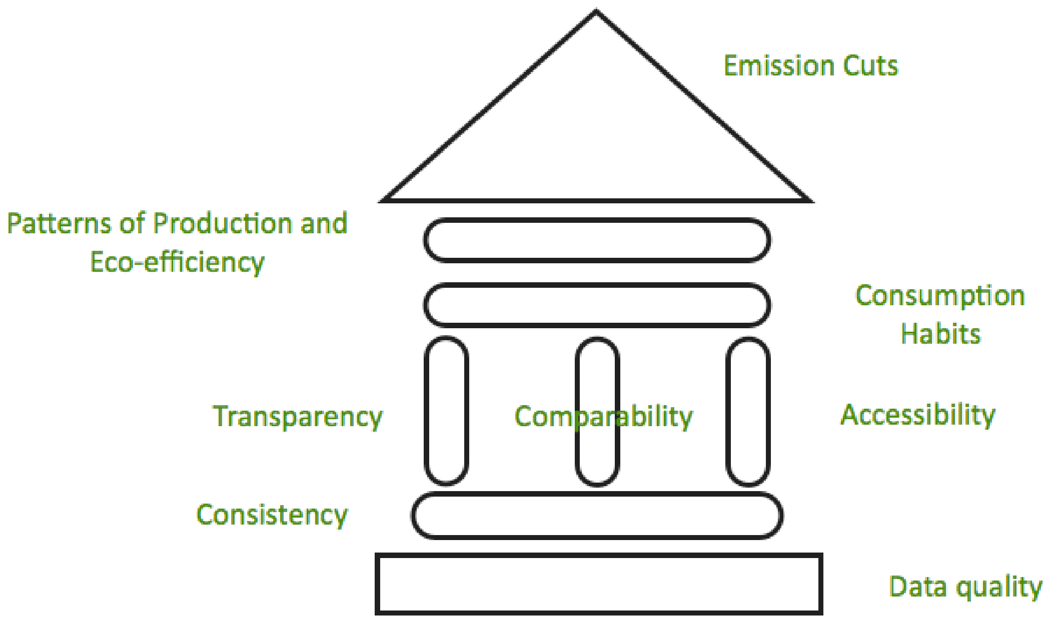

Figure 7. What does Carbonfeel provide?

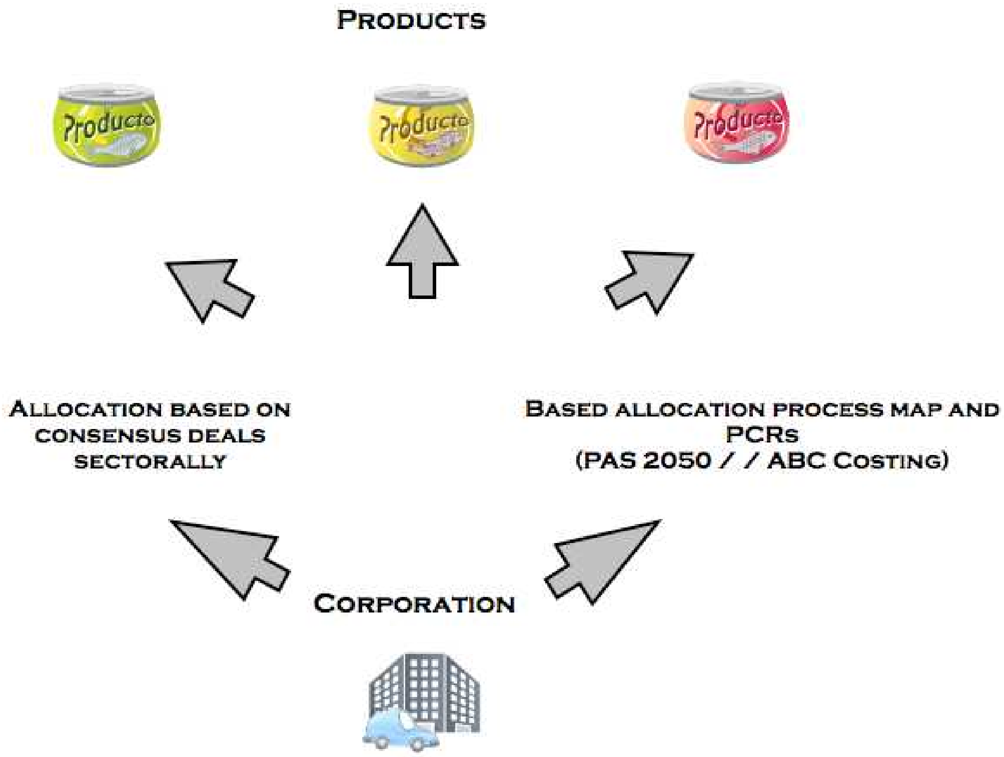

Figure 8. The integrated approach: moving from the corporation to the products.

2.8. Connecting the network: The role of information technology

Carbonfeel relies on information technology in order to provide the benefits of an integrated approach, the foundation related to data quality, i.e. obtaining the real carbon footprint of each good or service consumed.

This solves one of the great challenges of the technical studies related to life cycle analysis, which is nothing more than having the ability to 'assemble' the "real" footprint or primary data from each of links in the chain involved in the processes of the product life cycle to be calculated.

From the viewpoint of a computer analyst, this problem, faced from the perspective of the information exchange between various partners, requires only two things:

- Consensus on the semantics of computation
- Cooperation of the parties

Carbonfeel has a Committee of technical experts familiarized with MC3, input-output analysis, life cycle analysis such as PAS 2050, and others, which take the best solutions provided by each one to achieve an integrated approach. All this work is related to adopting some form of calculation. The semantic analyst's job is to compile these agreements into electronic dictionaries that provide the rules for computer analysts and databases so they can develop software able to calculate the carbon footprint based on these rules, and more importantly, to exchange information between different actors.

Assembling the life cycle

As discussed earlier, the mission of Carbonfeel is to organize information and knowledge about the carbon footprint, making it universally useful and accessible to all society. Translating this purpose to a practical language, we can say that, based on an integrated approach and the best available techniques, Carbonfeel determines how to calculate a carbon footprint on a neutral level (valid for any type of company), and also how to calculate the footprint for a particular sector. Sectorial standards will be created to be able to apply the rules to all economic activities sectors.

Once these standards, rules and calculation schemes are stablished, always in strict compliance with existing ISOs and future ISO 14064, ISO 14067 and ISO 14069, it will be possible to develop a software able to calculate, and what is more important, to exchange information between different actors.

Once the corporate footprint has been calculated, the deployment to products and services of the corporation is carried out primarily by means of two basic techniques which are, curiously enough, the same techniques that a CFO normally uses:

- Distribution of carbon loads directly to the products and services according to agreed sectorial schemes. This scheme is recommended for small and medium enterprises or corporations with little variety of products and services.
- Distribution of loads on a map of processes and activities. In fact, it is very similar to an ABC Costing study, well known in the accounting field. This method is ideal for the identification of inefficient processes and activities and is recommended for large corporations with complex process maps.

In the second case there is a clear connection with calculation techniques based on Life Cycle Assessment, already introduced into the market as PAS 2050 and Product Categories Rules PCRs. These may acquire a new dimension in the benefits they provide when focusing on an integrated approach.

With these raw elements, it is possible to consider (based on an integrated approach) combining the worlds of economics and the environment by implementing the carbon accounting system in exactly the same way that any organization does its financial accounting.

The idea is as simple as it is powerful. Each one of the goods or services purchased must be assessed as a debit in the footprint of the branch company. The products involved, goods or services sold generate the cumulative footprint passed on to the next link in the chain once the allocation of corporate footprint of the goods and services produced by the organization has been made.

Does this Carbonfeel footprint calculation represent a product life cycle as promoted by the standards of the ISO 14040 series? In fact, it is a life cycle from cradle to the gate, ready to be assembled in the following link (customer buying the product or service), but with a substantial difference as compared to a classic project. While in the latter the footprint has been calculated for a single organization (which has commissioned the study), with the assembly method, every link has estimated its own part of the whole life cycle, independently and based on actual footprints of its first level providers.

The question arises: what if the suppliers are not in the network of calculation and do not provide their footprint? This is the point where Carbonfeel resorts to the secondary data to come as close as possible to the reality of the study.

It is important to note that the integrated Carbonfeel approach is oriented towards a telematics assembly of "real" primary carbon footprint data. The secondary data cease to be the only possible data to take on an alternative role. The technology exists. Developing the semantics and required software is only a matter of time. The benefits are for everyone, in both the B2B and B2C environment. The entire network is benefited thanks to the accessibility provided by information technology. Government, businesses and citizens will have quality, consistent, transparent, comparable and accessible information. The building will have a strength that will help us fight climate change with better weapons.

A Carbonfeel project offers companies a real environmental accounting method based on a universal indicator such as the carbon footprint, which analyzes the corporation and each of the products and services generated.

Figure 9. Moving towards the green coin

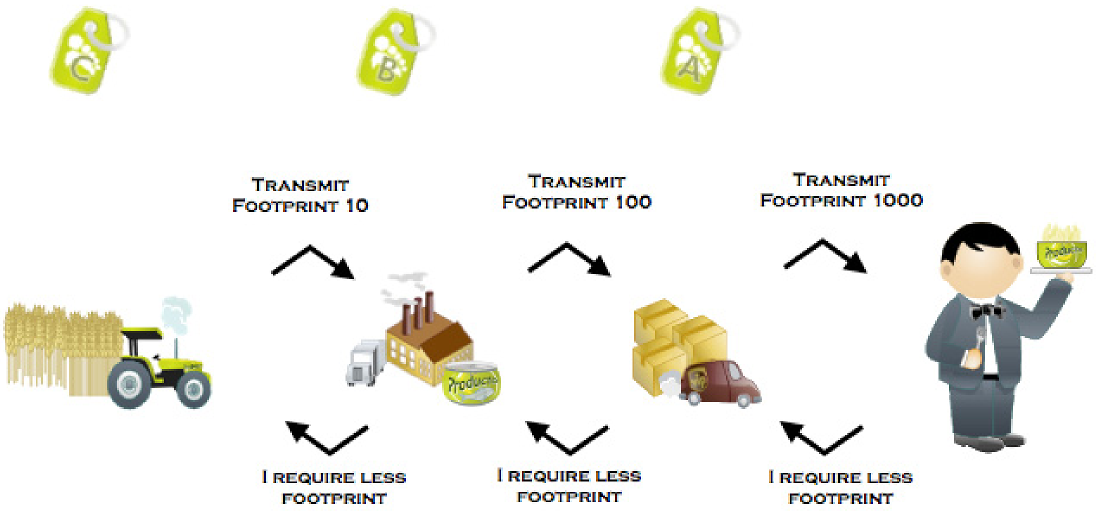

Figure 10. Global labeling (B2B and B2C)

3. Application of MC3 methodology and Carbonfeel philosophy in a case study: Calculation of the corporate carbon footprint of a cement industry in Spain

The climate change is one of the biggest problems the humanity copes with nowadays. Therefore, reducing the CO_2 emissions of sectors such as the cement industry, whose emissions account for roughly 5% of the total CO_2 emissions worldwide [20], is a primary goal in order to comply with the objectives laid down in the Kyoto protocol.

Throughout the next pages it will be presented the application of the organization-product-based-life-cycle assessment (hereafter OP-LCA) methodology (MC3) to three types of cement facilities in order to calculate the corporate carbon footprint of the cement manufactured in three different ways.

Our goal is not only to determine the footprint calculated in this way but also to demonstrate that the comparability between different brands and products is totally possible, thus providing a serious alternative to process-product-based-life-cycle assessment (P-LCA) methodologies. Moreover, as a result of the analysis, it will be also possible to identify the best ways forward to achieve the lowest possible footprint.

As mentioned, this case study was carried out with three potential scenarios in mind: Case A pertaining to a conventional integral plant which we will call "current", Case B which refers to a grinding plant and Case C, an integral plant which has been subject to the best available techniques (BAT).

The three scenarios were modeled with the same productivity of 1,000,000 t/year in order to simplify the comparability between them. Their differences as far as operability is concern can be drawn from the next descriptions of each one.

Case A – "Current integral plant"

In general terms, this type of plant includes a line that consists of the following processes:

After the crude cement has been ground and dried, the resulting product is a powder which is 80% calcareous, 19% clay and 1% iron corrector. The moisture is roughly 8%.

Next it goes through the four-step cyclone exchanger. There, heat is transferred from the gases to the crude cement; the residual moisture is dried; the water making up the clay is lost; and decarbonation begins.

After this operation, the crude product is placed into the rotating kiln at approximately 900ºC while the decarbonation, fusion and clinkerization reactions are completed. The fuel used is coke, which raises the temperature inside the kiln to nearly 2000ºC.

The newly formed clinker leaves the kiln at around 1500ºC and is then released onto a grate cooler, where it is cooled to 100ºC by means of air exchange. The gases from both the cyclone exchanger and the kiln are filtered before being released into the atmosphere.

Finally, the cement is ground along with the additives in a tubular ball mill until a particle size of roughly microns is achieved. The product is then packaged and stored until it is shipped.

Case B – "Grinding plant"

This plant receives the clinker from outside sources, generally imported from China and/or Turkey. Therefore, this plant simply grinds the outsourced clinker with the additives and ships the cement obtained.

At the present time, the great majority of the plants use closed circuit tubular ball mills with a highly efficient turbo-separator which allows the fineness of the cement to be controlled by means of centrifugal force. The dust is removed from the mill and the turboseparador by sleeve filters. Since the clinker may contain some moisture, the grinding facility usually has a hot gas oven. It does not generally have a drying chamber. Instead this process is carried out in the first grinding chamber. The final product, the cement, has a particle size of around 30 microns. It is transported by means of aerogliders to rubber belt bucket elevators and then to the cement stock silos. Finally the product is packaged and stored until it is shipped.

Since clinker is imported, the plants are forced to manufacture cement with the minimum percentage of this material, in order to cut costs. Therefore it is logical to use the maximum amount of subproducts as additives. However, we must remember that in Spain independent companies do not have access to materials like slag from blast furnaces or fly ash, which are monopolized by integral cement factories, which have exclusive agreements with the producers of these materials. Therefore, there are two possible options: either the manufacture of cement is carried out with limestone additives and a high content of clinker or with the use of materials such as bottom ash which may be classified as natural calcined pozzolana, since Standard EN 197-1 does not currently allow its commercialization as power station ash.

Case C – "BAT integral plant"

The operating process is the same as case A, but here the factory uses all the technologies and principles associated with the concept of the "Best Available Techniques" of the IPPC, at the current level. Below is a description of the latest innovations as compared to the previous reference.

After the crude product has been ground and dried, the dry powder undergoes homogenization, which produces a uniform product that facilitates even heating. This is carried out by means of a controlled flow system of the different layers of material as they enter the silo consisting of a mixture of compressed air at the exit of the filter, with or without a separate chamber. The stock of powder is the equivalent of around three days of kiln time.

Next the powder enters the cyclone exchanger, this time, during five successive steps, where the heat is transferred from the gases to the crude cement; the residual moisture is dried; the water making up the clay is lost; and decarbonation begins.

At the base of the exchanger, part of the total fuel is injected into the kiln, in the precalcination system, with the help of the combustion air supply from the head of the kiln through an ad hoc tertiary air duct. Fuel injection is carried out in several steps to reduce the emission of NOx.

According to the principle of BAT, the percentage of total fuel injected into the precalcinator is around 70%, with 30% being injected into the head burner (as opposed to 25% and 75% respectively in case A). Secondary fuels or waste materials such as used oils, paints, solvents and a certain amount of biomass are used.

The clinker leaves the kiln at approximately 1500°C, and is then released onto a high-efficiency grate cooler with air injection control grate plates, where it is cooled to 100°C by means of air exchange. Some of this air enters the kiln by the flue effect as secondary combustion air, and some goes to the tertiary air duct while the remainder is released into the atmosphere after being purified through the pertinent filter.

Similar to case A, the clinker is mixed with the additives and is ground, but this time, in a vertical mill with a highly efficient turboseparator that allows the fineness of the cement to be controlled by centrifugal force. Just like the other two cases, the final size of the particles is roughly 30 microns. Finally the product is packaged and stored until it is shipped.

Results and discussion

The results obtained with the computation tool are summarized in Table 4 to make them easier to understand and to be able to establish comparative criteria between the different scenarios.

CONSUMPTION CATEGORIES	**A - Current integral plant**	**B - Grinding plant**	**C - BAT integral plant**
Direct emissions	756.005,3	6.653,5	608.998,0
Indirect emissions	39.040,0	18.369,3	33.829,8
Material footprint	15.810,6	677.435,7	15.710,4
Footprint of services and contracts	2.818,3	131.728,7	2.825,1
Agricultural and fishing footprint	0,0	0,0	0,0
Forestry footprint	8.746,2	8.840,7	8.734,7
Water footprint	659,9	61,2	192,0
Soil use footprint	58,2	9,6	56,8
Footprint of wastes, emissions and discharges	180.428,3	59.344,6	119.943,1
Soil use counter footprint	11,6	2,5	11,6
TOTAL FOOTPRINT	1.003.566,8	902.443,3	790.289,9
TOTAL COUNTER FOOTPRINT	11,6	2,5	11,6
NET FOOTPRINT	**1.003.555,2**	**902.440,8**	**790.278,3**

Table 4. CO_2 emissions from different "inputs" (in tCO_2/year)

Based on the results obtained and reported in the previous section, the following observations can be drawn:

(1) By dividing the total footprint (1,003,555.2 tCO_2/year for case A, 902,440.8 tCO_2/year for case B and 790,278.3 tCO_2/year for case C) by the productivity (1,000,000 t/year), it is possible to obtain the amount of CO_2 that must be released to manufacture a ton of cement. These values are 1.00 tCO_2/tcement for case A, 0.90 tCO_2/tcement for case B and 0.79 tCO_2/tcement for case C. Therefore, the carbon footprint of cement may be considered high in theory. We are well aware of the enormous effort the sector has made over the years in attempting to reduce their CO_2 emissions by applying a number of different techniques, but there are still areas left to be explored and completed. In view of the results, some guidelines aimed at reducing CO_2 emissions in cement plants can be obtained:

Fuels and electric energy: Both direct and indirect emissions, easily account for the greatest part of the total footprint (75.33%+3.89% in case A and 77.06%+4.28% in case C). In case B, they seem to be lower (only 0.73%+2.02%) but that is just because a grinding plant does not need to use the kilns but it will do incorporate the intrinsic footprint of the purchased clinker (included into the materials category). It is also clear how the use of BAT allows for the reduction of the sum of direct and indirect emissions from 795,045.3 tCO_2/year (case A) to 642,827.8 tCO_2/year (case C); i.e., a reduction of 152,217.5 t CO_2/year (nearly 20%). Some possible measures would be the use of secondary fuels and sustainable energy sources or the reduction of the percentage of clinker in cements.

Materials: the footprint produced by materials is not too large in cases A (15,810.6 tCO_2/year) and C (15,710.4 tCO_2/year) accounting for 1.58% and 1.99% of their total footprints, respectively. However, owing to the enormous, but unavoidable amount of outsourced clinker purchased by plant B, along with the fact that this material has a large intrinsic footprint, in the case of the grinding plant, it is the materials category that accounts, without a doubt, for the greatest part of the total footprint (74.66%), reaching an absolute value of 677,435.7 tCO_2/year. For this reason, the lines of action taken to reduce the footprint should be based on more sustainable constructions and the optimization of the use of aggregates and minerals in general, but above all, in case B, it is primordial to reduce the amount of clinker in cement.

Services and contracts: it is not a highly significant category in cases A (2,818.3 tCO_2/year, the 0.28%) and C (2,825.1 tCO_2/year, the 0.36%) but it really is in case B, where the fact that the clinker must be imported with its consequent transport by ship, raises case B CO_2 emissions to 131,728.7 tCO_2/year (14.52% of its total footprint). In general, this footprint can be reduced by contracting the services of the most efficient companies in environmental terms. Another category of importance is the contracting of "office" services with a high added value, whose carbon footprint can be reduced mainly by saving on energy. In case B, it is clear that the best way forward is to find more efficient and sustainable means of transport for the imported clinker as well as closer suppliers, what would minimize the necessary traveled distances (despite the fact that the China is currently the largest export market owing to its low prices).

The agricultural and fishing footprints: this category has not been introduced into the analysis. This category is usually the first to be omitted for reasons of discipline although it can take on great importance in certain businesses and multinational companies, owing to the expenses incurred from travel, and the resulting cost in sustenance (not to mention company dinners, social events and invitations).

Forestry footprint: this footprint does not have very high values in relation to the total footprint (8,746.2 tCO_2/year in case A, 8,840.7 tCO_2/year in case B and 8,734.7 tCO_2/year in case C) with incidence percentages of 0.87%, 0.98% and 1.11% respectively. However, it should be controlled by making sure that the wood is certified and that it comes from forests managed under sustainable development programs and by demanding cellulose and wood products from suppliers with a small footprint or with plans to reduce their footprint. The forestry footprint that cannot be reduced should be offset by the counter footprint. At the present time there are companies that invest in creating forests, parks, pastures, etc. in order to increase their counter footprint, thereby decreasing their total net footprint. Therefore, the investment of natural capital in non-company owned land or even distant pieces of land should not be ruled out.

Water footprint: What is striking in this case is the great reduction achieved by using the best available techniques, decreasing the consumption from 269,725.0 m^3/year in case A to 78,462.0 m^3/year in case C (which is equal to a reduction of 659.9 tCO_2/year in case A to 192.0 tCO_2/year of case C, i.e., a reduction of 71%). Not only the new production techniques were important in this case, but also BAT are now being used for the selective collection of water whereby consumption is reduced through recycling techniques, collection of rainwater, greywater and others. In general terms, potable water (which requires a distribution network, pumping facilities, potablization processes, etc. and unnecessarily adding an enormous footprint to the product) should never be used for industrial processes.

Soil use: plants type A and C require much more soil than plant type B. Therefore, while the footprints of cases A and C (58.2 and 56.8 tCO_2/year respectively), that of case B is 9.6 tCO_2/year. Generally speaking, the footprint corresponding to this concept is small, which is no reason not to optimize this occupied space to the maximum. Moreover, the footprint can be reduced by means of counter footprint, for instance, new green zones and garden areas that form part of the property where the cement plants are located and which also serve as a screen of vegetation to combat contamination.

Waste materials: this category accounts for the 17.98% in case A, 6.54% in case B and 15.18% in case C, so they are all substantially high values, which would indicate that any influence exerted on them would lead to considerable savings in the total footprint, what was demonstrated by the achieved reduction of the waste material footprint (33.52%) which the use of BAT technologies got.

(2) Comparing the results A and C, it can be said that while the best available techniques are a complete solution, they allowed an important reduction of 213,276.9 tCO_2/year (21.25% of total emissions, from 1,003,555.2 tCO_2/year in case A to 790,278.3 tCO_2/year in case C). Summarized in Table 5 we can see the reductions depending on the consumption category.

CONSUMPTION CATEGORIES	Reduction (%)
Footprint of direct emissions	19.45
Footprint of indirect emissions	13.35
Footprint of materials	0.63
Footprint of services and contracts	-0.24
Agricultural and fishing footprint	0.00
Forestry footprint	0.13
Water footprint	70.90
Soil use footprint	2.41
Footprint from wastes	33.52
Soil use counter footprint	0.00

Table 5. Reduction of the percentage of the footprint according to consumption categories, thanks to the use of BATs

On the one hand, it is clear, even at first glance, how important are these techniques, above all, as far as the consumption of fuel, energy and water as well as waste emissions (particularly solid particles) are concern. On the other hand, they do not reduce other considerable footprints, such as the footprint of materials or that of services and contracts which even got worse. This singular effect is explained by the fact that the BAT need tend to involve more complicated processes, the human factor of control, security, projects and planning, etc. become more necessary, and this results in an increase of the footprint.

(3) As mentioned, case B does not include some important processes, such as pre-heating, burning in the kiln or cooling of the clinker. This way, it presents less consumption of fuel and electricity by saving on these high energy consumption operations. Moreover, it also has a lower demand for soil (since these are smaller plants) and a smaller quantity of wastes (for instance, solid particles present in the exhaust gases from combustion in the clinker kiln). However, it presents a greater consumption of raw materials since imported clinker must be purchased and transported from distant points of manufacture (generally from China). So the smaller footprint of this option is only due to that fact that the intrinsic footprint included in the imported clinker comes only from the energy footprint and not the total footprint.

Methodologies like MC3 allow for the inclusion of the intrinsic footprint of the materials consumed by means of their energy intensity or their embodied energy, but there are other factors such as the consumption of water needed to manufacture them, services and contracts involved in their manufacture, the demand for soil, forestry resources, etc. that the methodology is unable to process [21] and for this reason a slightly lower value was obtained. In fact if the plant that manufactures the clinker in China were similar to that plant, for example in case A, the final footprint that should be obtained in case B, would be the one pertaining to case A, along with the added footprint of transporting the clinker from China (since in case A this process is not carried out).

With this, what we are attempting to clarify is that by building grinding plants instead of integral plants, we are far from solving the problem of CO_2 emissions, instead we are transferring the problem from one country to another (generally to the less developed countries), for reasons related to the cost of energy, labor, etc. Therefore, if we analyze the situation in global terms, the problem is aggravated even more, since the technologies of these countries are generally less efficient and the long chains of merchandise supply and transport become a necessity.

4. Conclusion

Like it or not, our planet is finite and a finite system is incompatible with an economic subsystem whose paradigm is based on continuous and unlimited growth. Somehow we have to reconcile growth and sustainability, and to do so, our companies need to access transparent and comparable information to be able to make the best decisions so as not to compromise either their growth or the impact on the planetary ecosystem.

In answer to this, Carbonfeel has been designed with a core mission: to organize information and knowledge on the carbon footprint, making it universally useful and accessible to all society. In short, the point is to provide companies with the best available techniques for calculation and exchange of information within the processes of inventory, management, reduction and offsetting of GHG emissions generated by their own activities.

This information will allow companies to participate actively in improving their behavior, without having any effect on their business. Quite the contrary; their activities will start to focus on production patterns based on eco-efficiency and eco-design, and therefore lead to a reduction in costs. Moreover, customers will recognize a continuous improvement effort based on a credible label supported by many different certifiers, consultants, companies, associations, universities and others.

Carbonfeel starts out from a methodological basis proposed by the Compound Method based on Financial Accounts (MC3), inherited from the ecological footprint concept that has been extended worldwide by its creators William Rees and Mathis Wackernagel. The project takes advantage of other emerging methodological trends such as GHG Protocol, PAS 2050 or ISO 14064 standards and the future ISO 14067 and 14069, in order to get an approximation of the real calculation.

Supporting an integrated approach, the incorporation of information technologies makes Carbonfeel an innovative project that has burst into the market to completely change the focus of the classic studies of life cycle analysis, whose drawbacks in cost and study time had already been reported by different analysts.

The great paradox of the Carbonfeel method is that companies get a carbon footprint at the corporate level and the life cycle of all products and services without any restriction on the scopes, with the information provided in great detail. Moreover, this information is more extensive and of a higher quality as it is based on primary data (real footprint of its suppliers), and all at a cost and a time frame fully accessible to any corporation.

The telematic assembly technique provides an entire life cycle, where each corporation analyzes its own emissions (scope 1 and land use) on an autonomous basis for calculating the indirect footprint or inherited from its suppliers by the telematic assembly. The company stops worrying about the tracking of emissions that are out of view (scope 3 in the approach to corporate and upstream approach to product based on LCAs) and focuses exclusively on the part of their responsibility, the direct emissions and the organization's land use. Therefore, time of calculation is drastically reduced, making it assumable to all the business.

The 'green coin' can become a reality if we pay attention to the technological factor faced by the carbon footprint as a problem of information exchange.

A Carbonfeel project offers companies a real environmental accounting method based on a universal indicator such as the carbon footprint, which analyzes the corporation and each of the products and services generated.

Finally, the application of the organization-product-based-life-cycle assessment methodology (MC3) to three types of cement facilities in Spain (case A pertaining to a conventional integral plant, case B which refers to a grinding plant and case C, an integral plant which has been subject to the best available techniques BAT) shows that if we compare results A and C, the best available techniques allow an important reduction of 213,276.9 tCO_2/year (21.25% of total emissions, from 1,003,555.2 tCO_2/year in case A to 790,278.3 tCO_2/year in case C).

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