POLITECNICO DI MILANO

II Faculty of Engineering: Ingenieria dei Sistemi

Master of Science in Management, Economics and Industrial Engineering

Polo Regionale di Como

Sustainable Supply Chain Management Tools: A Reference Framework

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Academic Year 2010-2011

ACKNOWLEDGEMENTS

My gratitude to Professor Sergio Terzi, Professor Marco Taisch and Endris Kerga for their knowledge and guidance in the development of this project. To the Politecnico di Milano and the Engineering Faculty *(Sistemi)* for enriching my professional life with this program.

This work is dedicated to:
My family, for their constant and unconditional
Love, encouragement and support; and
my friends for the most amazing experiences
during this journey, their advice and
foremost for the friendships I will never lose.

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ABSTRACT

Today´s consumption rate exceeds the world´s natural rate of regeneration, which sadly means that humankind and the urge to satisfy their needs is over killing the place where we all live. Tons of disposed products are starting to invade places nearby the cities, industries are polluting air, land and water sources; some companies are neglecting a fair minimum wage or avoiding to grant social conditions in remote places. And all these phenomena are turning our life in the earth barely sustainable in a couple of decades, at the most one century.

Over the past decades scientists, engineers, businessmen, ecologists and governments along with non-governmental organizations are changing the mentality of production, the mentality of the new design trends and foremost are making the consumer aware of their buying and disposing behaviors.

By acknowledging the importance and the impact of Sustainable Supply Chain Management philosophy; it is necessary to switch and evolve the actual business conception towards a sustainable income. Economic and financial controlling and optimization is not longer enough, but should turn complementary with an environmental and social control and improvement. Then, it is important that all actors within a Supply Chain have enough available tools and are able to understand them according their context in order to make possible more subtle implementations with high positive impacts towards the new business perspective: Sustainability.

Keywords: Sustainability, Three-bottom line, Sustainable supply chain management, sustainable tools.

INTRODUCTION

Today´s consumption rate exceeds the world´s natural rate of regeneration, which sadly means that humankind and the urge to satisfy their needs is over killing the place where we all live. And the trouble points are not only present in the purchasing and spending behaviors societies are having but are also present in the products they throw away that will end up in a landfill or incinerated and also present in the processes companies perform in order to come up with a product that results appealing to the customer.

Fortunately over the past decades scientists, engineers, businessmen, ecologists and governments along with non-governmental organizations are changing the mentality of production, the mentality of the new design trends and foremost are making the consumer aware of their buying and disposing behaviors. Efforts have taken relevance and importance in the matter that different tools, methods, and methodologies have being created in order to satisfy the new "greener" era. In the first place, by designing and implementing tools that will allow reducing the toxic emissions, disposed quantities, selection of hazardous materials when a product is disposed; or trying to find a further reach to establish "after-use" monetary rates to the consumers in order to pick up the old product and take it back to the manufacturers for disassembly. All these actions obey to the end-of-pipe approach that initially seemed to be the solution of the inequality between regeneration rate of the environment and the production rate.

But it did not take long to understand these actions were barely the starting point in order to re-establish the ecosystem order while having a decent life style, in other words; being sustainable. Later, some techniques and tools approached the companies' productive process by quantifying their environmental impact during the different production stages, suggesting improvement solutions for each critic area and new designing methodologies in order to give the market a more environmental complying product. Government and NGO´s started to control and expose malpractices in order to inform the consumers that some companies were not helping the present and future generations while they increased their operations. Suddenly, customers were empowered to choose either a complying or cheap product in the market, and companies started to realize that their income was compromised first by their actions against the environment or negligence; and second

because their practices could be translated into a market share loss after environmentalists made public their reports of *bad-practice* companies.

After achieving own company improvement towards green issues, the next challenge was to guarantee that the raw materials could meet the company policies before the manufacturing process started. This concern brought rapidly the subsequently acting strategy towards a sustainable model: Integration of the supply chain actors in order to guarantee a sustainable input to be transformed and delivered into a more sustainable output. Although this perspective has being taking more importance during the last years, integrative tools and methodologies are still in theory, and practices about how supply chains are facing this transition has not been fully documented.

So far companies that are trying to achieve a sustainable supply chain configuration are implementing either one of these two approaches, the first one looking specifically towards its suppliers and made them comply and show evidence of environmental requirements. And a second approach by performing an internal observation of how the own company designs, manufactures and distributes their products taking into consideration packaging and toxic material reduction.

Regardless the efforts of having a sustainable operation and delivering complying products downstream still there are gaps among the sustainable supply chain management, mainly because companies fail in finding the tradeoffs between costs, emission reduction, new technologies and customers´ satisfaction. In order to close the gaps, collaborative processes must be held in order to design and improve the supply chain relationships, along with higher communication, education and motivation among its employees.

It will be helpful give some reference framework to the companies willing to start the sustainable supply chain management approach in order to ease their next steps towards a more sustainable position by characterizing some of the existent tools in a comprehensive language that can possible offer an understanding of the implications and considerations at least in a theoretical mode.

1 METHODOLOGY

In order to understand each aspect that could be reached by this work, it was necessary to find papers, books and reports regarding sustainability, what it means, its characteristics, what has been done and what should be done in order to achieve it in a Supply Chain Management context. The first sources were given by Professor Sergio Terzi while attending his lectures about Product Life Cycle Management, which were an essential starting point to comprehend how many dimensions this apparent new topic had.

It was not until reading *Cradle to Cradle: Remaking the way we make things* by McDonough and Braungart, that the real definition and dimension of sustainable design, production and product could be understood in each minimal aspect and how it could impact the society present and future´s sake. The explanations and examples offered in the book plus several documents regarding the three aspects (economical, social and environmental) of sustainability gave the means to start the consolidation of a wide understanding of what should be required in order to arrive to the complex concept of Sustainable Supply Chain.

By reviewing each aspect´s impact, considering the limitations it could face and foremost realizing the benefits it could bring by integrating it with the other two aspects in a certain instrument, it was possible to understand which kind of tools could be useful to include in the purpose of the work in order to guarantee a good reference framework for any interested part willing to participate in a integrative approach towards sustainability. For the selected group of tools a discrete profiling process was performed: search its history, its definition, phases, characteristics, case studies, pros and cons and further improvements propositions.

Afterwards by reviewing the tools' scope and primary impact areas, it was possible to determine different categories for classification that could respond according the Supply Chain Management needs towards a sustainable approach. A map is then defined in order to visually understand the relevance of each tool according to its category and the result that it may be obtained after its implementation. Later in the document a reflection about what Sustainable-Supply Chain Management means, which the differences with the usual supply chain model are, and which are the considerations to have in mind when implementing any of the tools in the search of the sustainable approach is presented with

the objective to give a general abstract of what can be faced in the coming years and which should be the ultimate result to be achieved.

A further standardized template is proposed in order to offer, to any interested part; summarized and consolidated information about each tool regarding their impact towards the achievement of a consolidated Sustainable Supply Chain Management result. The information given in the templates corresponds to the information found in the different sources of information used for the reference framework.

2 SUSTAINABILITY CONTEXT

The concept of Sustainable Value is more complex than it appears given that nowadays this term brings into consideration the extreme urge to switch the actual business model structure by claiming the integration of the three main areas that surround the concept. The Triple-bottom Line is the proposition where financial, environmental and societal aspects intersect; it is a new way to measure the bottom line, where profits go side-by-side with environmental and social performance and also a brilliant way to understand the concept of sustainability (Savitz, 2011).

A definition for sustainability is the capacity to endure or to maintain. Specifically related with the mankind, it will be the potential capacity of the human being for the long term maintenance while interacting with the economic, social and environmental dimensions. According to the economic model exercised through the recent years, the main needs of the society will be the provision of goods and services implicitly sized by the environmental management (resource availability) and ruled by consumption behavior; but what is being lately realized is that this economic behavior is having a huge impact in the social and environmental aspect, which are now required to be described in the same terminology as the economical factors, in order to reconcile the three aspects and guarantee sustainability.

Two models of how these three aspects interact are presented below. The first one has been already mentioned: the Triple-bottom line, which considers the interrelation among the three areas all together giving as a result a sustainable development, the relationship is showed in the graph below.

Some authors consider that having at least a good balanced relationship just among two of the aspects is already considered an achievement in pursuing sustainability. Therefore; for a company being bearable, viable or equitable is already an accomplishment but after about two decades, any of these two approaches are becoming just incremental improvements within the supply chain management and ultimately to the business management.

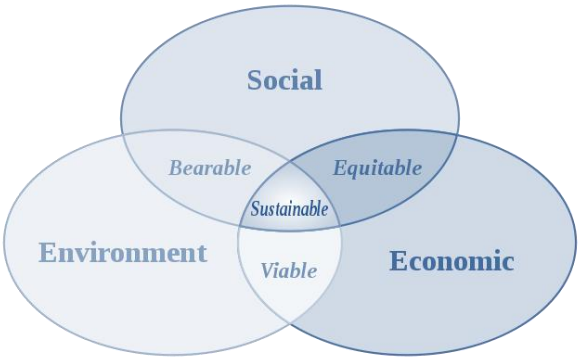

Figure 1. Triple-bottom line diagram (Adams, 2006)

The other model studied; presents a dependence and hierarchical relation among the three aspects, in which all converge in the fact that either economic or social aspects are restricted by the environment. The way to understand this model is simple and states that a gain in one of the sectors will be represented in the loss in another. Being able to find a balance among the three aspects will allow sustainability achievement and a win-win-win solution.

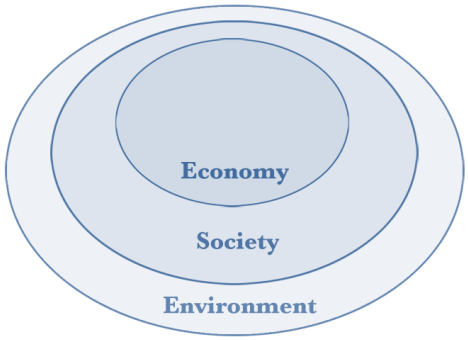

Figure2. Dependent sustainable pillars diagram (Ott, 2007)

Then a new concept is brought into consideration; *Sustainable Development*, which is the development that meets the needs of the present generations without compromising the ability of the future ones to meet their needs by considering any action in terms of economic, environmental and social arguments from the very beginning it is conceived. This new perception brings the notion of optimization of the used resources, while turns questionable the economical paradigm the world is used to be thinking of: Make profit and development from pure efficiency in the use of money. Instead, while having this new development model in mind; the obligation of increasing the productivity of natural

resources, closing the loop of the product lifecycle and increasing the environmental capital reinvestment are becoming mandatory.

Sustainability is being studied and managed over many levels or reference frameworks while considering time and space. It can be measured in terms of indicators, benchmarks, audits, indexes, assessments or reporting systems among others. Also some frameworks have been defined in order to seize the environment management and human consumption profiles.

Regarding the management level, some criteria for sustainability, especially for the environment; have been proposed. The first one, the renewable resources should provide sustainable yield, in other words; the rate of harvest should not exceed the rate of regeneration. A second statement is that a non renewable resource should have an equivalent development of renewable substitute; and lastly, the waste generation should not exceed the assimilative capacity of the environment to absorb/transform it.

Regarding human consumption, people are called to consume less at the same time that companies achieve full production cycle or closed product life cycle. These changes should consider the individuals´ lifestyle choices, purchasing behaviors and resource intensity as well as its productivity. Then a concept of “cradle to cradle” should be conceived in order to help the world to breathe and regenerate at its own pace in order to avoid an economic growth that depletes the resources in the long-run period.

Another concept that should be revised before entering to further discussion is the term: Value. In terms of economics is the worth of a good or service determined by a market which states that there is a value in use and a value in exchange and consequently will allow a discussion about price and pricing models. More economical theories should be considered in this regard, but this is not the purpose of this document. Nevertheless, it would important to mention that wealth maximization predicts that one will choose to obtain the good/service in the place where it is the cheapest. This statement emphasizes in the economical approach of the world´s thinking model and it does considers one of the Triple-bottom line aspect; except it is defined in a way in which the other two aspects are left apart from macro-economical consideration, let’s say are just considered as externalities.

But of course what it cannot be dismissed is the ethical approach of *Value* since we have seen that sustainability concerns the social aspect as well. Then ethically, value means a property of a physical or abstract object; representing a degree of importance. Considers the aim of determining what action is best to do or what approach of life is better; or at least attempts to describe the value according different perspectives. It deals with the conception of good or bad conduct that later may be regarded as ethically appropriate or not.

After the previous discussion about terms and definitions, the appropriate thing to do is delimit the concept and boundaries of sustainable value. It has been stated that it considers the business under the three aspects (social, environmental and economical). Then, the struggle at this point is that today´s corporate value definition is just considering the financial approach and leaves behind the other two factors wandering. Enterprises are aware of the importance that sustainability is taking among the world, but yet just few companies are starting to think, consider and take action towards this issue. Now any company that is able to consider value according these three aspects will be generating true sustainable value in the long term without jeopardizing the resources of the future generations.

The main purpose for the entire world will be to change their perspective in terms of business model, by starting to consider and measure factors regarding environment and society in financial terms in order to have a congruent framework. Then, all the profits and losses will be associated to a sustainable environment and the business world will be able to determine and compare a sustainable value tradeoff. Until now, the complex thing to do is the definition of the measurements that should be taken into account, in order to make diverse types of burdens comparable with each other, but expecting all the burdens being defined in the same terms is quite exhaustive and requires some imagination and innovation.

Subsequently, instead of defining burdens is better-off to redefine the measurements in terms of value addition and in this way, the new concepts will fit with the financial approach that has been used until now. The idea will be to express all the factors in terms of money in order to do an opportunity cost analysis. But this approach may fall in the principle of obtaining the things at the cheapest “price” or effort. So the initiative could be failing again in the purpose of considering social and environment as externalities since no

“apparent” value could beat the financial aspect. Another thing to be taken into consideration is that if the tradeoff between the three aspects is already accepted, we are assuming that our incubated model (second model presented) applies, and in that case its main principle fits: Whatever is gained in one of the aspects is going to represent a loss in the others.

How Sustainable value is going to be measured is not easy, nor impossible. One of the main tools already being implemented and does not suppose a big managerial change in the preliminary steps toward putting into practice sustainable value in a company is Life Cycle Assessment. Specifically evaluates the environmental impact of the already existent product/service through the entire lifecycle. It collects as much information as possible and tries to establish the environmental inputs (water, raw materials, water sources, etc) and their relative outputs. The environmental impacts increases as the resources go through the productive processes. Also inside the evaluated factors we may include human health, and in this way involve both former externalities into the business system.

It has also been develop a measurement that considers the unit impact to the habitat based on pollution and consumption known as Ecological Footprint. The main purpose is to compare the human impact associated with the earth´s regeneration capacity. Besides these methodologies, some benchmarks, indicators and indexes have been defined. Just to mention a few, in terms of indexes the following are the most important Environmental sustainability Index, Environmental Performance Index and Genuine Progress Indicator. In terms of auditing and reporting there are several: ISO 14000, ISO 14031, the already mentioned Triple-bottom Line or the Input–Output analysis. Considering the accounting field the methods suggested are Green accounting and the tool known as Sustainable value.

The sustainable value approach differs from existing approaches by the fact that it is value-based while all other existing approaches to sustainability assessment (such as environmental impact assessments) are burden-based, i.e. they are assessing environmental and social resource use directly on the burden that is created. Using the sustainable value approach, economic, environmental and social resources are assessed and aggregated based on their relative value contribution and can be expressed in a monetary unit (Igge & Hann, 2005)

3 CATEGORIES

The tools presented below have been separated into four main categories according to their approach, the procedures they held, the applicability, the results and the impacts they can bring to the different stakeholders and actors within the supply chain. This categorization has been defined after reviewing different papers from this past decade and by considering aspects such a Sustainable Supply Chain Management, which is gaining more importance each time in the corporative and market arena.

For instance, when reviewing the paper *Supply Chain Management for Sustainable Products* (Seuring, Supply Chain Management for Sustainable Products - Insights from Research Applying Mixed Methodologies, 2010) it was comprehensible that there was a difference between having a sustainable product and having a sustainable process. Then, the concept of sustainability within a company can have different meanings and can impact different aspects among it. And with this being said, the first category to be considered is the *Product based* category. Also when considering a sustainable process, what is expected to have is an improved operation characterized by having fewer failures, less negative impacts and less associated risks. In general it can be concluded that this type of sustainable approach considers the *Performance and risk based* category.

Although the previous categories take part mainly on the productive and value adding processes, some other activities regarding sustainability are also taking place in the strategic and supporting departments which allow the improvement of characteristics such as collaboration, co-operation and traceability among the departments. Some of the tools can be found in the *Management based* category; which requires that the whole company works under the same principles of sustainability and the outcome of these unified efforts will allow companies to compete even in an international market.

Under a generalized perspective and considering the economic approach of how the countries evaluate themselves and report their results (i.e. G.D.P., Imports and Exports); another approach of sustainability is coming from the Macro-economic perspective. It aligns the sustainability reporting with the already existent communication channels and accounting lines, which make the comparison among companies, industries and countries more suitable in terms of sustainability. As a result, *Reporting based* category is the fourth

category that was defined according to what has been said previously. A further definition of what each category means and considers is showed below.

3.1 MANAGEMENT

The tools that can be classified in this category go beyond the mere complying of policies, statements or stakeholders requests. Instead are tools that are considered by companies that are first movers or want to guarantee a sustainable operation and product before other companies apply the same approach, or even before governments and NGO´s start to become hard observers on the company operations.

Tools within this category allow the integration and direct inter-relation among the different players in company and with a further applicability within the supply chain concept. The bargaining power of the strongest link either from the company or the supply chain will lead by requesting to the other actors to join the same protocols, tools, procedures and ask for a transparent communication, which ultimately; will lead to a traceable and sustainable operation through the whole chain and foremost to the product delivered to the customer.

Since the decisions come from the strategic areas of the company and require changes through the entire company department and divisions, this type of tools are capital intensive and even more when the scope of the tool goes further into the integration of the whole supply chain.

3.2 PERFORMANCE AND RISK

This category considers the tools that allow company improvement and risk avoidance approach. More over it does not consider just improvement but also the performance of the company through time, includes changes and evaluates the outcomes through all the business units of a company. The risk avoidance comes when the implementation of a tool allows the customer and foremost the stakeholders to have a product that achieves complies every single characteristic according to the three-bottom line aspects.

These types of tools allow having a direct impact in the company income, market shares and branding reputation, etc. Some relationships between suppliers and customers

relationships are observed and enhanced in these types of tools and because of the additional enhanced relationships; the tools turn to be capital intensive.

3.3 PRODUCT BASED

This category considers the lifecycle of a product: has in mind the different design stages either for the product or process, considers the manufacturing stages from raw material until the final product to be sold and further disposal, and more importantly evaluates the sustainable impact of the product and process through all these stages. It considers the quantification of the impacts already held within the productive processes or coming directly from the product. Afterwards the tools may provide some guidance in order to optimize the resources with the same amount of impacts and even better, decreasing them.

Tools used in this category consider mainly the individual or own improvement. Companies can establish to improve a certain product of their mix or to improve a single process; but the scope of these tools does not go further to be implemented in other companies or suppliers in the first instances of implementation. It does allow the integration of a green or sustainable approach along with the different productive processes of a company like evaluating the opportunity of having an economical viable supply chain and obtaining a sustainable outcome.

3.4 REPORTING

Tools falling within this category are those that use the already well known Macro-economic reporting to inform to stakeholders about their improvements, actual operations and results. Since the macro-economic approach is widely used for reporting around the world and evaluates equally the same accounting lines, the tools will allow comparison of the sustainable accounts among companies, industries and even countries. All the information recorded in the tool report is for public use, allowing the stakeholders and basically anyone to read the company profile. Additionally, these tools also will require the evaluation of a third party auditor in order to guarantee reliability and transparency of the information that is being published.

The classification above has been also considered in terms of company responsiveness at the moment where it is decided to implement the tool. The possibilities are reactive, as a response after industry changing characteristics, government policies or market pressures. And in the other end, there is the proactive response, which describes an internal and voluntary initiative to eliminate the environmental burden, increase the working conditions and consolidate the company as a sustainable company, usually considered as first movers' actions or tools. Finally, the other characteristic that has been found is either the tools manage an operative approach or turn to be really strategic within the company profile.

This classification is proposed in order to achieve a further understanding of the tools´ impact in the new concept of Sustainable Supply Chain Management.

Figure 3. Tools 'Classification according to Sustainable Supply Chain Management definition

4 TOOLS

4.1 LIFE CYCLE ASSESSMENT (LCA)

Created around the 70´s in the United States and then adopted in Europe within different institutions and universities, was initially used to assess the environmental aspects (raw material and energy savings) of packaging of the product. In the 80´s, LCA was already used to analyze product under the perspective "from cradle to grave", which assesses all the environmental burdens from raw material down to waste removal (Klöpffer, 1997).

By definition LCA is a methodological framework for estimating and assessing the environmental impacts attributable to the life cycle depletion, tropospheric ozone creation (smog), euthrophication, acidification, toxicological stress on human health and ecosystems, the depletion of resources, water use, land use, noise – and others (Rebitzer, 2004). Under another perspective, the purpose of LCA is to balance the input with the output of the unit being evaluated but in practice this balance may never be complete while evaluating some of the features, for example energy. Researchers with diverse backgrounds come to an agreement that potential environmental impacts are linked to products, and then LCA supports pollution prevention and resource usage minimization while considering the entire life cycle process.

In the early 90´s the Society of Environment, Toxicology and Chemistry (SETAC) developed a "Code of Practice" or guidelines of how to use the tool and later LCA has also been defined by the International Standard Organization (ISO) as ISO 14040, which defines some of the tool aspects to take into consideration such as its *Goal and Scope definition* (ISO 14041), *Inventory Analysis*, *Impact Assessment* (ISO 14042) where the Life cycle inventory (LCI) is defined and *Interpretation* (ISO 14043) *or Improvement Assessment*[1]

[1] Name given to the fourth stage by the SETAC and SETAC Europe and diverges from the ISO definition, as ISO argues that Improvement Assessment is just one of the various actions that can be performed after the third stage is completed.

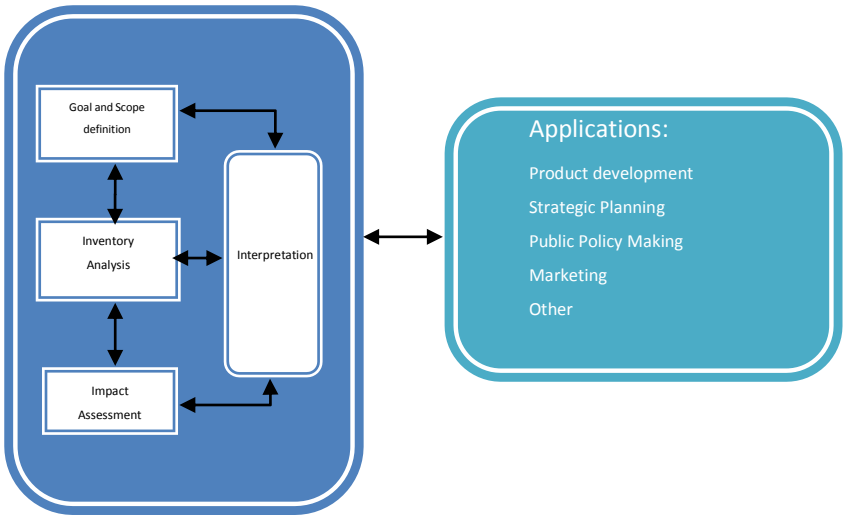

Figure 4. ISO14040 - Life Cycle Assessment diagram (Klöpffer, 1997)

4.1.1 GOAL AND SCOPE DEFINITION

The purpose of implementing LCA has to be stated, its objectives, the specific unit of evaluation, the depth to be reached as well as some characteristics once the project starts, such as the rules, boundaries and assumptions to be followed, data collection, working group and responsible. The clear and strict definition of these parameters will allow a consistent evaluation after the study is performed.

4.1.2 INVENTORY ANALYSIS

Considered the scientific and methodological stage of the LCA, in which the unit is analyzed according to its components (input-output) and the transformation processes. The arrival of raw materials, WIP, the product, the use and waste are all considered since they are the physical resources in the analysis. In addition, it has to be considered the energy resources required to transform, produce, transport, use and further disposal of the product within its life cycle as the immaterial resource. Outputs and emitted wastes (solid, liquid and gas) in this matter are co-products, either during the transformation process to be a product or to dispose the residual artifact.

At the end of this stage, the Inventory Table is defined as the list of input and outputs per functional areas of the specific unit. In this document, cumulated values for energy are defined in order to maintain a useful and standardized parameter. The most used factor is

the Cumulated Energy Demand which aggregates the feedstock energy such as crude oil or wood. (Klöpffer, 1997)

A list of outputs besides the final product is provided for further understanding is:

Output related categories	
Greenhouse gases	Depletions of stratospheric ozone
Human toxicological impacts	Eco-toxicological impacts
Photo-oxidant formation	Acidification
Eutrophication (BOD – Heat)	Odor
Noise	Radiation
Casualties	

Figure 5. List of Categories – Outputs (Klöpffer, 1997)

4.1.3 IMPACT ASSESSMENT (LCIA)

At this point the Life Cycle Inventory is defined, as the sum of the stages of Scope and Goal definition plus Inventory Analysis. From here on, actions considering product improvements, energy savings and emission reduction can be drafted; but first the collected data has to be transformed into impacts. The procedure consists in a classification of the outputs in a specific impact (i.e. CO_2, NO_2, CH_4, contribute to “global warming”); then in the characterization step, data is transformed into the unit contribution number to the correspondent category and normalized. Finally the weighting or Valuation (ISO definition) of the obtained results is performed, in which the values are measured according to the quality and availability or scarceness of the resources. This step is highly subjective and comparisons among systems should be done under strict and equal methodology in order to decide which of them may be better.

4.1.4 INTERPRETATION

The newest component of the LCA according to the ISO standardization (ISO14043), where the results obtained are subjected to a critical evaluation through the whole LCA. Each of the steps is analyzed by using quantitative tools, and gives a direction where to improve the impacted Business Units. At this point the resulting activities are not longer part of the Life Cycle Assessment tool.

In practice, it is possible to compare across the *impact categories*, especially when there are trade-offs between product alternatives. As an example a great discussion was held around the paper and the polystyrene cups, while some studies argued that polystyrene cups were greener because they weighted less as being disposed, paper cups studies revealed that they were greener since they turn in a less volumetric waste. Then the question here is which product is greener? And the answer is that each product is right considering the arguments, but it takes more information to bring up the green winner between paper, plastic or china cups. As Israel Kirzner, former professor of economics at New York University once said: "It is the individual who has goals and who deliberately deploys his perceived resource in order to achieve his goals most efficiently so far as is possible. To transfer this important concept of individual locative choice to society as whole is, at best, to engage in metaphor." Additional discussions about products tradeoffs are plastic can versus metal can or disposable diapers versus reusable diapers.

It is in this moment where the integration between technological, economic, cultural and social aspects and environmental issues takes place for the very first time. (Vezzoli & Manzini, 2008)

4.1.5 BENEFITS

LCA is applicable to any kind of product and to any unit where environmental concern and impact in the product´s life cycle is of interest. The LCA tool describes a product system and its environmental exchange in the short and mid-term, therefore gives the possibility to have updated and latest information about the unit being studied. It is useful as a first approach towards environmental related topics and further improvement. Also several iterations after the first implementation can be performed in order to follow the improvements obtained from the corrective measurements executed previously in the business unit.

Depending on the characteristics of the ecosystem within a region or country, generic and high quality databases can be created taking into consideration the standard economic value of the inputs and outputs. Furthermore the data can reflect the real conversion from input to output considering the nature and environment factors. This will allow the databases to become transparent, consistent and reliable to perform certain comparisons between products or within industries.

As for small and medium enterprises, it might be negligible the positive impact of LCA since they don't have the incentives to consider that their operations may affect the environment or don't have the economical resources to conduct such quantification. But in reality some S&ME are gathering around implementing simplified LCA approaches allow having small but significant win-win solutions, either in economical or environmental aspects. For instance these simplified approaches may help the S&ME to comply customer requests when applying as green suppliers, which is the ultimate objective of a green supply chain management.

When considering that LCA is being applied in a multinational, it is to assume that a LCA division, group or team has been established. Then, knowledge about which inputs and outputs should be considered, how to quantify them according to an economic or environmental principle and how to validate it, will be an everyday task that will allow some standardization and stronger comparison between results. Besides taking into consideration big companies and their bargaining power inside the supply chain, LCA could be also implemented and used within its suppliers, industrial customers and other stakeholders around the world.

This tool also gives guidance towards possible solutions and strategies to improve emission performance or optimization of the inputs usage and will provide information to discuss trade-offs and build co-operation throughout the life of every product "from cradle to grave" (Duda & Shaw, 1997)

4.1.6 LIMITATIONS

In the other hand LCA might have its limitations or cons in different aspects. For example LCI might not be enough to compare different assessments on product or production basis. Although the main idea while performing the LCI is to account all inputs and outputs, it is true that not all of them can be defined or quantified in the very first time. Or maybe the inventory quantification can be made according to the management structure that perhaps may not consider the same exact lines (I/O) or with the same procedures with another LCA study, turning impossible to make affirmations or comparisons about the product or process then it may be true that results coming from enterprise LCA are not suitable for S&ME´s.

In the first step of the LCA, *Goal and Scope definition*; the assumptions and choices might be subjective and not aligned to the environmental approach that is expected to be evaluated after the project is performed. Also the models defined within the implementation of the LCA are not sufficient to describe the entire spectrum of the environmental impact. It is possible not to have a direct negative impact in the evaluated unit, but perhaps the environmental impact could be only seen when the product has already left the associated process because the environmental impact is sum of processes that occur during the product life cycle and some of them remain doubtful or imperceptible for the unit responsible.

Some disagreements exist when characterizing the outputs, as the cumulative values represent the count of the overall evaluated unit´s outputs, therefore when the moment to see which could be the possible improvement areas, it will not possible to calculate emissions concentrations in a specific activity or within a time period. Consequently is not possible to establish a direct causality between an intervention and its real impact.

Considering the large number of quantification methods and the low experience among them, it is not possible to reach a standardized course that will allow results to be highly comparable within competitive products or industries. And even when a standardized quantification could be reached; results will not be comparable among similar products because they may use of different raw materials or different processes to do the final product and as a result the environmental impact will be different. Complexity also increases when the unit produces more than one output for a single input. Another issue to have in mind when performing the Inventory is that the quantification of each input/output needs to be done exactly in the same way along the units in order to make the comparison reliable.

Uncertainty and variability are absolutely present while going through the LCA stages, but low importance has been given to these two critical issues turning the possible comparisons unreliable, statistically speaking.

LCA´s are costly and time consuming since they are complex and data intensive, subject to technological changes and highly dependent on the information owners (either private or inaccessible). Changes in technology while doing the same product may have changes within the process and consequently the amounts either required to have the process or

the output product and co-products, then LCA´s are also unreliable to be compared within a long term.

Rather than being a proactive technique, it is a Cost-reduction tool.

4.2 ENVIRONMENTAL VALUE CHAIN

Initially considered as a soft philosophy of chain management, suggested that the participants should work together to serve the common goal of improving the environment. But it was until Prof. A. Stevels during a lecture in Stanford University, where the real structure of Environmental Value Chain Analysis (EVCA) was identified and properly defined. Considered as a tool for product definition that allows the enhancement of the environmental programs' effectiveness; it is a developed extension of Customer Value Chain Analysis, which cares for stakeholders' interests, their values and the approach towards a "green" product or processes. Considering that an appropriate definition of product is required, it is imperative to provide high value (including the environmental one) to the involved stakeholders participating within the processes.

The EVCA tool helped Royal Philips Electronics to go through an environmental switch and turn the company into one of the pioneers in terms of research and manufacturing of complete sustainable products. In the 90´s Eco-Design became one of the main points in the agenda of many companies and considered to be working along with the R&D departments. Instead A. Stevels, who was working for Philips Electronics at the time; along with K. Ishii developed an approach that allowed the introduction of Eco-Design in every single department that the product value had relationship with. For them it was not only matter of technology and strategy, but of cultural process.

4.2.1 MAINSTREAM FLOW AND STAKEHOLDERS IMPACT

It takes into consideration the actors within the value chain as well as the different stakeholders that may affect or might get affected during the process, environmentally speaking.

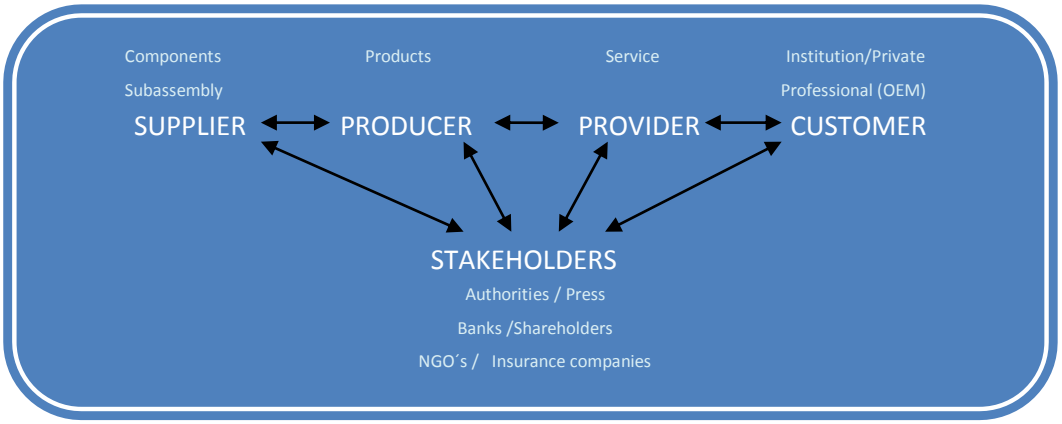

Figure 6. General form of an Environmental Value Chain (Stevels, 2007)

Here, the value of each actor is represented as well as the interactions of each of them with their pairs. They may exchange physical products or information.

4.2.2 INTERNAL VALUE CHAIN

It is also important to visualize the interaction of internal stakeholders within a company. Generally the interactions between departments are mainly information flows. Then it turns really important to have a clear picture of the cross functional exchange in the company´s internal processes to the outside world in order to get an accurate assessment.

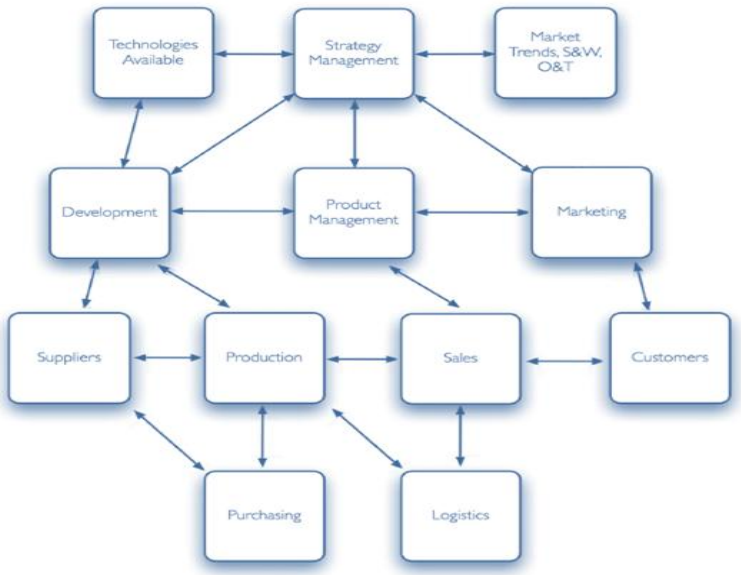

Figure 7. The Internal Environmental Value Chain (Stevels, 2007)

4.2.3 THE ISSUE CORRELATION MATRIX

The Issue Correlation Matrix (ICM) maps and makes clear the common issues and potential conflicts of interest between the main players in the value chain. Regarding sustainability, it shows the relationship between environmental issues and business departments turning the interaction more transparent. For each department (columns), crosses indicate which environmental and business unit (rows) ranks the highest from their perspective with a quantitative score. The count of crosses may reflect high correlation of a business unit or environmental issue within the company departments or make visible that some factors are not being addressed the way they should or it was not as expected.

An example of an implemented ICM by Philips Electronics is provided below.

	Environmental Department	Strategy Management	Product Management	Development	Purchasing	Production	Marketing	Sales	Total
Environmental Strategy	X	X							2
Specification (Functionality)	X		X	X	X		X		5
Quality	X				X	X	X	X	5
Environmental Score	X								1
Project Management	X		X	X		X			4
Environmental Communication/Competition		X	X				X	X	4
Production Technology		X	X	X					3
Cost		X	X		X	X	X	X	6
Investment		X			X			2	
Time to Market			X	X			X	X	4
Suppliers				X	X				2
Logistics					X	X		X	3

Figure 8. ICM results for Philips Electronics assessment (Stevels, 2007)

4.2.4 BENEFITS

One of the main benefits that a company may have after implementing EVCA is that it will allow the switching from a defensive or reactive approach to a proactive one in terms of environmental assessment. Considering that it is a qualitative tool it is quite helpful in the initial stages to an environmental approach usually when companies do not know where to start or how to start by helping, guiding and formulating an action road towards the objective. In this regard, what is additional to the tool is that not only helps manufacturing and R&D departments in green aspects but EVCA allows assessing environmental issues through the entire company departments. After implementing the Issue Correlation Matrix and knowing which of aspects have failed in the evaluation, EVCA helps to define an

environmental-targeted message for each of the implicated departments in terms of their own concern.

As the internal value chain is defined and the relationships among the departments are clear, it will be possible to identify the most favorable cross-functional group combination taking into consideration the value direction and departments' interaction when further projects (green or sustainable) are about to start.

The tool becomes a form of backbone for target specifications and roadmaps in the future (Ishii & Stevels, 2000) as it ensures that the internal value chain is well assessed and covered. Once the implementation and use has achieved a considered success and taking into account that value chains can become broader and wider, it is also possible to be inclusive with the suppliers and customers by adding their structures in the already mapped ECV.

4.2.5 LIMITATIONS

A bad ECV implementation may cause misunderstanding in the value proportions assessment regarding each stakeholder and consequently the defined product value can turn out into critical shortages and failures during the product development process. Although this tool gives a great approach towards the evaluation of the green relationship among the department, it does not define the parameters to follow when defining the actions that will improve the results, therefore the company must be cautious and documented actions or previous simulations should be performed in order to avoid bad impacts or enhance the desirable results.

It can generate "Lock-in" situations, which mean that improvements obtained for the whole value chain do not necessarily lead to environmental or economical advantages for single stakeholders. With this being said, this stakeholder will oppose the further implementation of new changes. (Stevels, 2007) Reassurance and continuous communication about the processes to be implemented and the expected results must be imperative in order to break resistance, and turn around the individual mentality towards a collaborative one.

Some evidence given by Stevels, shows that customer is reluctant to choose and buy an EVC- based product, mainly because ignorance. Strong stakeholder consideration during

the design and implementation of the project is vital, even a individual assessment of what is expected by each stakeholder and defining a communication channel of the progress of the project may help to give the right direction to the processes and ultimately to the product.

4.3 SUSTAINABLE SCORECARD

The original Balanced Scorecard was introduced in 1992 by Kaplan and Norton, which became a management tool that allowed a four angle performance perspective of a company (financial, customer, internal processes and learning and growth). This tool linked the different measurements, targets and objectives in a coherent and visual approach that permitted to set a consistent company strategy.

Some years after the SIGMA project – ***S****ustainability* ***I****ntegrated* ***G****uidelines for* ***Ma****nagement* launched an adapted version of the Balanced Scorecard, this time taking the already known tool to another level of applicability: a sustainable approach. The new tool still measures performance at all levels, uses KPI´s, and gives guidance, allows clear communication and helps implementing the company strategies. From the moment it was initially created until now, the well know Balanced Scorecard has a strong approach towards just one-bottom line feature (financial) and its relation with the other performance perspectives, leaving behind the social and environmental bottom line a little behind. As a result, this adapted scorecard allows modeling and addressing the issues of sustainability management (three-bottom line perspective) and rather than having a customer perspective, will refer to a stakeholder perspective that include environmental, social and economical actors.´

The SIGMA Sustainable Scorecard has established four working standpoints in order to achieve a sustainable management performance.

4.3.1 SUSTAINABILITY PERSPECTIVE

Several questions have to be in mind, for example how the company can reach success by being sustainable? How can the company measure sustainability as a whole, or how to measure social, economical and environmental issues? How to align all these measurements to achieve the company´s vision and mission?

Although there are relevant subjects to consider such as ecological sustainability, human rights and economic performance; is the interpretation of the company regarding sustainability the one that will set the roadmap to work with.

4.3.2 EXTERNAL STAKEHOLDER PERSPECTIVE

The critical issue in this standpoint is how to commit and engage the company activities with the stakeholders? It is going to be accountable and public? Can the company show the sustainable development contribution to its stakeholders?

In order to know that the company is doing well its homework according to a sustainable approach, some issues should be taken into account such as accountability of the accomplished development and stakeholders´ satisfaction. Here, some conflicts with the first standpoint may arise regarding the definition, since both intend to achieve sustainability, but the differentiation comes by setting the perspective of success for either of them. It is not the same to define sustainable success from the company´s point of view to the definition of stakeholders´ sustainable success.

4.3.3 INTERNAL PERSPECTIVE

This is the in-depth perspective that considers the processes that are going to be involved directly in the achievement of sustainability development and consequently are going to satisfy the stakeholders. Issues such as eco-efficiency, cost reduction and green production may help in this regard.

4.3.4 KNOWLEDGE AND SKILLS PERSPECTIVE

What should be learned? How to improve the existent activities that will let to achieve and excel a sustainable performance? Shifting the learning curves with continuous learning, conduct innovation through R&D department, investing in human capital are some of the activities that may be revised to seize this standpoint.

These four standpoints are correlated and the good execution of each of them will affect positively the others. They should not be seen separately but as a set of working perspectives to be followed in order to implement correctly a sustainable approach in the whole company and in the long run. After this Scorecard is completed, it will help in the prioritization of tasks and decision making process towards sustainability.

Even though each Balanced Scorecard is exclusive to each company, certain factors should be taken in consideration at the moment of definition. For example, critical subjects for one and each of the standpoints, indicators associated with the subjects, which drivers will affect the indicator, possible initial targets in order to set a controlling point and improvement activities to reach the new targeted indicators' values.

According to SIGMA Project, the Scorecard can be constructed using these following steps:

- Identify and agree organizational values, vision and mission.
- Identify and agree on key areas of performance where the business must succeed in order to achieve its vision and mission in line with its values.
- Build and agree in a driver model that explains and shows visually the linkages between key areas of performance, vision and mission.
- Identify and agree on indicators to measure success; identify the current and initial performances of each indicator, develop targets to be reached and time period to be achieved.

At the end, the company will have a map of how the drivers correlate and a one-sheet template that brings together the indicators, the target values and how they should be reached. Here the two examples of how a Sustainable Scorecard should look like (driver model and indicators template.

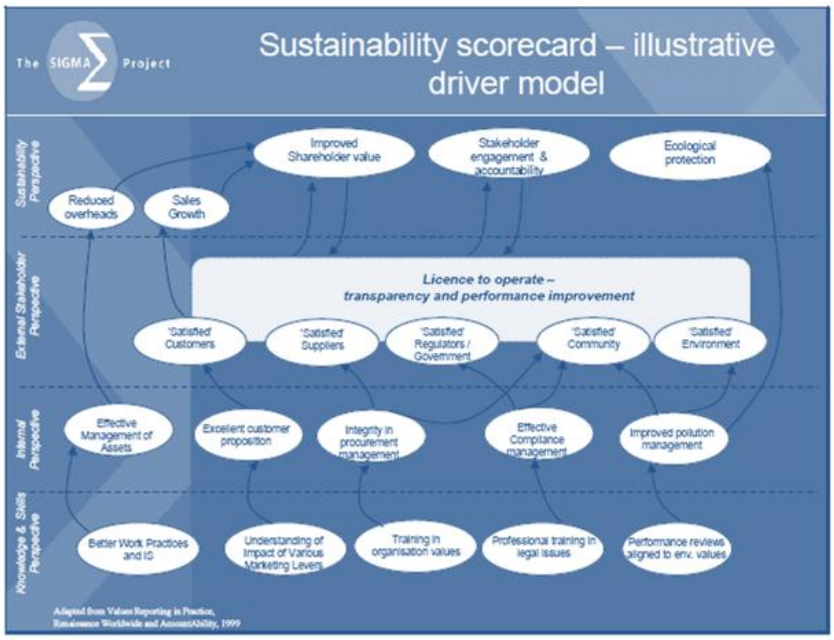

Figure 9. Sustainable Scorecard Drivers map

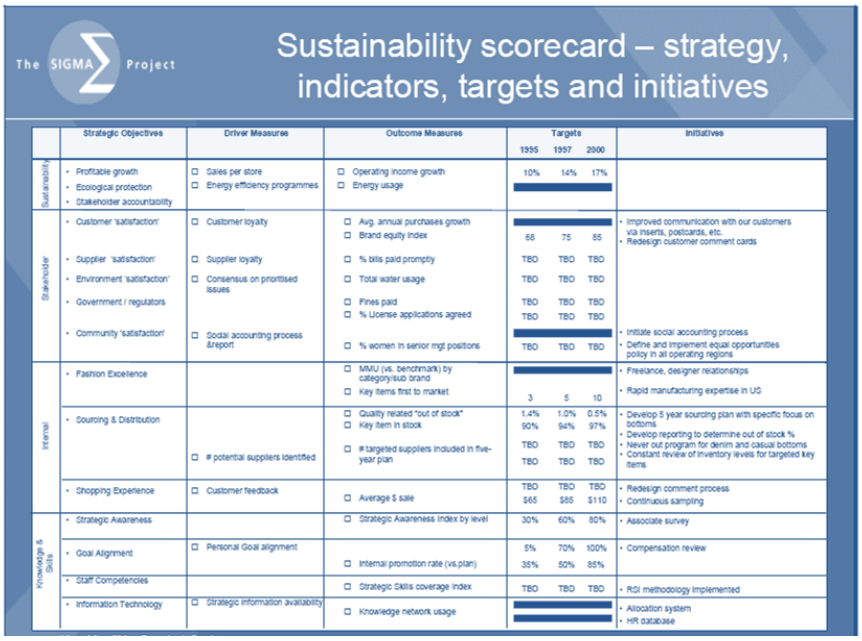

Figure 10. Sustainable Scorecard Strategy, indicators, targets and initiatives (SIGMA, 2003)

4.3.5 BENEFITS

The results turn out to be a coherent model that links the company activities and the KPI´s in the direction to its vision and to the milestone values of the organization. Since it is a framework that will fit the individual necessities of a company of what it considers sustainable, the Sustainable Scorecard is applicable within any sector and organization type thanks to its simplicity and generality. It will also allow improvements from the very beginning of the implementation that will improve the company performance in the long run in terms of operative and strategic approach.

Since the original version of the Balanced Scorecard is already being used in many companies around the world, it makes this sustainable version highly compatible to be implemented without a severe impact, and will go along with management tools that are already established and implemented. Although the SIGMA Sustainability Scorecard ideally operates at a corporate level, it is also suitable to work in a business unit-case or in a micro-level (SIGMA, 2003)

Since the main change of the tool is regarding its scope and approach, the Sustainable Scorecard reinforces the organization´s understanding and use of the KPI´s and objectives, and therefore supports and makes smoother the company decision making process.

4.3.6 LIMITATIONS

Since is a open tool and its results depend on how the company defines their objectives, values and how they are going to measure their performance; a misunderstanding of what sustainability is may create conflicts in terms of achieving a good map to work with in terms of sustainability. And even if the company is able to reach a consensus on the sustainable definition, setting the actions and correlating them towards its ultimate objective: three-bottom line consideration is quite hard. Not to mention that misinterpretation may also arise between the four standpoints.

The understanding of the sustainable approach as a corporation is comparatively straightforward, but extremely caution should be paid when assessing the priorities of the scorecard with the possible tradeoffs that could be presented among the different company departments.

Since this is a relatively new topic and in this concern also the tool, some trouble about defining the proper indicators, actions or targets can take place. It highly advisable to be innovative, but with caution; in order to seize each of the sustainable factors considered relevant for the company. It will be only with time and experience that the Sustainable Scorecard will be tuned towards the ultimate objective: three-bottom line approach.

4.4 MET (MATERIAL, ENERGY, TOXICITY) MATRIX

MET Matrix is a tool that summarizes the environmental impact at each stage of the product lifecycle. It takes the inventory of the most critical product´s aspects in the environment with an effortless approach. The tool is a combination of quantitative and qualitative information in a 3 x 3 matrix where input-output relationship is measured against product´s lifecycle. The three aspects to consider are *Materials* input/output cycle: takes into account environmental concerns regarding resource consumption and waste generation; *Energy* use: the amount of required energy in each phase of the product lifecycle. *Toxic* emissions: includes wastes in water, air or soil. The most common phases considered within the product lifecycle are *Production*: process starting from raw material extraction to production or manufacturing and afterwards transportation and sale; *Use*: considers the product since it has been purchased to the possible repairs that it might

incur; and *Disposal*: relevant to product discarding which can be done in several ways including recycling, incineration or land filling. (van Berkel, Willems, & Lafleur, 1997)

The information required to complete de MET Matrix is provided in its majority by the project team taking in consideration their knowledge and experience in the industry. This tool is adequate for start-ups and workshops of cross-functional designing and managerial teams that are requested to improve either product or process. It will allow a quick assessment in the identification of the different product´s impacts (Kortman, van Berkel, & Lafleur, 1995). Additionally its use can be enhanced and taken to an in-depth level by implementing eco-indicators (Knight & Jenkins, 2009) which will give the tool more specificity, turning the outcome in a more quantifiable and detailed analysis.

A visual reference of an implemented MET matrix is the following:

'MET matrix' for lightweight chemical detector product.

MET MATRIX: Lightweight chemical detector 3.2E		Materials – inputs and outputs	Energy use – inputs and outputs	Waste and emissions outputs
Production and supply of materials and components		Plastics (0.4 t) stainless steel (0.04 t)	High energy usage: stainless steel, plastics	tbd
In-house production		Fixings, solder, sieve material (0.02 t)	Process energy (wash and bake process) Est. 458,828 kg CO_2e	0.01 t hazardous waste 40 m^3 industrial effluent to sewer
Distribution		Packaging	Fuel	(Carbon emissions)
Utilisation	Operation	1 sieve pack per 250 h usage Batteries: 40 h lifetime	Est. 10,000 kg CO_2e	Contaminated sieve packs batteries
	Servicing	Broken/damaged parts	Transport	Plastic parts (0.02 t)
End-of-life	Recovery	Packaging	Upgrades generate est. 8920 kg CO_2e	tbd
	Disposal	Packaging (0.01 t)	Process est. 5000 kg CO_2e	Batteries PCB's Plastics (coated) (0.4 t)

Data based on 'per 1000 units'.

Figure 11. Example of an implemented MET Matrix (Knight & Jenkins, 2009)

4.4.1 BENEFITS

MET matrix can be successfully used to identify key environmental aspects of the product throughout its lifecycle as part of initial evaluations and quantification during an assessment. Its results can be easily understood by employees and professionals and will work as a conscious driven tool among the people since in a general way all the environmental impacts held in the production, use and disposal of a product are presented. Through time the same tool could work as an improvement instrument comparing it with a past MET matrix assessment. MET matrix can be used either in a specific product assessment or in a more general design process (Knight & Jenkins, 2009)

4.4.2 LIMITATIONS

Even though its structure is simple and easy to work with, it may require some customization prior its use which can turn out to be a barrier for further implementation. In other words, customizing the MET matrix into a more complete tool will lead into a loose of generality and simplicity and with this requiring a more experienced group to use it

Neither a standardization of product stages of its lifecycle or indicators in the MET line have been parameterized, then each MET matrix is unique and will not allow comparison among company´s products. So its impact will only remain under the company limits. If wanting to take it to the next level into a wider scope including several actors that participate within the product lifecycle, an initial consensus on indicators, dimensions and in depth reach is going to be expected from each player in order to make the results comparable and consistent in a general perspective.

4.5 GREEN SCOR

It is the upgraded version of the SCOR model and before describing the new approach it is necessary to give a foretaste of what the original model is based on.

SCOR (Supply Chain Operations Reference) model was created by the Supply-Chain Council as an effort to develop a standardized tool to evaluate the supply chain performance and being able to improve it. It gathers and consolidates the best practices and most common metrics along the different industries which makes this model quite full-bodied and customizable to any company willing to implement it.

The model breaks down the supply chain process in six categories that describe all the activities held within the chain.

Categories	Description
Plan	Processes related to planning, coordination and scheduling of the activities.
Source	Processes related to raw material providing, raw material receiving and storage.
Make	Processes related with material transformation until a finished product. Additional operations such as maintenance, repair and overhauling.
Deliver	Processes related to storage, packaging and product transportation to the customer.

Return	Processes related to delivering and receiving between customer and supplier (reverse logistics)
Enable	Processes that allow the material flow (data management, performance management, contract management, assets management among others)

Figure 12. SCOR Process Categories (Wilkerson & Raheem, 2003)

Additionally, the supply chain processes are also characterized by three primary types: Make to Stock, Make to Order (MTO), Engineer to Order (ETO). These two levels (Categories and Types) of the SCOR model can be graphically explained in the following figure.

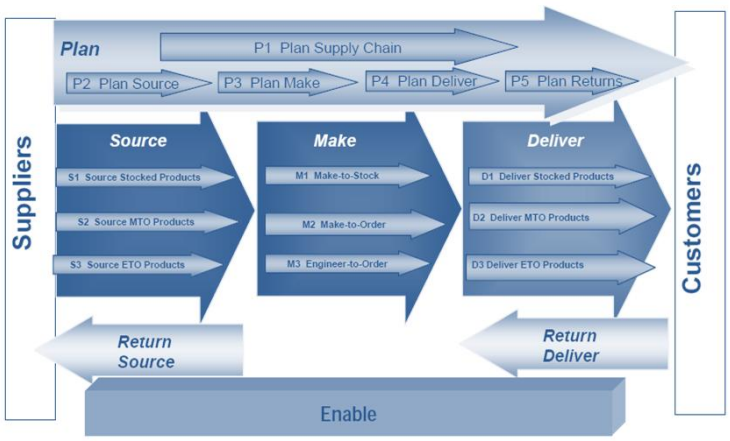

Figure 13. SCOR Processes (Wilkerson & Raheem, 2003)

Assuming that this image represents a company operation regardless the industry or role they assume in the supply chain, the model can be expanded up to describe the whole network starting from the raw material extraction until product disposal turning it into the characterization of a supplier -company - customer relationship.

Besides, this model/tool has general tables filled with information regarding optimized processes, metrics and indicators. All the information consolidated is considered as the best practices possible to manage each process; which ultimately are the true power and leverage behind the model.

4.5.1 THE GREEN APPROACH OF SCOR MODEL

Particularly this analytical tool provides a plain perspective between the supply chain functions and the environmental issues; therefore becomes also a management tool as it improves both aspects.

To come up with this integrated tool several points were evaluated:

- Research of green practices and metrics that could be implemented in the supply chain.
- Evaluate the existent SCOR model in terms of environmental impact and improvement.
- Consolidate and include the green findings (practices and metrics) in the SCOR model.

Since a set of processes was already established for the model, the following step was to evaluate each process in terms of environmental impact and determine how the statement was going to be defined.(Potential impact). Additional processes were included in order to assess the green issues in the proper way: Waste accumulation and disposal in the MAKE process, returns of product may come from other reasons additional to defective pieces for repair, such as recycling, reusing or remanufacturing.

As for metrics, environmental definitions were used in order to compare them with the performance attributes already defined for the initial SCOR and align them in order to guarantee green compliance also in this aspect. Then by matching environmental and managerial metrics, the resulting where those that allowed improvement in both sides.
Finally for best practices, the result was just including the green practices in the already existent documents, since the tradeoff between environmental and managerial practices did no harm the process.

The result of this consolidation effort is a tool that will help the supply chain personnel and the environmentalist to maintain a full perspective of the supply chain dynamics without incurring in negative tradeoffs.

Some examples are given below for further understanding.

Categories	Metrics
Plan	Compliance costs , Emissions cost per unit
Source	% of orders received with correct packaging, % of suppliers with current EMS systems
Make	Energy costs as % of Production cost, Waste as % of units of product
Deliver	Fuel costs as % per cent of Deliver costs, % curriers meeting environmental criteria

Return	Returned product as % Delivered Products
Enable	Facility energy costs as % of Total costs, Down time due non-compliance issues.

Figure 14. Examples for Environmental Metrics (Wilkerson & Raheem, 2003)

Categories	Best Practices
Plan	Supply chain partners collaborate on environmental issues Plans created to minimize energy use
Source	Select vendors with EMS system in place Establish environmental partnerships with suppliers
Make	Schedule peak production for off-peak energy demand time Minimize packaging material
Deliver	Route to minimize fuel consumption Retrieve packaging material for re-use
Return	Do not physically return product beyond economic repair Take back product for recycling
Enable	Implement EMS and track environmental performance Maintain equipment for fuel/ energy efficiency

Figure 15. Examples of Environmental Best Practices (Wilkerson & Raheem, 2003)

Going a bit further in the utilization of the Green SCOR tool, some footprints metrics have been defined to be measured through the whole supply chain (Carbon emissions, air pollutant emissions, liquid waste generated, solid waste generated, recycled waste, including others). A visual map of how the process of measurement is within the network is shown as a reference.

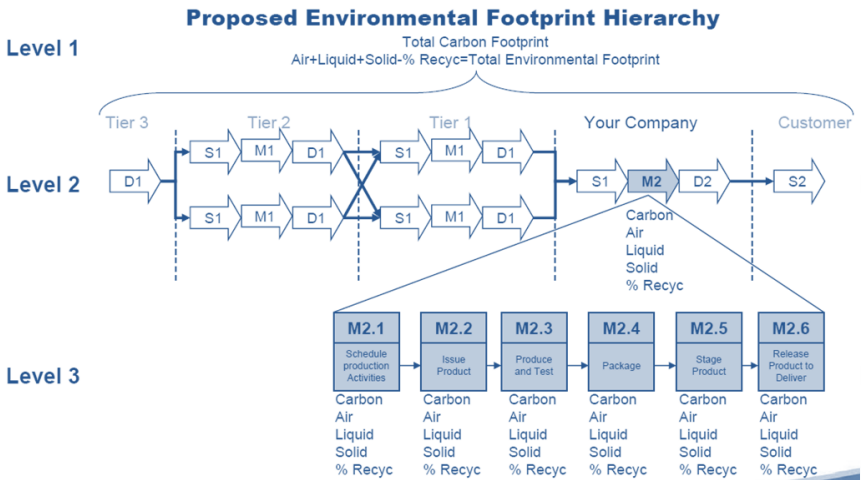

Figure 16. Environmental footprint metrics mapping (Wilkerson, 2008)

4.5.2 BENEFITS

By gathering and compiling information from all the associated companies in the Supply Chain Council and turning the information into standardized tables of processes, metrics and best practices, the Green SCOR model allows the companies to regulate, compare and improve their operations while using a common language between them.

Green SCOR model turns the supply chain in a sum of discrete activities allowing a better approach to control and improve the weak points in the characteristic company´s operation. It goes further in its scope by considering reverse logistics within its usage; therefore many actions can be traced while it turns in a less time consuming procedure i.e. activities like recycling and take-back programs. As the system is mapped, the company can fit to its needs the already known metrics and best practices; and when any potential improvement can be implemented, the company will be capable of first simulating the environment and company characteristics using software tools. The results obtained from this simulation will allow knowing where the improvement is going to impact and its intensity among the overall process. Additionally to the simulation and inherent results, it will be possible to identify and quantify different shadow effects that may be brought implicitly by the improvement action into the system, allowing the identification of tradeoff situations and letting a prior discussion and scenario simulation before implementing the improvement plan in the real world.

Additional to have a resemblance to LCA, Green SCOR gives a higher level of detail and examination. It allows going all through the macro processes and then inspect downstream to the business processes that generate the different impacts. Besides, it will be possible to find hidden environmental issues, take direct and localized actions to mitigate them.

Highly accessible since has standardized processes and manages a familiar language which will allow undemanding green implementations and increase the probability of a successful environmental management contribution.

4.5.3 LIMITATIONS

An initial challenge for any company is to start collecting the right data required to describe their operation and afterwards assess the environmental impact. Also some trouble can be found when trying to translate it to the already defined metrics. In this stage, what is going

to become more evident is the big gap that exists between the supply chain and their environmental performance. For instance, in order to prove the effectiveness of the Green SCOR it is necessary to educate the supply chain companies on its use and in this way the knowledge will allow the reduction of the gap.

A collaborative culture among the company´s employees is required as well as in sharing the information between supplier-company-customer relationships. Only in this way the supply chain approach towards environmental supply chain management will be successfully implemented.

Since the Green SCOR is a compendium of best practices and measurements among all the industries, this tool might have a lack of specificity where the company will have to work from zero in terms of possible indicators´ targets and best practices characteristic of their own core processes.

4.6 INTEGRATED PRODUCT POLICY

Products and services reflect the wealth of any society, the living standards, in a broader sense the quality of life (Sucharovová, 2001) and therefore the consumer society has also a negative effect on the environment on behalf of reaching and maintaining their status and lifestyle believes.

Created by the European Commission, to direct and support environmental innovations that allow a decrease in the high environmental impact along the product´s lifecycle (EU, 2001). Although most of the already implemented tools regarding environment protection and foremost a sustainable model, have been successful; their impacts are becoming less important and just incremental improvements have been reached. Then by doing an econometric analysis and reviewing company cases, it has been observed that environmental policies, theories such as technology push and market pull and business characteristics have also a great influence on environmental product innovations. (Rehfeld, Rennings, & Zeigler, 2006) But at the same time, some economic factors such as market prices seem to be huge barriers when trying to exploit and promote the environmental products/environmental innovations. At this point, it is also being observed that another

fact that should be considered while defining a policy, is the consumption habits and after disposal of the products which engages undeniably the consumer.

Another approach to explain the IPP creation is the awareness of the fact that there is a considerable difference between the price paid by the consumer and the cost that during its lifecycle a product really incurs in the society on different levels. There are hidden costs that society pays in forms of environmental impact that are not directly related with the exchange (price) between manufacturer and consumer. This phenomenon is called deformation of the market since there is not fair exchange of goods considering the further impacts of the products in the environment or social aspects. A product taking advantage of this fact enjoys unfair benefits in comparison with a green product (economically expensive); due its less damaging impact on the environment in the course of its life cycle, which does not burden society with excessive costs (Sucharovová, 2001).

The scope behind the Integrated Product Policy (IPP) is to be cooperative between industry, society and politics as a response to the complexity of the environmental issues that could not being seized by the actual protection and preservation. It should guarantee equal conditions on the market by stimulating better solutions while putting worse systems in disadvantage.

IPP is aware of the environmental impact from the very beginning of the product design and throughout the complete product lifecycle until its disposal, therefore optimization becomes possible in all the different stages of the product having a special focus in the consumers and users, since is the less impacted factor so far. This focus is critical since the consumer takes the ultimate choice and will allow that the environmental impact minimization.

Besides cooperation among the stakeholders while working towards a joint objective, it is also important to consider integration of the measurements and policies to be taken in consideration to the ecological, social and environmental aspects. There is no room to define a policy that will bring a negative tradeoff between the three bottom lines in the long run and because of this aspect communication is also required within the IPP.

As a visual representation of what IPP considers and has been discussed in the paragraph above there is the Kreuth cube.

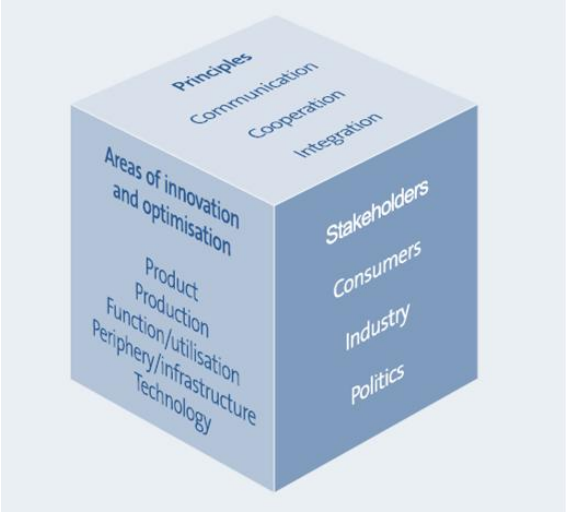

Figure 17. Kreuth Cube - IPP Dimensions (Hoke, 2001)

For IPP successful implementation several things should be kept in mind. Practicality and simplicity in the implementation and follow-up of the IPP are extremely important in order to let continuity and control from a governmental perspective. In this regard also government regulations shall be cautiously assessed since there are different levels of authority and consequently the regulations should be only applied in those levels which authority can be in the position to execute and risk can be controlled and minimized.

In order to have a consistent positive outcome from IPP, it is necessary to have periodic meetings with the representation of all the stakeholders and define the working structure according to the various dimensions for a specific time period. Since IPP assumes innovation and improvement not only in the product aspect but concerning its conception, preparation, production and the technologies used in the various stages; it is imperative not to ignore the periphery actors/parts/ technologies and the infrastructure in order embrace from all points the IPP scope. The IPP goal is to achieve continuous improvements in products and services regarding their effects in the environment and mankind along the whole product lifecycle.

The example below shows how the Bavarian government and the car industry are implementing a diversity of actions considering the IPP principles versus the product and life cycle dimensions.

Areas of innovation and optimisation related to	Principles of Action: Communication	Cooperation	Integration
Product	■ Product brochures and safety data sheets (Moulding Sand Binder and Aluminium Casting, p. 26) ■ Comparative assessment by eco-indices (Lamps, p. 39) ■ Material data base (Lamps, p. 39) ■ Achievement of comprehensive product quality by Total Quality Management (Non-wovens, p. 30)	■ Optimisation of pre-production: tanning and dyeing processes (Leather Covers, p. 28) ■ Development of a single material concept with external partners (use of secondary raw material, p. 74) ■ Simultaneous Engineering (Product Design, p. 42)	■ Company standard on environmentally compatible product design (Electronic Components, p. 32) ■ Eco-Analyses along the entire life cycle (Lamps, p. 39) ■ Research and development centre as platform (Product Design, p. 42)
Production	■ Training of employees (Raw Material Extraction of Bentonite as an Example, p. 24) ■ Environmental Management Handbook (Chain Drive Systems, p. 36) ■ Internal exchange of experience (Product Design, p. 42) ■ Optimised recycling through plastics identification system (Utilisation as Secondary Raw Material, p. 75) ■ Preparation of environmental statements according to EMAS (Production, p. 46)	■ Cooperation with other companies for optimisation of production (Engine Elements, p. 40) ■ Integration of different environmental aspects e.g. through power-heat-cold coupling unit (Production, p. 48)	■ Parallel project groups at the manufacturer and supplier (Chain Drive Systems, p. 36) ■ Integrated management system (Paint Thickeners, p. 27)
Function/ Utilisation	■ Advisory consultations (Moulding Sand Binder and Aluminium Castings, p. 26) ■ Elaboration of the customer desires in "product clinics" (Product Design, p. 43) ■ Environmental handbook for dealers (Distribution and Sales, p. 54) ■ Comparative test reports for consumers (Operation, p. 65) ■ Product label "Blue Angel" for car washes (Operation, p. 65) ■ Taking into account individual customer requirements by computer assisted customer advice (Logistics, p. 52) ■ Running of driving training for customers (Logistics, p. 52)	■ Exchange system for used clutches (Clutch, p. 35) ■ Research cooperation for improved product function (Chain Drive Systems, p. 37) ■ Participation in car sharing models (Mobility, p. 59)	■ Advantage for the user: manufacture, maintenance, distribution and repair come from a single source through selective distribution system (Distribution and Sales, p. 54) ■ Combination of local public passenger transport and motorised individual traffic through Park+Ride concepts (Mobility, p. 60) ■ Innovative financing models, e.g. job tickets, member tickets (Operation, p. 63)

Figure 18. Sample activities in the IPP fields of action in the Bayern automobile industry (Hoke, 2001)

It is important to note that IPP is not a new tool, instead it is a new approach characterized for its systematic, target oriented and conscious use of the existing instruments in the product lifecycle stages. While achieving this working schema one important outcome is that IPP is performing risk management since it avoids, reduces or renders more controllable the risk.

Additionally IPP makes possible the interaction with some other tools towards the same ultimate objective. Usually IPP adopts voluntary instruments such as cleaner production, eco-labeling, voluntary agreements among others.

4.6.1 BENEFITS

IPP in definition is a simple approach toward environmental improvement. It shows a clear requirement of characteristics as in this case is intended as principles, shows a defined structure of areas of innovation or at least where optimizations actions can take place, and where a directive group arranged with all the relevant actors is periodically called to meet in order to give monitoring to the initiatives that are being made through time.

Is one of the first times that sets and defines responsibility of the environmental negative impact to the consumers and their life styles believes. Then, the tool also takes into account

their buying behaviors and encourages the society to be environmentally responsible either by giving advice about the products that are being environmentally improved, re-educating their purchasing habits and controlling the way each person disposes anything that himself considers not longer useful.

The definition of a working group that considers the government as the authority stakeholder while interrelating with industries and consumers is a new conception. After all governments have been working in the environmental issues by themselves studying and setting policies that may not seized the complete problem or may turn into a uncompetitive market environment for some companies. By having a group in which all the stakeholders can interact, the environmental and furthermore the sustainable principle is being granted in every single aspect.

Another novelty present in this tool is that service in not considered granted as one of the different types of product that exists. A special approach is given to the service, especially to the peripheral approach regarding maintenance, repairing or recycling.

4.6.2 LIMITATIONS

Since is a voluntary practice and considering the exhaustive requirements to implement it, S&ME´s may be discouraged because they might not have the required capital and resources to launch all the improvements that can be suggested after the stakeholders meetings. Neither will be able a big company, instead a strong effort coming from an entire national industry will help to the assessment of a proper IPP along with the other involved actors. The tradeoffs that can be determined with the industry approach are going to be as realistic and beneficial as possible to the entire market. This effort must come as collaboration towards a sustainable future of the nation habitants. But also making and industry agreement is quite complex. Government participation and disposition is also decisive, and usually their managerial and legal structure will cause delays in the policies declarations that may also end up discouraging the initiatives among all the stakeholders.

Although periphery is considered for the first time and the impact of involving it in the assessment is a complementary and required action; this aspect requires a lot of help coming from the same suppliers by the hand of the industry and companies asking for their inclusion in the policy. Any policy or measurement to determine has to consider also the

impact, implications and possible solutions that supplier or periphery companies could carry without being left behind.

4.7 ECO-MANAGEMENT AND AUDITING SYSTEM (EMAS)

Scheme implemented by the European Commission since 1993, it is one of the most diffused and credible environmental voluntary certification schemes (soft instrument), which is based in negotiation and shared responsibility between the involved actors. It acknowledges and encourages organizations to improve their environmental performance on a continuous basis (Glavic & Lukman, 2007).

Initially, it was intended for the industrial market, but in 2001 it had gained enough status to be implemented in any type of company (industry, service, private and public) in order to guarantee a sustainable future for everyone. It promotes continuous improvement in a sustainable approach by implementing environmental policies, with systematic and periodic evaluation sessions and providing the information of their results to the public considering a company basis. The required public report via environmental statement must contain essential details regarding the ecological situation in the company location by the compliance of the actual statutory provisions for further validation and registration.

When implementing an EMAS, a company can expect in the first place a positive environmental improvement upgrading its green performance. Afterwards while consolidating the practices and letting the tool become more robust, it will be possible to see and to quantify a positive performance in terms of competitiveness. Aspects such as cost reductions, product innovations, processes optimizations and customer recognition are some of the benefits that can be achieved by integrating an EMAS into a company.

Figure 19. Conceptual EMAS framework (Iraldo, Testa, & Frey, 2009)

Firms willing to register their EMAS are required to do an initial environmental analysis, implement an environmental management system, perform an audit regarding these issues and write a statement. All these actions and documents will be analyzed by the corresponding agent (third party). To understand better the required processes to be able to report an EMAS, the following diagram is presented.

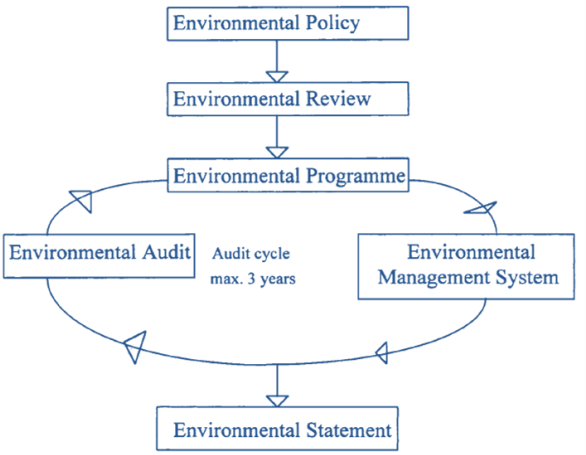

Figure 20. Main components of EMAS Regulation (Strachan, 1999)

The EMAS explicitly requires the inclusion of product planning and an advanced assessment of environmental consequences of the new products regarding the environmental policy and programs and eco-management audit as well. (Rennings, Ziegler, Ankele, Hoffmann, & Nill, 2003) Also some variables that should be considered in order to assess the linkage between environmental innovations and competitiveness are: performance indicators, the maturity of the system, the learning process given by its implementation and the organizational – strategic importance of EMAS.

Consequently, the company must be in the position to report its own operations and environmental achievements as well as the indirect environmental impacts it might incur with its operations and products. It Is considered an *Indirect environmental aspect* an element of the organization´s activities, products or services that has or can have an impact on the environment and which can result from the interaction of an organization with third parties and which can, to a reasonable degree; be influenced by an organization. (Iraldo, Testa, & Frey, 2009).

Product related issues such as R&D and packaging, capital investment, insurance services, practice contractors among others are considered as indirect environmental aspects. At the

end, competitiveness is improved by the linkage between the environmental management and the innovation management; specifically R&D department will be in the position to relate product development with strategic issues.

The usual environmental innovations presented in the EMAS participant can be divided in terms of organization, process and product related. Some descriptions are presented below:

Figure 21. Environmental innovations implemented by EMAS-participants (Rennings, Ziegler, Ankele, Hoffmann, & Nill, 2003)

Implementing EMAS inside a company will provide a more systematic approach towards the environmental management system and by having a third party to verify and audit the tool´s success, the company can demonstrate their already verified achievements to the stakeholders.

Since the EMAS is a public report that allows the examination of the environmental performance in a certain company, the requirement when writing the report is to use a friendly-user language, considering it can be read by their stakeholders, NGO´s or public in general.

4.7.1 BENEFITS

Considering certain aspects in the environmental improvements, it may achieve the same positive effect in the firms' competitive performance. The benefits coming from implementing an EMAS can be seen when interacting with the competitors in the market arena. Moreover it can conduct to improvements in productivity and lower costs of

compliance. These factors are over achieved during the process of adaptation of EMAS, since they bring implicitly a significant learning process and structure for the company. The overall effect is the improvement in most of the competitiveness aspects.

It improves corporate image in several aspects. First the report is open to the public and is read by practically anyone, if the registered performance shows an improvement through time or outstands among the other companies, then the company gains some reputation. Also the fact that the report has to be evaluated and audited by a third party, then this party and its knowledge guaranties the reliability of the report and the veracity of the information. In addition, since the result of the implementation of the EMAS links environmental performance with process competitiveness, then the product offered to the market has enough characteristics to be selected by the consumer above other choices, increasing the market share and consequently improving the company image.

In the initial approach when implementing EMAS nation-wide, the wide range of actors involved will consider all the key aspects regarding the scheme definition. These actors are: government, industry, quality management experts, country standardization agents and technical groups. This group will be responsible of defining the rules of accreditation
EMAS schemes provide descriptions of the environmental training that the responsible personnel should have when performing the EMAS activities.

EMAS is used as a communication tool among the external stakeholders which results in an effective tool. It can also contribute to the diffusion of environmental innovations and practices within industries.

4.7.2 LIMITATIONS

The results coming from this type of tools strongly depend on time and the congruency of the company efforts to achieve more improvements each time the cycle repeats. Disposition of a specific working team it is important, since it has to be controlling and monitoring all the actions and their results, documenting processes actors, targets, indicators that will help in the construction of the official document.

Before having an EMAS, there are several issues that need to be accomplished previous to the competent agent approval. This might be exhaustive the first time it takes place and could discourage companies that are not moved by market or industrial competitiveness.

Companies may show some reluctance against EMAS, since it is imperative to do public environmental declarations. Voluntary EMAS implementation in companies can be achieved but in the majority of the cases, the companies ask for something in return (i.e. ease in the regulatory control).

This environmental management system has being considered expensive, resource-intensive efforts that will finish in nothing more than an approval stamp like some some companies have affirmed. Companies unwilling to adopt EMAS scheme can easily switch towards ISO14000 since it is worldwide known and more flexible.

Its validity is only for European countries.

4.8 NATIONAL ACCOUNTING MATRIX INCLUDING ENVIRONMENTAL ACCOUNTS (NAMEA)

The tool known as National Accounting Matrix including Environmental Accounts shows the links between national accounts and economic indicators such as GDP (Gross Domestic Product, or Balance of Payments) with the environment. National Accounts are those accounts that describe a country´s economy using worldwide reporting standard system and applied for the calibration of parameters in economic equilibrium models.

Official overviews bring information regarding financial and economic situation of the reporting country. In the present, some environmental accounts have been added to the National Accounts in order to keep track of the economical impact against the environment. The most common accounts are substance account and environmental theme indicators where green house gas emissions, traffic emissions and recently water sources pollution are accounted.

Using environmental accounts calculated on the same basis of the National Accounts principles will allow the smooth incorporation of the environmental variables in the already

used macro-economic models. Although the economic accounts are measured in monetary terms, these accounts are measured in units of emission (i.e. kilograms if is physical waste, or joules if it is energy).

The procedure to calculate the environmental emissions is consistent with the one used to calculate the GDP. For example, when calculation the transportation costs, the NAMEA measures also the fuel consumption across and abroad the country (geographical perspective). Also while reviewing the Netherlands NAMEA (first country to use it) carried out between the 1993 and 1997; the report covered the depletion of crude oil, natural gas and six types of environmental degradation – greenhouse effect, ozone layer depletion, acidification, eutrophication, waste and wastewater (de Haan & Keuning, 2001).

NAMEA discriminates two groups of activities: households and industries which also include public services. The tool connects the inputs and outputs to the related economic activities that are directly responsible among these groups. When accounting the environmental aspects, some factors should be considered such as average temperature during the year, geographic resources availability, etc. Since these factors are intrinsic to each country, when reporting their national results, each country should publish also all the considerations and assumptions used when performing the environmental accounting report in order to be able to establish some comparisons or show clearly the differences between countries results.

This accounting considers pollution not attributed to current transactions, cross border pollution from the rest of the world, absorption by producers, clean up actions such as waste incineration and recycling, cross border pollution to the rest of the world and transportation of pollution by environmental media (air, land, water). Then substances are grouped according to the type of environmental stress, and afterwards aggregated in the corresponding indicators (de Haan & Keuning, 2001). Although the total amount of environmental stress can be assess and determined for a single accounting period, the damage it can bring now or in the future cannot be shown.

When consolidating the NAMEA report, the economic activities are related to the country policy goals obtaining their contributions in the macro-economic lines and also to their contribution to the environmental indicators and ultimately to the environmental problems (ozone layer depletion, acidification, etc). The comparison between economic lines and

environmental impact is usually perform at industry level, and afterwards; allows establishing relationships among the economic gain or loss compared with the level of employment, value added among a supply chain or with the levels or types of substance disposal. Statements about total pollution are not only determined by the country´s economy but also by its economical structure observable with this type of reporting.

Some examples are provided from the Dutch government regarding the substances flow accounting and the environmental themes, respectively.

	CO_2	N_2O	CH_4	CFCs and halons	NO_x	SO_2	NH_3	P	N	Waste
	11a	11b	11c	11d	11e	11f	11g	11h	11i	11j
	mln kg			*1 000 kg*	*mln kg*					
EMISSION BY CONSUMERS	36 790	3.53	21.17	45	109.42	2.05	6.77	8.64	115.44	5 120
Own transport	15 640	3.32	3.99	-	87.61	1.52	-	-	25.50	70
Other purposes	21 150	0.21	17.18	45	21.81	0.53	6.77	8.64	89.94	5 050
EMISSION BY PRODUCERS	163 270	69.32	618.58	803	591.09	234.08	180.89	84.49	903.37	10 050
Agriculture and forestry	9 230	26.32	448.95	5	32.51	1.75	176.50	53.01	612.79	860
Fishing	3 760	0.88	0.13	-	77.31	63.11	-	-	19.81	110
Crude petroleum and natural gas production	250	0.02	0.08	-	1.00	0.35	0.15	-	0.50	90
Other mining and quarrying	1 820	0.01	157.57	-	3.20	0.17	-	-	1.17	100
Manufacture of food products, beverages and tobacco	4 520	0.07	0.34	20	6.99	0.48	0.23	2.54	15.46	460
Manufacture of textile and leather products	420	0.01	0.05	-	0.58	0.01	0.01	0.03	1.95	50
Manufacture of paper and paper products	1 930	0.01	0.08	-	2.18	0.08	0.10	0.82	4.33	360
Publishing and printing	310	0.02	0.04	-	1.07	0.03	-	-	0.41	90
Manufacture of petroleum products	11 200	0.07	0.60	-	15.53	52.14	0.02	0.01	5.99	70
Manufacture of chemical products	22 470	35.06	3.11	231	27.65	12.22	2.77	7.51	19.37	1 980
Manufacture of rubber and plastic products	250	0.01	0.04	-	0.41	0.01	-	0.02	0.27	90
Manufacture of basic metals	8 870	0.01	0.09	-	9.35	10.09	0.07	0.17	3.98	110
Manufacture of fabricated metal products	530	0.03	0.04	-	1.42	0.04	-	0.02	1.33	80
Manufacture of machinery n.e.c.	380	0.02	0.04	-	1.03	0.03	-	0.07	0.90	80
Manufacture of electrical equipment	1 140	0.01	0.11	-	1.79	0.35	0.01	0.02	1.10	90
Manufacture of transport equipment	170	0.01	0.07	1	0.44	0.02	-	-	0.86	70
Recycling industries	370	-	-	78	0.15	-	-	-	0.00	740

Figure 22. Detailed presentation of the origin of substance flows in the Dutch NAMEA of 1997 (de Haan & Kee, 2004)

	Labour volume	Greenhouse effect	Ozone layer depletion	Acidi-fication	Eutro-phication	Solid waste
	ratios					
Production						
Agriculture and forestry	1.77	2.92	1.00	8.32	14.23	1.69
Fishing	0.05	0.03	0.05	0.05	0.01	0.13
Mining and quarrying excluding crude petroleum and natural gas	0.02	0.03	0.01	0.02	0.00	0.11
Crude petroleum and natural gas	0.05	0.54	0.04	0.10	0.02	0.03
Manufacturing						
Food products, beverages and tobacco	1.09	4.70	4.09	8.83	14.97	6.62
Textile and leather products	0.31	0.26	0.39	0.12	0.21	0.33
Paper and paper products	0.17	0.31	0.06	0.11	0.20	0.78
Publishing and printing	0.62	0.11	0.09	0.06	0.04	0.18
Petroleum products	0.07	2.23	0.10	3.03	0.11	0.17
Chemical products	0.56	5.99	5.17	2.43	0.83	4.69
Rubber and plastic products	0.23	0.23	0.86	0.10	0.04	0.25
Basic metals	0.19	1.32	0.14	0.78	0.09	0.45
Fabricated metal products	0.63	0.27	0.15	0.15	0.07	0.25
Machinery n.e.c.	0.56	0.35	0.29	0.21	0.12	0.43
Electrical equipment	0.68	0.38	0.86	0.20	0.12	0.35
Transport equipment	0.37	0.34	0.35	0.19	0.12	0.39
Wood and wood products	0.13	0.04	0.02	0.02	0.01	0.11
Construction materials	0.24	0.29	0.05	0.26	0.04	0.31
Other manufacturing	0.29	0.28	3.04	0.10	0.06	0.43
Electricity, gas and water supply						
Electricity supply	0.25	4.84	0.08	1.45	0.16	0.29
Gas and water supply	0.06	0.09	0.02	0.03	0.01	0.12

Figure 23. Cumulative pollution per unit of final demand relative to the aggregate cumulative pollution per unit of final demand (de Haan & Keuning, 2001)

Different types of analysis can be performed after the NAMEA is consolidated, such as percentage of pollution attributable to a certain industry, or cumulative pollution amount within a value adding process; direct or cumulative emissions in a macroeconomic perspective in terms of households, industries, to imports or exports.

When economic policies regarding environment are taken by a country, this tool will allow the analysis of the politic impact through a specific period of time. Suggestions about simulating the economic situation with certain environmental impact or vice versa through the linear programming of the NAMEA have been considered. Also the periodic reporting of the NAMEA will allow creating a timeliness data base regarding environmental aspects, relationships between environmental indicators and economic lines, which ultimately will result in a comprehensive information system of the environment, economic, and social accounts.

4.8.1 BENEFITS

The NAMEA allows comparison of industries between countries in terms of environmental threats. The comparisons are possible because it uses the macro-economic principles and accounts well diffused around the world As mentioned above, it also allows the comparison among different environmental impacts regarding different approaches such as industry, sales, imports, exports, taxes, etc. Comparisons can be performed in a time line series or between countries' industries. This tool can be also used for debates regarding the three-bottom line factors (environmental, social and economic) when policies are about to be declared and legalized since as already mentioned, allows the comparison among different sectors, industries or impacts.

Since the Macro-economic models have already been described mathematically it allows doing Ceteris paribus modeling introducing the environmental accounts and providing evidences of how a country economy can be affected by assigning different values to the variables considered. In consequence, it allows a logical approach towards the interaction between a country´s economy and its environmental scenario. Also with the modeling a prior observation of the country reaction towards and specific action can be simulated, instead of trying proof and error approach which by all means will be hazardous to try with a nation's economy or environment. Visualization of who, when and where the pollution

takes place in a macro economic perspective according to the industries will be physical evidence to assess particular regulations, restrictions or penalties to the responsible agents.

Regarding the quantification characteristics similar to the economic principles, a standard or dimension has already being set in order to allow the inclusion of additional environmental factors to be considered in the future .

A good analysis will help address and enhance country´s sustainable development.

4.8.2 LIMITATION

The cost issue is considered when implementing environmental measurements but not in exact terms of a company. Even mathematical models can be performed; truth is that none of the existent models have been able to describe accurately the real economic situation of a nation. Then, costs can be under or over estimated considering a certain environment improvement. Also since it is a relative new instrument and it allows to assess the relationship between macro-economic lines and environmental impacts, the entire relation has not been well understood as the cumulative effect are presented with some probability in the future and this report considers past economical and environmental situations.
In countries where certain sectors or industries are polluting over the average or above the country limits, the public information easily obtained with this tool may show possibilities of re-location of manufacturers and in general companies to places where the polluting impact is not high. Subsequently, the information provided by each country may lead to an effortless exit for highly polluting companies to places where the entrance can be seen as an investment rather than a pollution addition.

Still NAMEA does not have the social aspects completely incorporated to the Macro-economic models and neither a direct relation with the environment issue, avoiding the possibility to have a more integrative tool towards sustainability. .

A guideline of how the economic and environmental accounts should be quantified will allow a standardized comparison of the countries´ NAMEAs. Nowadays, the NAMEA just shows the own country picture regarding economics and environment. The guideline can include absolute or relative indicators that can be usefully compared in order to assess which country´s actions and performance are helping the environment even this kind of

comparison may allow to determine if a certain country is over performing in the quest of a sustainable world.

4.9 DESIGN FOR ENVIRONMENT

Design for Environment (DfE) can be defined as a systemic process by which firms design products and processes in an environmental conscious way. It considers the process of developing a product, taking in consideration the reduction of its environmental impact. The ultimate scope is to design products and processes that are functional, attractive, economic and produce no harm effects either to the environment or the society under a systemic procedure. It applies either for an existing product or for the development of new ones.

Initially conceived by Fullerton and Wu in 1998, where they assumed that producers should choose a certain degree of recyclability in their products. Today, it has been estimated that 70% of a product´s environmental impact is locked in at the design stage. Therefore what is optimal while considering the three bottom line aspects is to seize the improvement during the initial phases of the product life cycle, meaning in the R&D activities, product concept and engineering design and in the process concept and engineering design. The following graph explains visually what has been stated above.

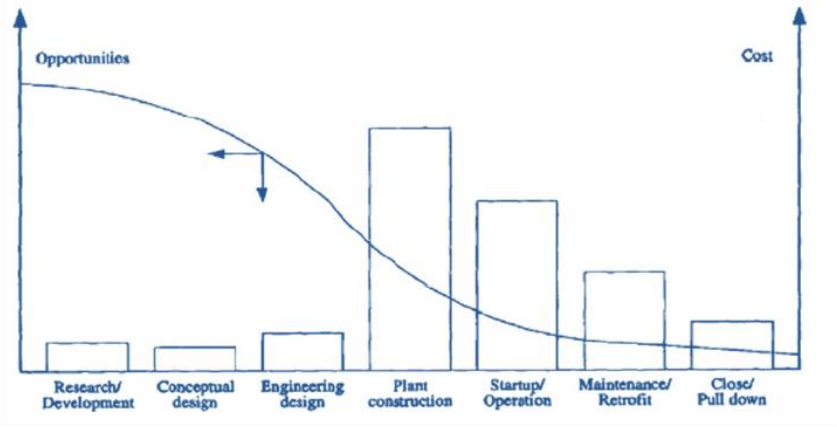

Figure 24.Opportunities of environmental impact minimization along the process life cycle (Diwekar & Shastri, 2011)

There are several defined types of Design for Environment approaches, considering that there are several stages in the product to be design; and also considering just a single stage approach. When considering the product design some strategies are available such as

efficient design, which keeps the input of resources to a minimum with the mentality to doing more with less. Safe design considers avoiding toxic or hazardous substances in materials or production processes that mainly can generate health problems to employees or consumers and ultimately to the environment. Another concept is Cyclic design, where the resources are materials that can be continuously cycled through industrial or natural systems, in other ways it avoids wastes by turning each material a resource. The last example is Communication design, which guarantees that the product-related environmental communication is accurate, relevant, informative and verifiable. This approach goes for a consumer-efficient response towards the market products. Ultimately, it provides the management with a procedure to integrate environmental aspects into the regular product development process.

Motivations in order to adopt a DfE approach are broad considering the environmental issues, economical aspect that it might bring or taxes benefits it can provide. Some considerations are: cost reduction, competition, market demand, social responsibility, corporate policy, regulations, supplier request among others (Lenox, Jordan, & Ehrenfeld, 1996).

The following step-guide proposed by the Victoria local government in Australia can give an immediate idea of how to approach the DfE tool (State Goverment of Victoria, 2011).

4.9.1 MAPPING PRODUCT LIFECYCLE

It is important to have the product lifecycle map in order to understand where the environmental impacts may occur. A general model of product lifecycle considers extraction of virgin materials, production, consumption, recycling and disposal. Afterwards identify where materials and energy needs are, where wastes and emissions are produced and classify them whether in toxic, hazardous or not. It is important to quantify the impacts as accurate as possible.

4.9.2 IDENTIFY MAIN ENVIRONMENTAL IMPACTS

Make a list of the identifiable environmental impacts during the design process and their sources. Wastes, toxicity, emissions, water use, land filling, incineration and their corresponding greenhouse gases or volatile organic compounds are some examples of the impacts.

4.9.3 SELECT THE DFE STRATEGY

Choose the proper strategy that will allow the minimization or elimination of the main and stronger impacts. It is important to consider “green/greener” tradeoffs or conflicts that may arise during the production process and the material requirements. Sometimes unavailability of a substitute resource makes the design process harder or the resulting product does not comply with the different laws or policies already ruling the product`s market.

4.9.4 DESIGN CONCEPT

Explore different ideas, search in blue oceans, use peripheral knowledge and try to be innovative are some suggestions to have in mind in this phase. Having always in mind the question: Can it be achieved in a different way that will help reduce the environmental impact?

Evaluate design concepts against environmental requirements and compliance; allow as much tradeoff as possible taking also into consideration the cost constraints.

4.9.5 BENEFITS

By starting to use DfE, the productive structure will start to do a switch towards a further and refined concept of sustainable achievement. In some point to remediate or repair the multiple effects that the past and actual products and process can bring will no longer be the main issue With the approach suggested by DfE the results is going to be products and processes that have already avoided pollution, are safe, comply with government regulations and satisfy the consumers without compromising the future generations resources; in other words it is a proactive tool.

Since the main results to be obtained are during the different stages of design, it means that corrections and optimization of prototypes are assess during these phases where by definition are the less expensive stages were modifications can take place, therefore it also influence the costing structure of a product.

Each company, taking into consideration the type of product and process can choose from a wide set of DfE of tools, the main issue to have in mind is to keep the consumer requirements while implementing the tool. Raw material utilization, design trends, product

core concept or extended services are some of the characteristics that can be evaluated when trying to improve the product with a DfE tool.

4.9.6 LIMITATIONS

Many customers still stay with the actual products which are low environmental approached because of cost and performance considerations or because ignorance or misbelieve. Regarding the cost issues it is also important to state that Government should be in the position to consider tax reduction to the environmental-approach companies in order to fix a competitive price product in the actual markets.

As globalization takes place, a relocation of the different department according to the availability of resources (material, human, immaterial) and the costs incurred can make DfE challenging since optimal designs can come from Germany or Switzerland but production might take place in Latin America or China, where possible materials substitutes are scarce, or simply are not available, turning the product price higher of what it has been planned.

It is quite simple to get lost in the product concept when trying to translate customer needs especially in the moment where the economic evaluation versus the product design and process design is being performed. It is well known the phrase: Less is better, but here less must comply with whatever the consumer wants and needs having into consideration a sustainable approach.

4.10 ENVIRONMENTAL MANAGEMENT SYSTEM (ISO 14001)

In 1996, the International Organization for Standardization (ISO) considered the 14000 series - the Environmental Management System (EMS) as a standard. An EMS provides structures, policies, practices, procedures, resources, etc in order to reduce the negative environmental impact while improving the management control of a company (Nishitani, 2010).

In order to adopt ISO 14001, companies have to achieve five basic principles: Continuous improvement, environmental policies, planning, implementation and operation, checking and corrective action, and management review.

Environmental policy	The environmental policy and the requirements to pursue this policy via objectives, targets, and environmental programs.
Planning	The analysis of the environmental aspects of the organisation (including its processes, products and services as well as the goods and services used by the organisation).
Implementation and operation	Implementation and organisation of processes to control and improve operational activities that are critical from an environmental perspective (including both products and services of an organisation).
Checking and corrective action	Checking and corrective action including the monitoring, measurement, and recording of the characteristics and activities that can have a significant impact on the environment.
Management review	Review of the EMS by the organisation's top management to ensure its continuing suitability, adequacy and effectiveness.
Continual improvement	The concept of continual improvement is a key component of the environmental management system; it completes the cyclical process of plan, implement, check, review and

Figure 25.The key elements of an ISO 14001 EMS (Petroni, 2001)

Additional to these principles an accredited party has to certify the process and the company per se. It requires an environmental policy development, monitoring of objectives' progress, mitigation of environmental negative impacts and continually revision of the EMS in order to ensure the continuous improvement. Regarding the environmental policies, those are highly based on human capital resources, meaning that they depend on tacit skills that can only be acquired through worker involvement and teamwork. Therefore the standard implicitly could create social and organizational abilities, which can evolve into a sustainable competitive advantage for the company. While developing information systems it enhances the communication and later awareness of the environmental impact on the value chain (Cañon & Garcés, 2009).

It is important that during the implementation phase some aspects are taken into account with some dedication such as internal and external communication processes, EMS records and documents, their effective management, identifying, planning and managing the activities according the objectives and targets, identifying potential emergencies and develop procedures for preventing and responding in case they occur (Petroni, 2001). Time and effort can vary according to company size, type of product, mix of products and

number of employees in one hand. On the other, variations can be presented according to scope and registration pursued.

Once adopted, additional to the standardized process and further certification, supplementary benefits can be reached such as reduced costs of waste management, energy and resource consumption savings, decrease in distribution costs, image improvement to mention some. Indirect benefits result in a simplification of compliance, improved public relations and increased profits from a preventive, proactive approach to compliance and management of environmental liabilities (Petroni, 2001).

Even it is a voluntary tool to adopt, lately the number of companies adopting the ISO 14001 has been increasing in a fast pace, as usually the profit with certification is higher than without it in the long term. Definitely, the adoption of the EMS standard is a sign of pro-activity towards the green approach. Foreigner customers and markets are becoming a significant stakeholder group encouraging the adoption of ISO 14001. An explanation could be that many multinational enterprises that have already adopted the standard ask ISO 14001 as an obligatory requirement in order to operate in the globalized supply chain.

Additional to ISO 14001, which is the only EMS standard that has complementary designations, there are: ISO 14004 (General guidelines on principles, systems and supporting techniques), ISO 14010-14012 (Guidelines for environmental auditing), ISO 14020-14025 (Environmental labels and declarations) and ISO 14040-14049 (Life Cycle Assessment).

4.10.1 BENEFITS

National and foreign suppliers can obtain advantages by implementing ISO 14001 since it is a worldwide standard. Any company holding the ISO 14001 certification is able to perform in an environmental positive way. Since it is worldwide recognized it will grant companies an easier access to the international market. With this being said, another benefit coming from the certification is that a place for negotiation can be granted since its implementation can generate an exchange of regulatory relief between countries and companies. Perhaps we can describe the standard consequences with the Domino effect, companies that have already adopted a certification, are requiring their domestic and foreign suppliers to do likewise in the global supply chain

The standard is applicable to any type of company, even in the last years; governments and public institutions are starting to implement it and getting certified. This will generate a positive advantage to local governments and ultimately to countries, since the compliance of the standard will generate trust, confidence to the society and competitive advantages in its operations.

Top management involvement in the strategic area is required, while in the operative will build motivated and responsible employees. These reactions will increase cooperation and collaboration between the two parts and ultimately, will have as a result a quality and environmentally assessed product.

When considering a multinational context, the ISO 14001 standard will ease the process of coordination between plants all around the world and will enhance the divisions' capabilities and resource availability.

4.10.2 LIMITATIONS

ISO 14001 requires a large initial capital investment besides the first registration fee. Additionally an intensive training along the strategic professionals to operative employees is needed, considering a systematic management and decision making approach which is translated in human capital investment but initially a significant cost for any company. These reasons make that S&ME´s turn a little bit skeptical about implementing the standard.

Documentation and consultancy are quite expensive during the initial stages of the implementation. Also processes modifications may carry a high capital investment that in the short run will be considered unjustified. Afterwards when the ISO 14001 has already being certified, costs regarding registration maintenance are fixed annually and requires a specific staff to be working in continuance of the standard within the company.

4.11 SOCIAL ACCOUNTABILITY INTERNATIONAL

Social Accountability (SA8000) is an auditable standard for third parties verification system to ensure both ethical sourcing of products and goods; and workplace conditions worldwide. It is applicable to any size of company and to any industry sector. It is also considered as a response to the business sector in order to address consumer and investor perceptions of the emerging global social issues. Some standards are defined regarding SA8000, which is based on the International Labor Organization and on the Universal Declaration of Human Rights and the Convention on the Rights of the Child of the United Nations.

Child labor, forced labor, health and safety, freedom of association, right of collective bargaining, discrimination, disciplinary practices, working hours and compensation are issues where the standard is applied to. All the mentioned above will help the firms to outsource production to less developed nations, since social, environmental and reputation issues have become more important in their original countries and the increased power of societies and markets are turning more demanding towards a commonly referred Corporate Social Responsibility program .

The definition of the management standards regarding the SA8000 are presented below.

SA8000 Sstandard[1]	Description[1]
8.1	*Child Labor:* Prohibits the use of child labor (less than 15 years of age, unless local regulations are higher); requires corporate support for the education of school-age workers; time spent daily on work and school cannot be more than 10 hours; that the corporation does not expose children either inside or outside the workplace to hazardous or unhealthy situations.
8.2	*Forced Labor:* Prohibits the use of "forced labor."
8.3	*Health & Safety:* Requires safe & healthy working conditions, health & safety training for all workers, clean and sanitary working and living conditions (if company provided).
8.4	*Freedom of Association and the Right to Collective Bargaining:* Requires that the corporation allow, without discrimination, workers to form trade unions and engage in collective bargaining.
8.5	*Discrimination:* Prohibits discrimination based on gender, race, caste, etc., in hiring, compensation, training, promotion, or retirement.
8.6	*Disciplinary Practices:* Prohibits use of coercion or corporal punishment.
8.7	*Working Hours:* Prohibits required work in excess of 48 hours/week, and requires at least one day in seven off. Allows up to 12 hours/week overtime at a wage premium.
8.8	*Compensation:* Requires that the corporation pay workers a legal minimum and locally derived "living wage."
8.9	*Management Systems:* Requires a company policy for social accountability that includes social accountability audits for the corporation itself and its suppliers and sub-contractors.

[1] Adapted from Leipziger (2001) and SA8000 (2001).

Figure 26.The SA8000 series of social accountability management standards (Miles & Munilla, 2004)

Additionally to these standards, any organization willing to apply the SA8000 has also to implement a Social Management System in order to ensure the compliance and further improvement of the requirements (Göbbels & Jonker, 2003).

The SA8000 scope is focused mainly in managing and controlling the value chain, in working and employment conditions, but also allowing the opportunity to incorporate individual or company stakeholders' related issues. It has also developed a partnership among different SA8000 holders that may interact within the supply chain such as governments, international agencies and civil institutions since its standards are more normative and outcome-based than process-driven.

This tool has gained importance with the increasingly widespread adoption of standardization tools such as ISO 9000 and ISO14000 management systems. Besides, the further implementation of SA8000 will be trouble-free and economical when the other two tools are already implemented.

Firms implementing SA8000 will obtain a leveraged social reputation that will help to differentiate their products and the company reputation, will have pricing reductions from government policies and will give a competitive position in the markets where they work. It will also be applied throughout the company supply chain and its certification may become a "green light" for registered firms in a globalized market. And with time, SA8000 will turn in non-economical criteria that will strongly influence the supply chain decisions, such as passing the social accountability requirements through the value chain actors; resulting in a domino effect throughout the whole chain. When SA8000 audits are held, it does not only ensures that processes are within the pre-established boundaries, but will also require a detailed in-situ visits, employee interviews and stakeholders perceptions in order to ensure the tool compliance.

4.11.1 BENEFITS

SA8000 reduces information asymmetries between supply chain partners; therefore, brings closer suppliers from all around the world and develops cooperation, trust, coordination and clear communication.

This tool allows comparability and consistency through time and among companies. It establishes rules and the way the rules are going to be evaluated and in this way avoid bribes, cheating, or inconsistent information in the accounting report.

By implementing the three managements systems (economical, environmental and social), the company will consolidate the ultimate consecution of a three bottom-line sustainable company. As a consequence, the company will enhance its position in the labour market, attract more skilled and trained work force shifting into higher levels of productivity and quality, and allow the final customer have a social sustainable product/service

4.11.2 LIMITATIONS

Consolidation of a SA8000 can be extremely expensive and monitoring must be performed at the lowest possible cost. Also the capital investment will depend on the directives knowledge and approach towards social issues. Usually when a company has to cut off expenses or searches for an improvement in the overall income, the first lines that are cancelled are those regarding social investment, complementary trainings, etc. So, it makes the social aspect highly vulnerable and low probable to be investing in. Not to mention that audits and visits to the suppliers are mandatory.

Since it is the three-bottom line aspect that has being considered the least, reluctance and skepticism to implement the whole standard is considerable. Perhaps companies are trying to consider the principles that they are in position to adopt and to guarantee, but not major efforts are being made by government or certification institutions to make companies adopt a social standard.

SME´s with limited resources may have a difficult time complying with the SA8000 standards and even more if they have not implemented the ISO standards yet.

4.12 GLOBAL REPORTING INITIATIVE

In 1997 CERES (the Coalition for Environmentally Responsible Economies had identified three unwilling factors: Companies were being asked for different types of information about environment and social aspects, the reporting of the information being found was varied in content, inconsistent, could not be comparable with companies within same industries, irregular when considering time frequency; and signs of an increasing number of guidelines reporting, frameworks coming from different countries, sectors and sources. Thus, Global Reporting Initiative (GRI) was born with the mission to elevate sustainability reporting practices to make it equivalent to a financial report and its characteristics.

After the revision held in 2000, GRI and its Sustainability Reporting Guidelines have the potential to improve the usefulness and quality of information reported by companies about their environmental, social, and economic impacts and performance. The GRI aims to develop a voluntary reporting framework that will elevate sustainability reporting practices to a level equivalent to that of a financial report in thoroughness, comparability, auditability and general acceptance. (Willis, 2003)

This version has four annexes; part a: Introduction and General Guidance; part b: Reporting Principles and Practices, part c: Report Content, where the main sections are stated (CEO statement, Profile of Reporting Organization, Executive summary and Key Indicators, Vision and Strategy, Policies, organization and Management Systems and Three bottom-line performance) and part d: Annexes.

GRI considers three institutional innovations: define the process in order to generate successive guidelines, a multi-stakeholder process to produce the guidelines and an organization that will be a guardian or as the tool defines as a steward of the guidelines and the implicit process. During the process the characteristics that must be implicit are trust and commitment while consolidating the information and when delivering the information

This voluntary tool allows the balance between a wide group of objectives such as keeping a perspective between a social change and defining the corresponding goals or between the option of a broad consultation and the efficient pursuit of technical objectives. (Szejnwald, de Jong, & Lessidrenska, 2009)

A primary goal of reporting is to contribute to an ongoing stakeholder dialogue. Reports alone provide little value if they fail to inform stakeholders or support a dialogue that influences the decision and behavior of both the reporting organization and its stakeholders. (GRI, 2002)

The reporting has been created under these five strategic principles: Inclusiveness, international multi-stakeholder process, based on wide consultation and iterative testing and self-correction, maximum use of internet, transparency and fast pace and efficiency. The first two were proposed in order to create a broad sense of support and neutrality in order to overcome systemic barriers, mistrust opposition and skepticism

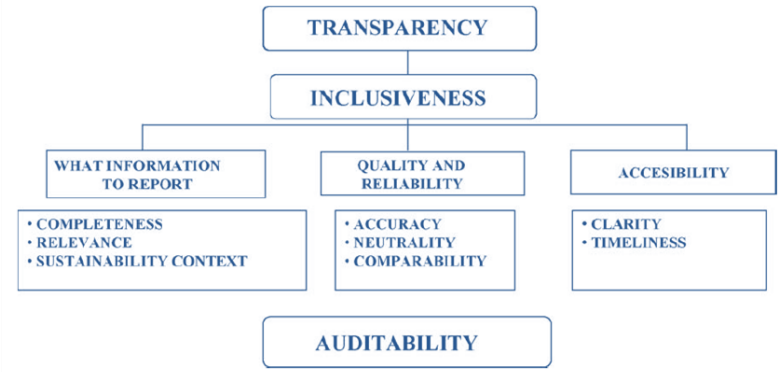

Figure 27.The GRI Reporting Principles (Moneva, Archel, & Correa, 2006)

GRI considers three categories of sustainable indicators, correlated with the three-bottom line aspects. Regarding the social performance, the approach is on how the company contributes to the well being of its stakeholders and the society through its labour, governance, safety practices and human rights. As for economic performance the direction is towards itself and community financial performance by assessing the economic impacts on the stakeholders keeping a close observation in sales, profits, wages, taxes, debts and interests and capital expenditures among others. Considering environmental indicators, the study must concern in the impact on present and future generations. Topics that should be followed are waste management, environmental risk control, supply chain impacts, energy conservation, emissions, diversity and wildlife conservation just to mention some of them.

GRI has the premise of self-improvement on a periodic basis

4.12.1 BENEFITS

GRI is a voluntary-based tool and used by all types of companies which leads to new norms, practices and languages that will collaborate in the materialization of new concepts of corporate and collective responsibility and accounting. It allows the comparisons between companies and in time periods. This can enhance users comprehension of past, present and future performance.

It gains visibility and control of the triple bottom line in a corporate level even they still need further development it can be used as a demonstration of brand recognition, prestige and influence.

Allows the use of capital markets and NGO´s to promote and ensure sustainable business practices and in terms in which these institutions will be empowered with the information they may need to track corporations' accountings. Customers and consumer are enabled to influence the markets through their purchasing decisions by being well informed about goods and service.

GRI has free access to anyone and it can also become a stakeholder to the GRI enabling the possibility to leave comments on the report´s guidelines. Companies are then encouraged to maintain frequent dialogues with their different stakeholders that will give to the top management a diverse overview of the company.

4.12.2 LIMITATIONS

Users of the SA8000 are free to leave behind those indicators that they may find irrelevant, inconvenient or which they don't have information, inhibiting the possibility to turn the tool into a standard for further comparison between industries.

SME´s could find the Guidelines extremely demanding considering the organization resources. On the other hand their stakeholders, activist or investors may consider the SME´s reports insufficiently specific.

It has been challenging to place systematically the broad variety of disclosure needs and expectations of a wide range of report users and company stakeholders. Efforts to improve

GRI are now focused on improving the reporting the Guidelines rather than improving the verification and additional credibility procedure.

It is considered as a template or a mere source of inspiration (Hedberg & Malmborg, 2003)

4.13 POLLUTION PREVENTION (PP / P2)

Considered as the father of the modern approaches towards a positive industrial and environmental management, and after the past three decades Pollution Prevention (P2) still is useful in the initial stages when considering reduction at source and recycle activities in order to minimize wastes and increase efficiency of processes and products and ultimately achieving an improvement in the cost structure. The EPA defines P2 as the *use of materials, processes, or practices that reduce or eliminate the creation of pollutants or wastes at the source. It includes practices that reduce the use of hazardous materials, energy, water, or other resources and practices that protect the environment conservation and efficient use.*

This tool/method has allowed the switch from a compliance pollution reduction point of view into a strategic issue in which the company can make plans towards long run competitiveness (Cagno, Trucco, & Tardini, 2005) making this tool really attractive for improving environmental performance while granting a financial benefit.

P2 is based in the idea that pollution generation can be reduced or eliminated by increasing the resources usage better known as Waste Management (WM); and which main element of the "Pollution Prevention Act" 1990 are: reduction at source, in process recycling, on site recycling, off- site recycling, treatment to reduce danger, safe environmental disposal and direct disposal into the environment.

4.13.1 REDUCTION AT SOURCE

This term refers to the activities which imply the reduction of the polluting amounts introduced into a waste flow before being recycled, treated or discharged; and reduces the negative impact to the society and the environment. The techniques usually implemented in this point are WM and Cleaner technologies that may involve activities such as improved

operations in the factory, waste recycling within the process, process modification, material or product replacement, waste material selection and separation.

4.13.2 RECYCLING (IN PROCESS, ON SITE AND OFF-SITE)

Recycling activities can limit the negative environmental impact when no further reduction of material of usage in possible then it turns in a lower hierarchy level of P2. When materials are defined as waste, this means a loss in the processing of resources when investments are required as well in order to perform afterwards some pollution controls. The differences between the recycling modes depend on where it is performed (within a production line, after the production line or when materials are wastes to be disposed)

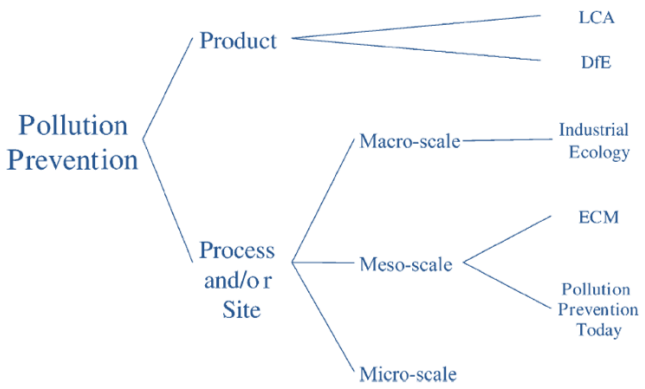

Figure 28. Evolution of the methodologies to design and manage eco-efficiency from early P2 definition (Cagno, Trucco, & Tardini, 2005)

When implementing P2, a company is required to grant certain amount of capabilities in order to achieve a good sustainable strategy. P2 forces the re-conception of the corporate approach towards production issues, such as materials, energy and their efficiencies. This process requires a strong employee involvement rather than a technology intensive approach.

There are two main prevention models: Prisma methods and projects relying on quickscan. (Bruijn & Hofman, 2000)

4.13.3 P2 ACCORDING TO PRISMA METHOD

Plan developed on basis of the Prevention Manual of the American Environmental Protection Agency consists in four steps: Planning and organization, assessment, feasibility study and implementation. It performs a comprehensive analysis of the material flow in

order to quantify and implement the P2 options. This model requires a high level of involvement in the company, an intensive capital investment and uses a comprehensive analysis of the environmental canvass.

Later on, efficiency was also requested and demanded for S&ME but considering the capital investment associated with the Prisma method another solution was requested in order to come up with an economical and less time consuming P2 method.

4.13.4 P2 ACCORDING TO QUICKSCAN

This method allows a quicker assessment of P2 and less time and capital intensive. It consists in a quick evaluation of the material flows in order to reach a P2 working plan, but which not requires an active role of the companies. While performing the scan, possible corrective actions can be stated without further consideration or discussion. The duration of the quickscan projects is positively associated with the results obtained, as more days the quickscans lasts, more and better results are achieved during the time. Quickscans are cheap to implement, require little involvement and focused on mapping the potentiality of P2. (Bruijn & Hofman, 2000) The implemented measurements can be described as housekeeping practices.

Another aspect brought with the P2, is that it settled an industrial transformation and environmental policy evolution towards the inclusion of the environment and social aspect to the core system perspectives used at the time, economy. The primary goal of industrial ecology is to promote sustainability by optimizing resources within different stages (virgin material, finished material, components, product, obsolete product and ultimate disposal). For the first time the terms “cradle to crave” and “cradle to cradle” start to have some relevance within the business since they both considered the P2; ultimately the main advantage will be towards the product lifecycle conception switch. Furthermore, P2 allows the analysis of the supply chain integration and the collaboration between them when considering an advanced reach of the tool.

Since it is a really informal model, it allows the involvement of more companies in just one project turning it, to an inclusive model.

4.13.5 BENEFITS

Pollution Prevention acts directly on cost efficiency factors impacting company performance indicators regarding productivity, material and process efficiency and foremost reduced pollution impact. Once implemented the P2 activities it will take around two to five years to have the payback of the investment, but from the very beginning the Bill of Materials will be reduced as well as the waste material. Its effects will also last in the long term, since it will allow the different procedures to switch into a cleaner process and materials with less material requirement. At the end the result will be that future problems will be avoided from the very beginning.

Although social aspect is not defined and impacted, implicitly the training and involvement of the employees guarantees a better human capital working towards a environmental approach. And the more employees that know about the material flow the better the results of the P2 projects.

It improves the overall core productive efficiency and protects resources/raw materials by switching from end-pipe solutions into prevention solutions. While implementing this tool it forbids or restricts the pollution to be transferred from place to place or within the value chain. P2 also allows easier compliance of environment regulations when it transforms waste streams into product components, which is seen a P2 successful project.

4.13.6 LIMITATIONS

After decades from its definition, the tool has reached to point where it only provides incremental improvements, then is seems that imagination and innovation will allow the evolution of the tool to remain useful in the companies. Will be also important to consider while defining a new P2, the aspects that showed some flaws in the time or that did not allow the companies to do a good use of the tool.

For instance a real difficulty was presented by the S&ME since they found complications to engage the tool since it required a capital investment to obtain significant results. Also as the P2 projects turned more comprehensive and deeper in their reach, it was difficult to control or to overcome the obstacles that could be presented. Since it is mainly a human capital intensive it, the results will only rely on the employees' commitment. Therefore it is

required to redefine the protocols in order to implement the tool in a more intensively and grant comprehensive follow-ups.

The P2 scope needs to be magnified beyond the firm level reach by being more inclusive within the value chain actors, starting with the supplier-client relationship. It also fails in setting specific actions to implement, it allows to find the waste and where, but not specifies how.

5 TOOL´S CLASSIFICATION

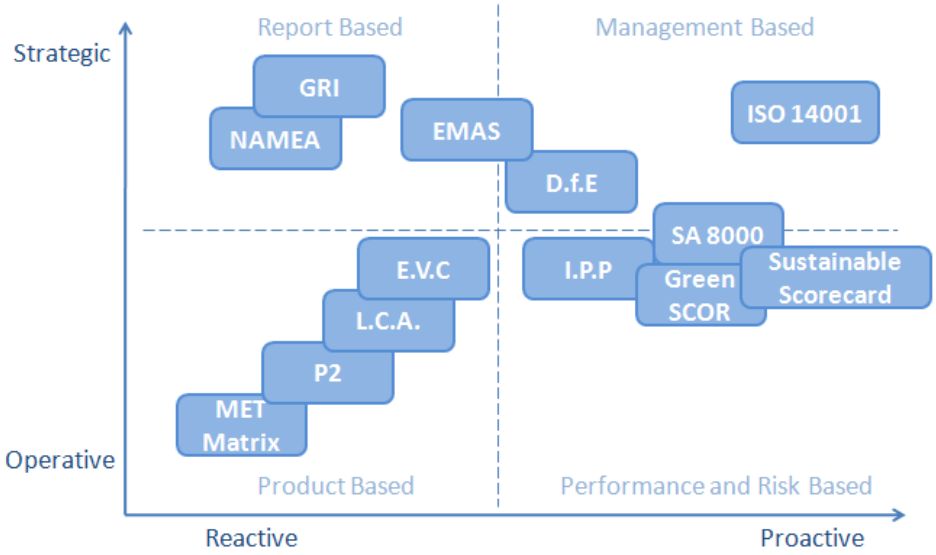

Figure 29. Tools' Classification according to S-SCM approach

The classification is structured in terms of the four categories previously defined and explained, and stated from the less to the most essential regarding each category. It is important to notice that there are some tools that share more than one category according to their approach and ultimate outcome after the implementation.

- Product based tools: Met Matrix, Pollution Prevention, Life Cycle Assessment and Environmental Value Chain.
- Performance and Risk based tools: I.P.P. Green SCOR, Sustainable Scorecard and SA8000.
- Report based tools: NAMEA, GRI and EMAS.
- Management based tools: DfE, EMAS, SA800 and ISO 14001.

It is important also to mention that the importance of the tool and the relevance changes through time along with the Supply Chain approaches evolve during time. Once P2 was the innovative and *avant garde* tool to implement in a company, but today it is already an implicit activity that any company must have implemented in order to be economically viable. With this being said, it is important to have in mind that what it is sustainable

innovative today might not be any longer a novelty in the future, but their importance and impact to arrive to a future evolution must not be neglected.

6 SUSTAINABLE SUPPLY CHAIN MANAGEMENT IMPLICATIONS

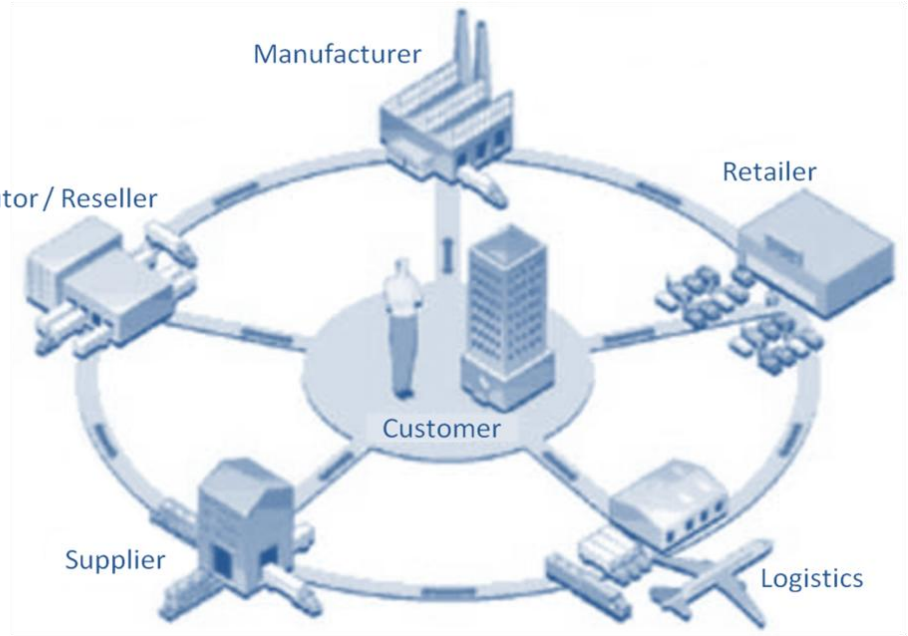

Figure 30. Supply Chain (Managing a Supply Chain can be as simple as it sounds , 2011)

According to the purpose of this work, Supply Chain Management considers the inter-relation among different actors such as supplier, manufacturer, logistics, distributor, retailer and customer and explains the supplier-"*own company*"-customer relationship. Their relationships are based on information, physical and money exchange among them and lately, their relationship has also incorporated reverse logistics.

In order to give a better definition of the ultimate concept: Sustainable – Supply Chain Management some global drivers are going to be defined and explained in order to look forward to the concept and philosophy behind it.

6.1 INDUSTRIALIZATION

This phenomenon brings a massive weight to the present and future generations since it considers three main aspects that are tried to be slowed down by the sustainability concept. The first one is the material consumption, as industrialization takes place and customer are asking for more products in an always decreasing time, companies are obliged

to reduce their time to market, increase the products offer, increase the production rate just to mention some consequences. All these responses towards the massive consumption and the industrialization forces are generating bigger amounts of pollution, our second aspect; without seizing its impact and foremost increasing the need of a robust waste management system (third aspect) able to process the waste in the same rate as the consumers purchase behavior is having.

Not being able to control these increasing rates will end up in a severe negative impact in the climate and global warming, in the actual biodiversity and furthermore in the ecosystems' functionality which at some point will jeopardize the human kind survival.

6.2 PROLIFERATION AND INTER-CONNECTION OF CIVIL SOCIETY

Additional to the diagram above, other actors that have gained importance and are considered in order to reach a full conception and perspective of Sustainable Supply Chain Management are: Non-Governmental Organizations (NGO), civil society, and Government. Lately what these actors have to say and to offer to the sustainability approach is a wide open communication among the entire group. After broad and clear communication channels are developed characteristics such as transparency, responsiveness and no – secrecy will characterize the supply chain relationships.

Transparency will allow all the actors to supervise others´ activities and outputs from upstream to downstream, take corrective actions and better off to replicate and copy the good practices in other points of the supply chain. Responsiveness will increase since a direct consequence of the transparency already obtained, therefore any issue or criticality can be discovered by any actor and the direct responsible will take immediate responsibility of it. Additional to these two characteristics is the no-secrecy matter between the actors, which will also allow replicating the good practices through learning, training and educations not only into the supply chain but also within the industries or second and third tiers relationships.

6.3 EMERGING TECHNOLOGIES

This driver can generate a radical and positive change towards the impact that sustainable supply chain management can provide. The important issues to take into consideration in order to have an optimized output from this driver is to consider renewable energy sources and processes, come up with innovative technologies that are available to anyone and to improve the already existent Information technologies. By considering these three aspects it is important to avoid the centralization of the new technologies since it will provide benefits just to a certain company or area. Instead when considering a globalized supply chain structure, it is expected that the chains switch towards local suppliers and implement the technologies not only because it will become a competitive issue, but it will also bring some development in the local area.

Third driver does considers mainly the environmental and economic aspects´ impact, but when setting certain conditions of how the breakthroughs should be managed and implemented it certainly brings a benefit within the social aspect, turning the driver into a sustainable potential source.

6.4 POPULATION, POVERTY AND INNEQUITY

Although these drivers are mainly related to the social aspect of sustainability, the impact of mismanagement of them can turn out to affect either the economic scenario of a country and affect the availability of natural resources.

It is important to explain the rationale behind these drivers, first is Population and its increase year by year without taking into account the world´s natural regeneration rate and by neglecting this factor; resources for each person standing in this planet will be reduced and certainly jeopardized. Some countries have managed to handle a relative constant and average income to each worker according to the resources available; but some other, despite some organization efforts to avoid hunger, to educate population about sex and anti-conception instruments have been constantly decreasing their lifestyle into points in which the population is considered within poverty ranges. In these places malnutrition, primary alimentary resources scarceness, lack of medicine prevention and foremost government negligence is turning the people into unlivable levels which should be no

longer tolerated around the world, considering that today the world has the tools and the technology to avoid these types of population degradation. Being conscious of the fact that the tools to avoid poverty, hunger and death are already in the hands of some others, allows the determination that resources and technologies are unequally distributed. Without controlling these three drivers the consequences are social decay, which at some point will cause political cause and ultimately terrorism.

But it is possible to come back from this unwilling scenario by setting some little rules within the supply chain management. Companies are in the position to guarantee a sufficient minimal wage which will provide the workers and their families a bearable lifestyle that allows their development and population improvement through generations. Complementary actions to the minimal wage are social development within the local area and wealth creation. Supply chain locations can be benefited by the company´s investment in social and medical issues of their workers and families. These positive practices will allow to the company win community and government confidence, increase their reputation and have operations that at the end will provide a sustainable development for them and for the local community they work in.

After discussing these drivers, what is required at this point is to face the Sustainable Supply Chain Management (S-SCM) definition, impact and the tools relevance towards its achievement.

6.5 S-SCM DEFINITION

According to (Seuring & Müller, 2008) in their paper *From literature review to a conceptual framework for sustainable supply chain management*; a definition for Sustainable - Supply Chain Management is the managementof material, informattion and capital flows as weel as coopertaion among companies aling the supply chain while integration goals from all three aspects of sustainable development (environmental, economic and social), which are derived form customer and stakeholder requirements. In sustainable supply chains, environmental and social cirteria need to be fulfielled by the members to remain within the supply chain, while it is expected that competitiveness would be maintained through meeting customer needs and related economic criteria. It is also important to mention that

while trying to achieve a S-SCM, tradeoffs between stakeholders andshareholders should not take place at any moment, otherwise the structure will not be sustainable at all.

Previously it has been discussed that the products should embrace a “craddle to grave” and lately a “craddle to craddle” approach of their products, that ultimately will affect in a positive approach their productive structure and performance. *Craddle to grave* term considers the final destination of the product after being disposed by the user in the early stages of the product design. It is an attempt to close the product lifecycle loop. A better approach towards the closed loop is *Craddle to craddle* which not only plans the end of life of the product in the early design stages but it does plan the reutilization of the disposed materials into new productive cycles, either as a part of the same productive chain, or being a part of other new products´ raw materials.

After considering different literature refrences some factors or what should be considered as values are required to be always be taken into account for all and each Sustainable Supply Chain and its management.

- Improvements within the supply chain must always reduce emissions into air, water and land. These improvements should specifically concentrate in Carbon footprint, Greenhouse Gas emissions (GHG), Volatile Organic Compounds (VOC´s), Nitrous oxides (NO_x) and Sulfure oxides (SO_x) among other toxic materials. The emissions should be controlled in three main material transformation processes: manufacturing, incineration and landfilling. More toxic emission and processes should be considered.
- S-SCM must support and offer financial help in the research of innovative technologies and innovative resources that will lead to a more sustainable process and product.
- Within the S-Supply Chain there must be an increase in collaboration, communication, transparency and traceability. All companies must encourage this values inside their companies and then turn them into compatible characteristics among the chain.
- S-SCM must guarantee diversity in their operations by considering minorities and local communities into their staff and granting their safety before, during and after

productive processes and considered also when transfering and relocating an activity.

- Always act under the concept of Waste Minimization, and when possible implement the zero waste approach, which is align to the cradle to cradle concept by recycling, reusing and recover activities.
- Care about the water resources, preserve them, have an optimized use of it, and controlled afterwards disposal. Companies should avoid water poisoning by disposing contaminated fluids into unpolluted water sources that will jeopardize either communities water supply or ecosystems´ balance.
- Implement an Energy efficiency approach by optimizing the energy consumption at all times. If possible switch to a supplementary source of energy that generates lower pollutant emissions and ultimately to search for renewable sources of energy.
- Keep in mind a collaborative and supportive mentality inside the company and among the whole S-Supply Chain. When required offer trainning activities either to suppliers or customers in order to propagate the positive impacts of implementing a specific tool. It will enhance suppliers' relations since they are going to be considered as key actors and shared improvements will lead to exclusivity contracts.
- Consider the impacts at local level, when the effects occur in the immediate vicinity of the production site, route or landfill; on regional level, when effects saturate a certain geographical area (smog from industrial zones) and on global level, for example climate change.

In order to turn these tools more effective and after all turn the companies more competitive, the awareness of these tools to the customers and citizens should increase in order to guarantee the long run implementation of the instruments towards the vision of green supply chain management and a sustainable world.

Additional to the review done above, a template has been created in order to standardize in a general way the tools' profile. This in order to give some managerial help about what the tool is, which actors can be impacted by the tool, a little description in order to see what is for, its major limits and benefits and further considerations to take into account

when deciding if implementing it or not. It is a one-page template that summarizes the tool information considering a Green Supply Chain Management (GSCM) approach.

7 TOOL´S TEMPLATES

7.1 DESIGN FOR ENVIRONMENT (DFE)

<table>
<tr><td>TOOL:</td><td colspan="5">Design for Environment - DfE</td></tr>
<tr><td>Classification:</td><td colspan="2">Management</td><td>Proactive</td><td colspan="2">Strategic</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="2">Three -bottom line impact</td><td colspan="2">Economical</td><td colspan="2">Environmental</td><td>Social</td></tr>
<tr><td colspan="2"></td><td colspan="2">X</td><td></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td rowspan="2">Supply Chain impacted actors</td><td>Supplier</td><td>Producer</td><td>Service Provider</td><td>Customer</td><td>Stakeholders</td></tr>
<tr><td>X</td><td>X</td><td>X</td><td></td><td></td></tr>
<tr><td colspan="6"></td></tr>
<tr><td>Time requierement</td><td colspan="2">Mid, Long - Term</td><td>Capital Investment</td><td colspan="2">High</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Tool Description:
A systemic process by which firms design products and processes in an environmental conscious way. The ultimate scope is to design products and processes that are functional, attractive, economic and produce no harm effects either to the environment or the society under a systemic procedure.

Several approaches can be implemented: Efficient design, Safe Design, Cyclic design, and Communication approach.

The procedure generally considers the product lifecycle mapping, identification of the main environmental impacts, selection of a DfE strategy and the Design concept.</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="3">Benefits:
• Structure will switch towards a further and refined concept of sustainable achievement.
• The results is going to be products and processes that have already avoided pollution, are safe, comply with government regulations and satisfy the consumers.
• Corrections and optimization of prototypes are the less expensive actions.</td><td colspan="3">Limitations:
• Many customers still stay with the actual products which are low environmental approached because of cost and performance considerations.
• Relocation of the different department according to the availability of resources.
• It is easy to get lost in the product concept when trying to translate customer needs.</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Observations / Considerations:

Today, it has been estimated that 70% of a product´s environmental impact is locked in at the design stage.</td></tr>
<tr><td colspan="6"></td></tr>
</table>

7.2 ECO-MANAGEMENT AND AUDITING SYSTEM (EMAS)

TOOL:	*Eco-Management and Auditing System (EMAS)*			
Classification:	Management – Reporting based		Proactive	Strategic

Three -bottom line impact	**Economical**	**Environmental**	**Social**
		X	

Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
		X			

Time requierement	Mid-Term	**Capital Investment**	Not quantifiable

Tool Description:

Firms willing to register their EMAS are required to do an initial environmental analysis, implement an environmental management system, perform an audit regarding these issues and write a statement. All these actions and documents will be analyzed by the corresponding agent (third party).

The EMAS explicitly requires the inclusion of product planning and an advanced assessment of environmental consequences of the new products regarding the environmental policy and programs and eco-management audit as well.

Benefits:	**Limitations:**
• Positive effect in the firms' competitive performance. • Significant learning process and structure for the company. • EMAS is used as a communication tool among the external stakeholders which results in an effective tool. It can also contribute to the diffusion of environmental innovations and practices within industries.	• The results coming from this type of tools strongly depend on time and the congruency of the company efforts. • There are several issues that need to be accomplished previous to the competent agent approval. • It is imperative to do public environmental declarations. • Its validity is only for European countries.

Observations / Considerations:

The required public report via environmental statement must contain essential details regarding the ecological situation in the company location by the compliance of the actual statutory provisions for further validation and registration.

The company must be in the position to report its own operations and environmental achievements as well as the indirect environmental impacts it might incur with its operations and products.

7.3 ENVIRONMENTAL VALUE CHAIN (EVC)

TOOL:	*Environmental Value Chain - EVC*				
Classification:	Product based			Reactive	Operational
Three -bottom line impact	**Economical**		**Environmental**		**Social**
			X		
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
	X	**X**	**X**	**X**	**X**
Time requierement	Short , Mid - Term		**Capital Investment**	Not quantifiable	

Tool Description:

It is a developed extension of Customer Value Chain Analysis, which cares for stakeholders' interests, their values and the approach towards a "green" product or processes**.**

Allows the Internal environmental value chain definition, proper for each company, making possible to visualize in a clear manner how a decision impacts within the value chain.

Involves the entire company and assess it in terms of business units and environmental impacts (Issue correlation Matrix)

Benefits:	**Limitations:**
• Allows the switching from a defensive or reactive approach to a proactive one in terms of environmental assessment. • Allows assessing environmental issues through the entire company departments. • The tool becomes a form of backbone for target specifications and roadmaps in the future.	• It does not define the parameters to follow when defining the actions that will improve the results • It can generate "Lock-in" situations, which mean that improvements obtained for the whole value chain do not necessarily lead to environmental or economical advantages for single stakeholders

Observations / Considerations:

A bad ECV implementation may cause misunderstanding in the value proportions assessment regarding each stakeholder and consequently the defined product value can turn out into critical shortages and failures during the product development process.

Customer is reluctant to choose and buy an EVC- based product, mainly because ignorance.

7.4 GREEN SCOR

TOOL:	*Green SCOR*				
Classification:	Performance and Risk based		Proactive	Operational	
Three -bottom line impact	**Economical**		**Environmental**		**Social**
	X		**X**		
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
	X	**X**	**X**	**X**	**X**
Time requierement	Mid-Long Term		**Capital Investment**	Not quantifiable	

Tool Description:

Standardized tool to evaluate the supply chain performance and being able to improve it. It gathers and consolidates the best practices and most common metrics regarding an economic and environmental approach.
The model breaks down the supply chain process in six categories that describe all the activities held within the chain: Plan, Source, Make, Deliver, Return, and Enable.
This analytical tool provides a plain perspective between the supply chain functions and the environmental issues.
This tool has general tables filled with information regarding optimized processes, metrics and indicators.

Benefits:	**Limitations:**
• Allows the companies to regulate, compare and improve their operations while using a common language between them. • Turns the supply chain in a sum of discrete activities allowing a better approach to control and improve the weak points in the characteristic company´s operation. • Gives a high level of detail and examination. (macro-processes to business units)	• Collecting the right data required to describe their operation and afterwards assess the environmental impact. • A collaborative culture among the company´s employees is required as well as in sharing the information between supplier-company-customer relationships. • It might have a lack of specificity where the company will have to work from zero in terms of possible indicators´ targets

Observations / Considerations:
Is a tool that will help the supply chain personnel and the environmentalist to maintain a full perspective of the supply chain dynamics without incurring in negative tradeoffs.

Highly accessible since has standardized processes and manages a familiar language which will allow undemanding green implementations

7.5 GLOBAL REPORTING INITIATIVE (GRI)

TOOL:	*Global Reporting Iniciative - GRI*			
Classification:	Reporting based		Reactive	Strategic
Three -bottom line impact	**Economical**		**Environmental**	**Social**
	X		**X**	**X**
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
		X			
Time requierement	Mid - Term		**Capital Investment**	Low

Tool Description:

Its mission is mission to elevate sustainability reporting practices to make it equivalent to a financial report and its characteristics. This version has four annexes; part a: Introduction and General Guidance; part b: Reporting Principles and Practices, part c: Report Content, where the main sections are stated and part d: Annexes.

Considers three institutional innovations: define the process in order to generate successive guidelines, a multi-stakeholder process to produce the guidelines and an organization that will be a guardian or as the tool defines as a steward of the guidelines and the implicit process.

GRI has the premise of self-improvement on a periodic basis

Benefits:	**Limitations:**
• Voluntary-based tool and used by all types of companies. • It gains visibility and control of the triple bottom line in a corporate level. • Allows the use of capital markets and NGO´s to promote and ensure sustainable business practices.	• Free to leave behind those indicators that they may find irrelevant, inconvenient or which they don't have information, inhibiting the possibility to turn the tool into a standard for further comparison between industries. • SME´s could find the Guidelines extremely demanding considering the organization resources.

Observations / Considerations:

It has been challenging to place systematically the broad variety of disclosure needs and expectations of a wide range of report users and company stakeholders. Efforts to improve GRI are now focused on improving the reporting the Guidelines rather than improving the verification and additional credibility procedure.

7.6 INTEGRATED PRODUCT POLICY (IPP)

TOOL:	*Integrated Product Policy - IPP*				
Classification:	Performance and Risk based		Proactive		Operational
Three -bottom line impact	**Economical**		**Environmental**		**Social**
	X		**X**		
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
	X	**X**	**X**	**X**	**X**
Time requierement	Mid , Long -Term		**Capital Investment**		Not quantifiable

Tool Description:

The scope behind the Integrated Product Policy (IPP) is to be cooperative between industry, society and politics as a response to the complexity of the environmental issues that could not being seized by the actual protection and preservation.
IPP is aware of the environmental impact from the very beginning of the product design and throughout the complete product lifecycle until its disposal, therefore optimization becomes possible in all the different stages of the product having a special focus in the consumers and users, since is the less impacted factor so far.
It is necessary to have periodic meetings with the representation of all the stakeholders and define the working structure according to the various dimensions for a specific time period.

Benefits:	**Limitations:**
• It shows a clear requirement of characteristics as in this case is intended as principles, shows a defined structure of areas of innovation or at least where optimizations actions can take place. • The definition of the working group considers the government as the authority stakeholder while interrelating with industries and consumers.	• S&ME´s may be discouraged because they might not have the required capital and resources to launch all the improvements that can be suggested after the stakeholders meetings. • Any policy or measurement to determine has to consider also the impact, implications and possible solutions that supplier or periphery companies could carry without being left behind.

Observations / Considerations:
It is a new approach characterized for its systematic, target oriented and conscious use of the existing instruments in the product lifecycle stages.
IPP makes possible the interaction with some other tools towards the same ultimate objective. Usually IPP adopts voluntary instruments such as cleaner production, eco-labeling, voluntary agreements among others.

7.7 ISO 14001 – ENVIRONMENTAL MANAGEMENT SYSTEM (EMS)

TOOL:	*Environmental Management System – ISO 14001*				
Classification:	Management Based			Proactive	Strategic
Three -bottom line impact	**Economical**	**Environmental**			**Social**
		X			
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
	X	**X**	**X**		
Time requierement	Mid, Long - Term	**Capital Investment**		High	

Tool Description:

An EMS provides structures, policies, practices, procedures, resources, etc in order to reduce the negative environmental impact while improving the management control of a company. Companies have to achieve five basic principles: Continuous improvement, environmental policies, planning, implementation and operation, checking and corrective action, and management review.

An accredited party has to certify the process and the company per se in ISO 14001. Some dedication such as internal and external communication processes, EMS records and documents, their effective management, identifying, planning and managing the activities according the objectives and targets, identifying potential emergencies and develop procedures for preventing and responding in case they occur.

Benefits:	**Limitations:**
• Any company holding the ISO 14001 certification is able to perform in an environmental positive way. • Since it is worldwide recognized it will grant companies an easier access to the international market. • The standard is applicable to any type of company. • Will ease the process of coordination between plants all around the world	• Requires an intensive training along the strategic professionals to operative employees. • Documentation and consultancy are quite expensive during the initial stages of the implementation. • S&ME´s turn a little bit skeptical about implementing the standard when considering the costs.

Observations / Considerations:

It requires an environmental policy development, monitoring of objectives' progress, mitigation of environmental negative impacts and continually revision of the EMS in order to ensure the continuous improvement.

7.8 LIFE-CYCLE ASSESSMENT (LCA)

TOOL:	*Life Cycle Assessment – LCA (ISO 14040)*			
Classification:	Product based		Reactive	Operational
Three -bottom line impact	**Economical**		**Environmental**	**Social**
			X	
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
	X	**X**			**X**
Time requierement	Short – Middle Term		**Capital Investment**	Medium	

Tool Description:

LCA is a methodological framework for estimating and assessing the environmental impacts attributable to the life cycle depletion, tropospheric ozone creation (smog), euthrophication, acidification, toxicological stress on human health and ecosystems, the depletion of resources, water use, land use, noise – and others. The purpose of LCA is to balance the input with the output of the unit being evaluated but in practice this balance may never be complete while evaluating some of the features, for example energy.

Composed by four stages: Goal and Scope definition, Inventory analysis, Impact Assessment and Interpretation.

Benefits:	**Limitations:**
• Applicable to any kind of product or any business unit. • Provides updated information about the unit being evaluated. • Allows simplified version of LCA for S&ME´s • Gives guidance towards solutions and strategies to improve emissions performance. • From “cradle to grave approach”	• Not enough to compare different assessments on product or production basis. • Models defined within the implementation of the LCA could not be sufficient to describe the entire spectrum of the environmental impact. • Not possible to establish a direct causality between an intervention and its real impact. • LCA´s are costly and time consuming since they are complex and data intensive, subject to technological changes and highly dependent on the information owners

Observations / Considerations:

Can be applied to Product development, Strategic Planning, Public Policy making, Marketing.

Can be implemented within the Supply chain, in order to start minimization of outputs from the supplying stages.

Uncertainty and variability are absolutely present while going through the LCA stages. It is important then to consider them or to have an assumptions record in order to avoid misinterpretations.

7.9 MET (MATERIAL – ENERGY – TOXICITY) MATRIX

TOOL:	*MET (Material – Energy – Toxicity) Matrix*			
Classification:	Product based		Reactive	Operational
Three -bottom line impact	**Economical**	**Environmental**		**Social**
		X		
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
		X			
Time requierement	Short - Term	**Capital Investment**	Low	

Tool Description:

The tool is a combination of quantitative and qualitative information in a 3 x 3 matrix where input-output relationship is measured against product´s lifecycle.
It considers three aspects:

- Material input/output
- Energy use
- Toxic emissions

Within the product life cycle stages: Production, Use and Disposal.

Benefits:	**Limitations:**
• Identifies key environmental aspects of the product throughout its lifecycle as part of initial evaluations and quantification. • Its results can be easily understood by employees and professionals and will work as a conscious driven tool among them. • MET matrix can be used either in a specific product assessment or in a more general design process	• It may require some customization prior its implementation. • MET matrix is unique and will not allow comparison among company´s products.

Observations / Considerations:
This tool is adequate for start-ups and workshops of cross-functional designing and managerial teams that are requested to improve either product or process.
If wanting to take it to the next level into a wider scope including several actors that participate within the product lifecycle, an initial consensus on indicators, dimensions and in depth reach is going to be expected from each player

7.10 NATIONAL ACCOUNTING MATRIX INCLUDING ENVIRONMENTAL ACCOUNTS (NAMEA)

TOOL:	*National Accounting Matrix including Environmental Accounts (NAMEA)*				
Classification:	Reporting			Reactive	Strategic
Three -bottom line impact	**Economical**		**Environmental**		**Social**
	X		**X**		
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
		X			**X**
Time requierement	Short Mid - Term		**Capital Investment**	Low	

Tool Description:

It shows the links between national accounts and economic indicators such as GDP (Gross Domestic Product, or Balance of Payments) with the environment.

Environmental common accounts are substance account and environmental theme indicators where green house gas emissions, traffic emissions and recently water sources pollution are accounted. Although the economic accounts are measured in monetary terms, these accounts are measured in units of emission.
The tool connects the inputs and outputs to the related economic activities that are directly responsible among industries and households.

Benefits:	**Limitations:**
• NAMEA allows comparison of industries between countries in terms of environmental threats. The comparisons are possible because it uses the macro-economic principles and accounts well diffused around the world. • It allows a logical approach towards the interaction between a country´s economy and its environmental scenario.	• Costs can be under or over estimated considering a certain environment improvement. • The public information easily obtained with this tool may show possibilities of re-location of high pollutant manufacturers. • Still NAMEA does not have the social aspects completely incorporated to the Macro-economic models and neither a direct relation with the environment issue.

Observations / Considerations:

Since these factors are intrinsic to each country, when reporting their national results, each country should publish also all the considerations and assumptions used when performing the environmental accounting report in order to be able to establish some comparisons or show clearly the differences between countries results.

7.11 POLLUTION PREVENTION (P2)

TOOL:	*Pollution Prevention – P2*			
Classification:	Product based		Reactive	Operational
Three -bottom line impact	**Economical**		**Environmental**	**Social**
	X		**X**	
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
	X	**X**		**X**	
Time requierement	Mid - Term		**Capital Investment**	High

Tool Description:

Useful in the initial stages when considering reduction at source and recycle activities in order to minimize wastes and increase efficiency of processes and products and ultimately achieving an improvement in the cost structure.

P2 is based in the idea that pollution generation can be reduced or eliminated by increasing the resources usage better known as Waste Management (WM); and which main element of the "Pollution Prevention Act" 1990 are: reduction at source, in process recycling, on site recycling, off- site recycling, treatment to reduce danger, safe environmental disposal and direct disposal into the environment. There are two main prevention models: Prisma methods and projects relying on quickscan.

Benefits:	**Limitations:**
• Acts directly on cost efficiency factors impacting company performance indicators regarding productivity, material and process efficiency and foremost reduced pollution impact. • It improves the overall core productive efficiency and protects resources/raw materials by switching from end-pipe solutions into prevention solutions.	• The tool has reached to point where it only provides incremental improvements. • S&ME find complications to engage the tool since it requires a capital investment to obtain significant results. • The P2 scope needs to be magnified beyond the firm level reach by being more inclusive within the value chain actors.

Observations / Considerations:

While implementing this tool it forbids or restricts the pollution to be transferred from place to place or within the value chain. P2 also allows easier compliance of environment regulations when it transforms waste streams into product components, which is seen a P2 successful project.

7.12 SOCIAL ACCOUNTABILITY INTERNATIONAL (SA 8000)

TOOL:	*Social Accountability International – SA8000*			
Classification:	Performance and Risk based		Proactive	Strategic
Three -bottom line impact	**Economical**		**Environmental**	**Social**
	X			**X**
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
	X	**X**	**X**		
Time requierement	Mid - Term		**Capital Investment**	Medium	

Tool Description:

An auditable standard for third parties verification system to ensure both ethical sourcing of products and goods; and workplace conditions worldwide. It is applicable to any size of company and to any industry sector.

Considered as a response to the business sector in order to address consumer and investor perceptions of the emerging global social issues. Child labour, forced labour, health and safety, freedom of association, right of collective bargaining, discrimination, disciplinary practices, working hours and compensation are issues where the standard is applied to.

Benefits:	**Limitations:**
• Reduces information asymmetries between supply chain partners; therefore, brings closer suppliers from all around the world and develops cooperation, trust, coordination and clear communication. • Allows comparability and consistency through time and among companies.	• SA8000 can be extremely expensive and monitoring must be performed at the lowest possible cost. • It makes the social aspect highly vulnerable and low probable to be investing in. • SME´s with limited resources may have a difficult time complying with the SA8000 standards

Observations / Considerations:

Firms implementing SA8000 will obtain a leveraged social reputation that will help to differentiate their products and the company reputation, will have pricing reductions from government policies and will give a competitive position in the markets where they work.

SA8000 will turn in non-economical criteria that will strongly influence the supply chain decisions

7.13 SUSTAINABLE SCORECARD

TOOL:	*Sustainable Scorecard*			
Classification:	Performance and Risk		Proactive	Operational
Three -bottom line impact	**Economical**		**Environmental**	**Social**
	X		**X**	**X**
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
		X			**X**
Time requierement	Short - Term		**Capital Investment**	Low	

Tool Description:

Management tool that allows a four angle performance perspective relating the different measurements, targets and objectives in a coherent and visual approach that permitted to set a consistent company strategy considering a sustainable approach.
It considers: Sustainability Perspective, External Stakeholder Perspective, Internal Perspective and, Knowledge and Skills Perspective.
It can be constructed by identifying company values, vision and mission, KPI´s, build a driver model showing KPI´s linkages and agree on indicators measurements and targets.
The company will have a map of how the drivers correlate and a one-sheet template that brings together the indicators, the target values and how they should be reached.

Benefits:	**Limitations:**
• The Sustainable Scorecard is applicable within any sector and organization type thanks to its simplicity and generality. • Since the original version of the Balanced Scorecard is already being used in many companies around the world, it makes this sustainable version highly compatible to be implemented without a severe impact. • It reinforces the organization´s understanding and use of the KPI´s and objectives, and therefore supports and makes smoother the company decision making process.	• Its results depend on how the company defines their objectives, values and how they are going to measure their performance setting the actions and correlating them towards its ultimate objective. • Extremely caution should be paid when assessing the priorities of the scorecard with the possible tradeoffs that could be presented among the different company departments. • Some trouble about defining the proper indicators, actions or targets regarding sustainability.

Observations / Considerations:

Misinterpretation may arise between the four standpoints
It is important to have a clear concept of sustainability and how this term will affect both the company and their stakeholders.

8 CONCLUSIONS

When considering evaluating the opportunity to implement any of the existent tools into a business context, a prior knowledge about all the possible options and its characteristics is crucial. In that way, the company's strategic division will have a better understanding of what could perfectly suit the company needs, define a scope and visualize the possible results previous a full implementation of the tool. Characterizations of some of the available tools is shown in this document; but the study and classification of other tools is required in order to offer any type of industry or company the best tool possible according to each individual needs. This further work will allow companies to have a full documented tool report that will help them to reach in any way their sustainability objective with less capital and human investment in the earlier stages.

After having selected a possible tool that will be implemented within a process, product or strategy; it is also important to have in mind that intangible characteristics such as open communication, collaboration, co-operation and transparency in the different stages shall be present at all times in order to guarantee the best possible outcome of the project. These characteristics need to be developed and should be encouraged and motivated from top management until detailed business units in the initial phases where the company finds a need of change, specially towards a sustainable approach.

By acknowledging the importance and the impact of Sustainable Supply Chain Management philosophy; it is necessary to switch and evolve the actual business conception towards a sustainable income. Economic and financial controlling and improvement is not longer enough, but should become complementary with an environmental and social control and improvement. In order to smooth the required switch, initial encouragement should come from governments, nongovernmental organizations and ultimately by consumers. For the first two agents, what could be provided by them in the first place are trainings, conferences and policies. Also motivators like tax reductions can be applied to those companies that are willing to turn their operations more sustainable. All these initiatives are going to offer the companies a higher possibility to explore new markets and sooner or later will enhance the adoption of the Sustainable Supply Chain Management among all industries.

Although this sustainable approach is required now days and it has been defended in this document; it initially seems a huge economic cost with no apparent reason rather than a new trend. It is important to see these capital and human expenditures as a medium and long run investments that will guarantee world's natural regeneration and foremost the human race survival without sacrifices. Even by achieving the integration within the supply chain actors, the entire structure will be able to reduce several double costs and impact positively the financial issues by optimizing aspects such as quality sampling, refurbishment, product's conformity, recycling and disposing, pollution management and emission prevention and already required supplementary activities that are will diminish the harm already done.

Regarding the availability of the tools and after realizing some of these instruments suffer slight transformations during time according to the companies' profiles and specific needs, the next evolved versions of the tools shall target the inclusion of the three bottom line consideration and impact in order to comply in the best way possible its objective towards the achievement of Sustainability.

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ANNEX – TOOL TEMPLATE

TOOL:					
Classification:					
Three -bottom line impact	**Economical**		**Environmental**		**Social**
Supply Chain impacted actors	**Supplier**	**Producer**	**Service Provider**	**Customer**	**Stakeholders**
Time requierement			**Capital Investment**		
Tool Description:					

Benefits:	**Limitations:**
Observations / Considerations:	