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**EMM Model. Environmental Management
Maturity Model for Industrial Companies**

DISSERTATION

submitted for the Degree of Doctor of Philosophy by

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ABSTRACT

Environmental management has become an important issue within companies. Despite being a lot of environmental tools that companies may use, there is not a model that guides them towards environmental excellence and makes them see which tool they should use according to their maturity stage. This research hypothesizes that successful corporate environmental management evolves through a series of characteristic stages; independent of industrial context.

The research literature in this type of models is scarce, without going into a deep analysis of how environmental management evolves within industrial companies, and hence, not being helpful within companies.

As a consequence, the main objective of this research is to define an evolutionary environmental management maturity model. For the development of this model an iterative process has been followed, starting with some semi-structured interviews among 19 companies within the Basque Country and two day workshops with environmental experts. As a result of these methods, the first version of the EMM (Environmental Management Maturity) Model has been developed. This version has been improved with the results obtained from a survey carried out within Spanish and Italian companies, leading to the second version of the model. Afterwards the development process was moved to the UK, obtaining

some important information through a survey and semi-structured interviews. The third and final version of the EMM Model was completed.

The EMM Model proposes six maturity stages: Legal Requirements, Responsibility Assignment and Training, Systematization, ECO², Eco-Innovative Products and Services and Leading Green Company. For each maturity stage a description, the people involved, the different policies, indicators, Causal Loop Diagrams and Behavior Over Time graphs have been defined.

It can be concluded that the maturity stages and consequently the different parts of each of the stages in this research can provide valuable guidance for industrial firms aiming to make progress in environmental matters, as the EMM Model helps them to identify in which maturity stage they are and sets out steps that they can take to move forward.

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INTRODUCTION



Environmental management has become an important aspect in current organizations, however there is still much to be done. The awareness about environmental issues started in the 50s with several environmental problems. However, it has not been until the 90s when companies started taking control of their environmental management due to legislation pressure and other stakeholders' pressure. In parallel, different standards and tools have been developed during these years to help companies to improve their environmental management. Nevertheless, not all the companies have environmentally improved in the same way and there is not a guide that lets them know where they are and what are the following steps that they should take. The main objective of this research is to create a detailed qualitative model of the evolution of the companies' environmental management. Through several maturity stages companies will be able to identify in which stage they are in and progress to the next stage.

1.1 WHAT IS ENVIRONMENTAL MANAGEMENT?

Environmental dimension is part of the sustainability triangle in which economic and social issues also take part (Ludevid 2000; Kleine and Von Hauff 2009). The economic dimension focuses on profitability, productivity and competitive capacity. The social dimension includes the motivation and satisfaction, good working conditions and a decent wage. And the environmental dimension works on the raw materials savings, polluting emissions reduction, waste reduction and new green products design among other issues. This last dimension is the one where this research is focused on.

Specifically, environmental management “involves the study of all technical and organizational activities aimed at reducing the environmental impact caused by a company’s business operations” (Cramer 1998).

1.2 ENVIRONMENTAL MANAGEMENT HISTORY

It is widely known that environmental management has emerged as an issue of great interest among companies (Céspedes Lorente and De Burgos Jiménez 2004). However, the awareness of society started in the 50’s when the first alarms appeared due to environmental problems. Until that moment there had only been some few groups aware of the importance of nature conservation (Hunt and Johnson 2006). Some of the important milestones in this decade were the 4,000 deaths due to the London smog in 1952, the mercury poisoning discovered in 1956 in Minamata, Japan; and the fire in the Windscale nuclear reactor causing a radioactive release in 1957 (Hunt and Johnson 2006).

In the 1960’s, environmental issues elicited little discussion at executive levels (Walton et al 1998). Nevertheless, society started to question the possible consequences of an insensitive development with the environment (Rodríguez and Ricart 2000). The publication in 1962 of the book “Silent Spring” of Rachel Carson (1962), could be the event that helped triggering the problem between the

economic development and the environment (Ricart and Rodríguez 1997; Hunt and Johnson 2006). The society raised for the first time the dangers that an uncontrolled development could have for the human being and the nature (Ricart and Rodríguez 1997).

In the early 70's, the first energy crisis caused a shock in the business sector since the energy could no longer be considered as an unlimited resource but as a scarce resource that needed to be managed and preserved (Ricart and Rodríguez 1997; Shrivastava 2007). It is also in this decade when the book "The limits to growth" of Donella H. Meadows et al. (1972) was published.

In the 80's, several disasters strongly raised awareness of the developed countries. The leakage with methyl isocyanate in the Union Carbide plant in 1984, in the Indian city of Bhopal, caused approximately 4,000 deaths and 200,000 injuries (Blacconiere and Patten 1994). One of the causes of these deaths was the lack of environmental protection and management of hazards (Morehouse 1994). In 1986 the Sandoz warehouse fire in Basle polluted the Rhine. In 1989, the tanker Exxon Valdez discharged into the sea more than 50,000 tons of oil (Patten 1992). As a consequence, more than 6,020 miles of Alaska coast were seriously affected (Ricart and Rodríguez 1997). Many scientific studies were carried out to assess the environmental effects of the Exxon Valdez oil spill (Boehm et al 1997). 1987 was the Environment year in Europe and the Brundtland Commission used for the first time the term "sustainable development" (Redclift 2005) and it was described as the one that allows satisfying the necessities of the present generation without preventing future generation of satisfying their own necessities (Brundtland Commission 1987).

It was in the 90's when Shell was fined with a million pounds due to oil pollution in Mersey. It was also in this decade when the first norms and certifications came out to help companies with their environmental management. In 1992 the BS 7750 British Standard about Environmental Management Systems (EMS) was published. In 1993 the Spanish Standards UNE 77-801 and UNE 77-802 about EMS and environmental auditing were published (Hunt and Johnson 2006). After the success of the ISO 9000 standards family, in 1996 the ISO 14000 set of

standards was published. It was designed for the environmental management of all type of companies. The chemical and automotive industries have been the first ones in implementing the ISO 14000 set of standards (Boudouropoulos and Arvanitoyannis 1999).

As a clear example of this environmental evolution, it should be highlighted the change in water quality of the Gipuzkoan (Basque Country) rivers after twenty years. Arluziaga (2002) presented the results of sampling the quality of the Gipuzkoan rivers made in 2001, and they were compared to those taken 20 years before in the same sites. The studied rivers were: Bidasoa, Oiartzun, Urumea, Oria, Urola and Deba. Generally, there is an improvement in the physical and chemical water characteristics (conductivity, pH, O₂, heavy metals...) and the number of aquatic organisms has increased what indicates cleaner rivers. All this improvements have been possible thanks to a better environmental management, not only by society but also by companies.

1.3 BACKGROUND LEGISLATION

One of the first objectives in the environmental management is the legal requirements fulfillment. Every company needs to be aware of the current legislation that is applicable to it. There are five legal levels for Spanish companies: International, European Union, State, Autonomous Community and Local.

The Spanish Environmental Management Legislation is very recent. Most of the state laws have arisen or have been renewed since it joined the European Community in 1986 (Hunt and Johnson 2006). Before this union, there were not many laws.

The first laws regarding environmental issues did not have the purpose of combating industrial pollution but to protect green spaces. This is the case of the

*National Park Law*¹ in 1916. The first sign of concern about the industrial pollution is reflected in the *Irritating, Unhealthy, Harmful and Dangerous Industrial Activity Regulation*² in 1961. In 1972, after the Conference of the United Nations, where it was discussed the obligation of the States to preserve and protect the environment, the *Law of Protection of the Atmospheric Environment*²² was published. Three years later, in 1975, the Government introduced two new environmental laws: the *Protected Natural Spaces Law*², that has been repealed; and the *Municipal Solid Waste Law*² in force. In 1985 the new *Water Law*² was enacted removing the Law of 1879. This Water Law was again updated in 2001.

After joining the European Community in 1986, the *Royal Legislative Decree of Environmental Impact Assessment*² was approved and the *Law of Municipal Solid Waste*² was modified to adapt it to the Community requirements. In that year the *Toxic and Dangerous Waste Law*² was approved. Together with these laws many other provisions of lower rank exist (Hunt and Johnson 2006).

The environmental legislative aspects that companies should take into account are water discharge, emissions to the atmosphere, waste management and contaminated soils and noise (Hunt and Johnson 2006).

1.3.1 Water Discharge

Companies need authorizations to discharge waste water, distinguishing between continental waters and marine waters. The basic state regulations for water discharge in continental waters are the *1/2001 Water Law*² and the *Regulation of Public Hydraulic Domain*², approved by the *Royal Decree 849/86* where all what is need for the authorization is detailed. All the discharges that have certain contamination load need authorization. The authorization will limit the

¹ http://reddeparquesnacionales.mma.es/parques/org_auto/red_ppnn/historia.htm

² All the state laws could be found in <http://www.boe.es>

concentrations of toxicity, persistence and bio-accumulation. Moreover, some substances emissions have limit values. This is the case for example of mercury and cadmium.

The basic regulations for the authorization of water discharge in marine waters are the *Coastal Law 22/88* and the *Coastal Regulation* approved by the *Royal Decree 1471/89*. Furthermore, there are other provisions that establish some emission and objective limits for some substances, such as the *Royal Decree 258/89*.

It is worth highlighting that most of the Spanish legislation about water discharge has been developed based on European Union directives (Hunt and Johnson 2006).

1.3.2 Atmosphere

The generation of atmospheric emissions implies the direct or indirect discharge of any substance to the atmosphere (Walss Auriolles 2001). As previously stated, the basic norm from which existing legal provisions have subsequently emerged, is the *38/1972 Law of Protection of the Atmospheric Environment*. Its objective is to prevent, monitor and correct the air pollution situations. Specifically, the emissions generated in industrial centers are regulated by the *Royal Decree 833/75*. Depending on the activities of the companies there are different norms regarding the air pollution emissions (Hunt and Johnson 2006).

1.3.3 Waste Management and Contaminated Soils

Waste is any substance or object that the holder has disposed or discarded (Pongrácz and Pohjola 2004). There are some substances that in some quantities and concentrations are known as hazardous waste as they constitute a risk for human health, natural resources and the environment. The *Royal Decree 833/1988* regulates the production and management, supervision and monitoring and sets out responsibilities and sanctions in case of an inadequate management of hazardous waste.

The contaminated soils are known as the soils that have been degraded as a consequence of human's activities and therefore their use is being restricted. The *22/2011 Law of Waste and Contaminated Soils* addresses these issues.

1.3.4 Noise

The relationship between environmental noise and citizens' health is one of the most significant reasons why environmental noise has emerged as a major issue in environmental legislation in recent years (Murphy and King 2010). There are several laws concerning different types of noise. Some of them are the *Royal Decree 2028/86* that regulates the motor vehicles noise level, the *Royal Decree 245/89* that focuses on construction equipment, the *Royal Decree 1316/89* that corresponds to the legislation of noise at the different workstations and the *Royal Decree 213/92* that establishes the noise specifications that should be included in the household equipment labeling.

1.4 ENVIRONMENTAL MANAGEMENT OVER THE LAST YEARS

Already in the 90's and even more strongly from the year 2000 until now, the implementation of environmental actions by companies has considerably increased. This might be due to several reasons. Owing to the previous disasters and its subsequent society awareness growth, the environmental regulation has pushed companies to improve their environmental management (Bansal and Roth 2000; Claver et al 2007; Collins et al 2010; Tsai et al 2011). Another reason for socially responsible business has been the concern with the environmental effects of their activities, in part because of the deterioration provoked by past activities (Angell and Klassen 1999; Ludevid 2000; Claver et al 2007). Consequently, there has been also an increasing demand for products and services that minimize environmental impact (Abarca and Sepúlveda 2001; Park and Seo 2006). This environmental pressure of the different stakeholders has had a great influence in the companies' environmental behavior (González-Benito and González-Benito

2006; Bremmers et al 2007). Currently, companies are also looking for economic justifications in the implementation of environmental practices (Lee et al 2010; Valentine 2010).

In recent years, the dissemination of environmental management tools and standards has widely spread among companies (Ardente et al 2006; Boiral and Gendron 2011). The implementation of tools and concepts such as environmental impact analysis, strategic environmental assessment, environmental flow assessment, life cycle assessment, carbon footprint analysis, eco-labeling and standardized EMS has allowed companies to better measure, manage and communicate their environmental performance (Emilsson and Hjelm 2002). Nevertheless, there is a limitation on the use of current tools as there is no indication of which tools should be used depending on the company's environmental management maturity. Each tool has a specific use but it is not indicated which one is better for the company's current situation.

It appears that companies tend to perceive the evolution of their environmental management as unique, focusing on the particular characteristics of their firm and its context. However, this research works on a more aggregated perspective defining the generic environmental management evolution that industrial companies follow.

Moreover, not all the companies have environmentally reached the same maturity stage. In the academic literature there have been several classifications about the different stages that companies might be in. All these classifications are explained in **Chapter 2**. However, these classifications are still incipient, since they do not describe how companies can move forward from one stage to the following one and do not deepen into the different steps that companies should take to go towards environmental excellence.

What are the characteristics of environmental management evolution in companies? Which is the recommending path that companies should follow towards environmental excellence? This research answers these questions and therefore, the aim is focused on the development of an evolutionary model that

companies may use to improve their environmental management; going through several maturity stages.

1.5 RESEARCH OBJECTIVES

As it has been mentioned, the main objective of this research is to create a detailed qualitative model of the evolution of the companies' environmental management: Environmental Management Maturity (EMM) Model. This environmental model will help companies to understand the environmental management evolution and move towards environmental excellence. The EMM Model should include three important aspects:

1. It should take into account all the environmental management elements available to improve the environmental issues within companies. In this regard, the EMM Model should indicate the agents that need to be involved in the company, the policies that a company should follow to improve its environmental management, the indicators that needs to take into account and some tools that may help to move forward.
2. It should use the concept of maturity stages, defining chronological steps that companies take towards environmental excellence. The preliminary fieldwork indicates that companies working towards improving their environmental management go through similar patterns of behavior that appear to evolve from within the firm. These patterns are discussed in the context of stages of maturity (Fraser et al 2002). As a consequence, the elements described above should be ordered according to different maturity stages.
3. It should be supported by systemic thinking, using a wider perspective of understanding the problem that is being analyzed without particularizing for each company. Consequently, this model does not only identify how to progress but it also explains the reason of the environmental management evolution. It permits to analyze the

endogenous causes without focusing on the external causes of the problem. In this regard, the EMM Model will present causal loop diagrams (CLD) and Behavior Over Time (BOT) graphs to understand the evolution in each of the stages.

1.6 THESIS ORGANISATION

The structure of the development of this research is shown in **Figure 1**. The remainder of this thesis is organized as follows. **Chapter 2** describes the literature review that was undertaken on environmental management in addition to the existing environmental maturity models. It gives a comprehensive overview of the findings that have been identified in the literature and the limitations of previous studies.

Chapter 3 presents and justifies the methodology applied in the research.

The methodology is followed by the presentation of the model development and improvement phase in **Chapter 4**. For this phase, semi-structured interviews among Basque companies, Group Model Building (GMB) workshops, surveys among Spanish, Italian and UK companies and semi-structured interviews among UK companies have been used and the preliminary results have been presented.

Chapter 5 describes the final EMM Model in detail describing each maturity stage and the elements that take part in each of the stages.

Chapter 6 describes how the EMM Model validation was carried out, to demonstrate the validity and adequacy of the model. The case studies and a simulation model are presented in this chapter.

Chapter 7 ties the different conclusions presented in the thesis together and ends outlining limitations and future research.

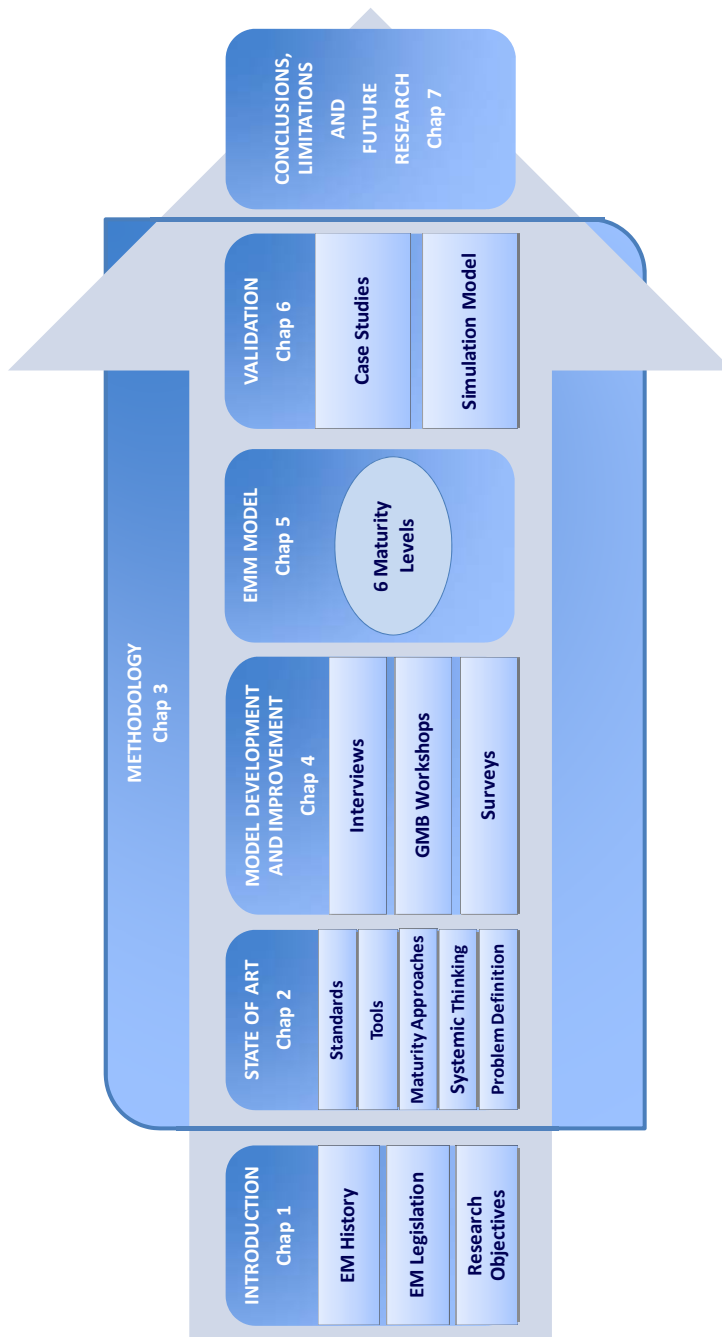


Figure 1. Thesis structure

STATE OF THE ART

2

Taking into account the objective pursued, this chapter gives an overview of the literature review. First of all the concept of environmental management and the different environmental tools available in the literature are explained. Afterwards, the available environmental maturity models are identified. Nevertheless, all these models do not present the path that companies should follow towards environmental excellence neither the structure of the environmental management evolution within companies to better understand how it works and be able to make the right decisions. From there on the importance of systemic thinking is presented, discussing that problems should be analyzed from a wider perspective analyzing the interrelations of all the aspects that take part in the system, in the analyzed problem.

2.1 ENVIRONMENTAL MANAGEMENT

As it has been previously mentioned, the environmental aspect is part of the sustainability triangle together with the economic and social dimensions (Ludevid 2000; Kleine and Von Hauff 2009). In particular, environmental management involves all activities that help in the reduction of a company's environmental impact (Cramer 1998).

Different methods and tools have been developed to help companies to minimize their environmental impact (Cramer 1998; Emilsson and Hjelm 2002; Ardente et al 2006; Boiral and Gendron 2011). Environmental flow assessment, strategic environmental assessment, environmental impact analysis, life cycle assessment and standardized Environmental Management Systems (EMS) are some of the tools that companies may use for this purpose (Emilsson and Hjelm 2002; Petrosillo et al 2012). Firms have been implementing proactive environmental practices by using management systems to reduce the impact of their activities on the environment (Melnyk et al 2003). Some companies have also started to collaborate with their supply chain partners in the environmental aspects. Green practices derived from this collaboration include environmental goal setting and shared environmental planning among others (Vachon and Klassen 2008).

2.2 ENVIRONMENTAL MANAGEMENT TOOLS

There are several tools that might help companies to reduce and communicate their environmental impact. The most common ones in the literature are presented below (Lenzen et al 2003; Weidema et al 2008; Noble 2009; Knight and Jenkins 2009).

2.2.1 Assessment Tools

2.2.1.1 Environmental Impact Assessment (EIA)

The first formal Environmental Impact Assessment (EIA) system was established as a result of the US National Environmental Policy Act (NEPA) in 1969 (Momtaz 2002; Toro et al 2010). EIA is a planning and management tool for sustainable development (Momtaz 2002). More specifically, it is a decision tool employed to identify, examine and evaluate the possible environmental consequences of certain proposed development actions (Cashmore 2004; Koornneef et al 2008; Toro et al 2010) and its reasonable alternatives, which can have significant effects on the environment (Koornneef et al 2008). It can be used to identify the type, magnitude and potential changes in the environment as a result of an activity or policy and also helps to convey this information to decision-makers (Toro et al 2010). It can be seen as a preventive management tool for the systematic evaluation of actions (Snell and Cowell 2006).

EIA is a process covered by several international standards, as ISO 14000, dictating that as many environmental aspects as possible should be identified in a project assessment (Lenzen et al 2003).

2.2.1.2 Strategic Environmental Assessment (SEA)

A related procedure is the Strategic Environmental Assessment (SEA), which aims to include environmental impacts into strategic decision making (Alshuwaikhat 2005; Chaker et al 2006; Koornneef et al 2008; Zhu et al 2011). In developed countries, SEA has mostly emerged as an extension of existing environmental impact assessment (EIA) systems (Retief et al 2008) so that environmental assessments are conducted at all levels of decision-making (Chaker et al 2006). It is, in other words, the EIA of policies, plans and programs (Alshuwaikhat 2005).

The main tasks of SEA are to identify, to predict and to evaluate likely environmental consequences of the decision makings as well as to provide with

prevention and mitigation measures (Zhu et al 2011). It is recognized as an important decision support tool for integrating environmental considerations along with social and economic considerations into proposed policies, plans and programs (Chaker et al 2006).

Evaluating SEA has received considerable attention in the international academic literature in recent years; however, research into the application of these criteria suggests that they are not equally applicable in all decisional contexts (Noble 2009).

2.2.1.3 Environmental Flow Assessment

Assessment of environmental flow is the basis from which to solve the ecological problems caused by water shortage and pollution, and it can also provide a scientific guide for water management, regulation, and configuration (Yang et al 2012).

Environmental flows may be defined as water that is left in a river system, or released into it, for the specific purpose of managing the condition of that ecosystem (King et al 2003).

2.2.1.4 Eco-Design and Life Cycle Assessment (LCA)

The phenomenon of “green design” became especially important in the 90’s (Madge 1993). Eco-design creates products or processes taking into account all the environment aspects and hence reducing the environmental impact (Knight and Jenkins 2009).

Life Cycle Assessment (LCA) is used in the design process, to introduce environmental aspects in a new product taking into account its complete life cycle from design to withdrawal. In life cycle thinking, the focus is not on a specific site, process or organization but instead on an overall view of the impacts of products and services. This kind of thinking involves looking along the whole life cycle from the extraction of raw materials from the Earth all the way through to the return of

these materials to the Earth. It entails a cradle-to-grave consideration of all the stages of a product system (Owens 1997; De Benedetto and Klemeš 2009; Roy et al 2009).

In 1997 a series of standards, that is the ISO 14040 series, was developed to provide guidance on undertaking LCA studies and a new version of these series came out in 2006. LCA involves the evaluation of specific elements of a product system to identify its environmental impact (De Benedetto and Klemeš 2009). This helps in the prioritization of activities to improve environmental performance and it has implications for decision-making (Tillman 2000).

The LCA methodology is described by four steps: goal definition, inventory analysis, impact assessment and interpretation (Georgakellos 2006; De Benedetto and Klemeš 2009; Roy et al 2009; Bersimis and Georgakellos 2012). The inventory analysis phase is the most work intensive and time consuming compared to other phases, mainly because of data collection (Roy et al 2009).

2.2.1.5 Carbon Footprint Analysis

During the past decades, society has shown an interest in climate change and global warming issues. Therefore carbon footprint calculations are over the last years in strong demand (Wiedmann and Minx 2007; Weidema et al 2008; Lee 2011). There have been many definitions and suggestions on how the carbon footprint should be calculated (Weidema et al 2008). Tierney (2008) describes a carbon footprint as a way for an individual or company to determine the impact of its activities on the environment. It might also be seen as the amount of greenhouse gas (GHG) emissions that are directly or indirectly caused by an activity or by the life cycle of a product (Wiedmann 2009). Wiedmann and Minx (2007) suggested that the term carbon footprint should only be used for analyses that include carbon emissions. It might seem that LCA and carbon footprint are quite similar. The main difference is that carbon footprint is based on a single indicator while LCA focuses on multiple indicators (Weidema et al 2008).

2.2.2 Communication Tool. Eco-Labeling

There are many different communication channels that may help companies to externally communicate the environmental improvements carried out within their companies: environmental reports, web page, press, etc. One of the most specific environmental tools is the eco-labeling that is becoming widely used.

Eco-labeling is a process whereby certain consumer products are identified in the market as demonstrating relative environmental benefits over comparable products (Goggin 1994). The eco-labeling is a way of presenting environmental information to the consumer (Clift 1993) and enables consumers to make their purchasing decisions with environmental information as an additional criterion to price and quality (Hale 1996). Eco-label seems a good tool to address information gaps that arise in the market (Maneiro and Burguillo 2007). Therefore criteria for achieving an eco-label must be as simple and transparent as possible. The criteria involved must cover the main components of environmental impact and resource depletion (Clift 1993). The rationale behind the eco-label concept is to provide a guide for consumers that products have been manufactured in the most environmentally sound way and that they are fit for their purpose when in use (Hale 1996). Consumers who are already aware of environmental issues will choose the product which has been awarded with an eco-label in preference to one which has not (Hale 1996). For this reason, eco-labeling provides firms with a means of differentiating products (Amacher et al 2004).

Under these circumstances, eco-labeling is presented as an instrument of environmental policy with the potential to attract those consumers concerned about the environmental impact of their consumption patterns and would be willing to change certain habits by switching to products with less environmental impact, provided they had accurate information (Maneiro and Burguillo 2007).

Worldwide, more than a dozen 'seal of approval' type awards exist from the 'EcoMark' in Japan; to the 'Green Seal' in the US; the 'Environmental Choice' program in Canada; the 'White Swan' awarded by the Nordic Council; the German 'Blue Angel'; and the European 'Eco-label' among others (United States

Environmental Protection Agency 1993). These types of labels are characterized by being voluntary; operated by independent third party organizations (Goggin 1994; Cason and Gangadharan 2002).

Most schemes award labels on the basis of analyzing product lifecycles, including the identification of all significant inputs and outputs as a result of manufacture, use and disposal (Goggin 1994). The European eco-labeling scheme generates environmental performance criteria that a product must meet in order to be awarded with the label. These targets will be updated every three years in the light of technical progress and industry response (Goggin 1994).

The basic analytical tool to evaluate the impact of a product on the environment (from the extraction of raw materials and the production and manufacturing processes through to disposal) is life cycle assessment (Hale 1996).

2.3 ENVIRONMENTAL MANAGEMENT SYSTEM (EMS) STANDARDS

Together with the aforementioned tools there are some specific standards. For years, environmental consulting firms have offered to help in the implementation of different environmental management standards to improve companies' environmental aspects. There are many international environmental standards that might be useful for companies willing to improve. These standards state specifications and guidelines on environmental management systems, environmental audits, eco-design, eco-labeling, life cycle assessment, environmental behavior evaluation and environmental communication (Aenor 2008).

From all the available standards, the environmental management system (EMS) standards are the most frequently used among companies of different sectors (Morrow and Rondinelli 2002; Iraldo et al 2009). For this reason, this section is going to focus on the EMS standards.

An EMS is defined as a transparent, systematic process, with the purpose of identifying and implementing environmental goals, policies, and responsibilities, as well as regular auditing of its elements (Steger 2000; Heras and Arana 2010; Petrosillo et al 2012). However, the application of an EMS scheme may not be a sufficient condition to guarantee improvements in an organization's environmental performance (Iraldo et al 2009).

There are some international, national, departmental and local EMS standards. Focusing on the Basque Country, we can observe three main groups of standards from the internationally best known to the more local one: ISO 14001, EMAS and Ekoscan.

2.3.1 ISO 14001 (International Standards Organization)

As it has been previously mentioned, the set of standards ISO 14000 is international. It was first launched in 1996, developed in the context of other EMS initiatives (Campos 2012). The specific norm of this set of standards that looks at the environmental management system is the ISO 14001. It is intended to establish or strengthen the environmental policy, identify environmental aspects, identify environmental objectives, implement a program to achieve environmental policy objectives, monitor and measure the effectiveness, correct problems and deficiencies and revise the company's system for promoting environmental continuous improvement (Weaver 1996; Jackson 1997; Morrow and Rondinelli 2002). Certification of an ISO 14001 is currently an important requirement for those companies wishing to participate in a global market (Bernardini 2008). In 2011 there were 267,457 companies with ISO 14001 certification in 158 countries³.

The ISO mentions that an EMS should include the establishment of an environmental policy that expresses the commitment of top management to comply with laws and continuously improve (Fredericks and McCallum 1995). In

³ The ISO Survey of Management System Standard Certifications. www.iso.org

addition, there must be a commitment to continual improvement, prevention of pollution and compliance with environmental legislation. And finally the company's environmental policy must be documented, implemented, maintained and communicated to all employees and available to the public (Lamprecht 1996).

On the other hand, it does not measure the actual environmental performance of a company (Krut and Gleckman 1998). The certification means that companies commit to comply with the legal regulations for environmental improvements, but there is no external measure to ensure that these improvements are being met (Rondinelli and Vastag 2000).

2.3.2 EMAS (European Eco-Management and Audit Scheme)

EMAS Regulation is a voluntary standard of the European Union that was first launched in the 90's (Abeliotis 2006; Petrosillo et al 2012). The European Eco-Management and Audit Scheme Regulation is similar to ISO 14001 in its requirements (Sulzer 1999). Unlike ISO 14001, EMAS requires organizations to submit an environmental statement; it is more rigorous in reducing environmental impacts to levels not exceeding those corresponding to economically viable application and requires organizations to disclose much more information (Morrow and Rondinelli 2002). Consequently, EMAS requirements go beyond those of ISO 14001 (Neugebauer 2012). For some companies the advantages of this certification are to reduce costs, the closest surveillance of the production processes, and the competitive advantage achievement and recognition for their efforts (Abeliotis 2006). More than 4,500 organizations were certified in June of 2012 around Europe, being Germany, Spain and Italy in the top three⁴.

⁴ www.ec.europa.eu/environment/emas/

2.3.3 Ekoscan

Ekoscan was created in the Basque Autonomous Region, one of the regions in Spain where ISO 14001 registrations are most highly concentrated (Heras et al 2008). Ekoscan was created in 1998 by Ihobe, the publicly owned Basque Agency for Environmental Management, but it was in 2003 that Ihobe took the decision to advance and enable the Ekoscan model to be certifiable. Nowadays there are more than 215 certified companies among the Basque Country⁵. The aim of the Ekoscan is to enable Small Medium Enterprises (SMEs) from the Basque Country to improve their environmental behavior, as well as to comply with environmental legislation. The Ekoscan standard involves drawing up an Environmental Improvement Plan (EIP), which is viable from both a technical and a financial standpoint (Heras and Arana 2010).

2.4 DIFFERENCES AMONG EMS STANDARDS

The following table highlights the main differences among the EMS standards most commonly used among Basque companies (Table 1). These differences have been taken out from the mentioned articles in the previous section from the standards themselves.

⁵ www.ihobe.net

Table 1. EMS standards' main differences

	ISO 14001	EMAS	EKOSCAN
Extent	Private standard that could be applied internationally.	Community regulation for companies in the EU.	Private standard in the Basque Country.
Previous environmental analysis	Suggests that an environmental revision may be useful to develop an EMS.	Requires the preparation and verification of an initial environmental revision.	Requires a previous economic-environmental diagnosis.
Information public availability	The environmental policy needs to be public.	The policy, program, system and performance need to be public through an environmental declaration that is externally verified.	The environmental improvements need to be available to interested parties.
Legislation	There needs to be a legal "fulfillment commitment".	The company needs to fulfill the environmental legal requirements.	Implies the legislation fulfillment in a period of 3 years since the certification audit.
Commitments and requirements	It does not state the degree of environmental improvement.	Environmental impacts should be reduced using Best Available Techniques (BAT) where economically feasible.	Measurable environmental results are set up.

2.5 ENVIRONMENTAL MATURITY APPROACHES

2.5.1 Importance of Maturity Approaches

Maturity models typically describe the characteristics of a process or an activity at a number of different stages of performance stages, developing from some initial stage to some more advanced stage (Fraser et al 2003). At the lowest stage, the performance of an activity may be rather poor. As the stage increases, activities are performed more systematically and are better defined and managed (Fraser et al 2003). Maturity models suggest that the subject under study may evolve through a number of intermediate stages on the way to maturity.

Maturity models may be seen both as assessment and as part of a framework for improvement (Dooley et al 2001). Maturity assessments can be performed by an external auditor, or by self-assessment. Whilst self assessments can be performed by an individual in isolation, they are perhaps more beneficial if approached as a team exercises to have several opinions from different perspectives (Fraser et al 2002).

Maturity approaches have their roots in the field of quality management. One of the earliest approaches is Crosby's Quality Management Maturity Grid which describes five phases of quality management that companies evolve through: Uncertainty, Awakening, Enlightenment, Wisdom and Certainty (Crosby 1979; Crosby 1996). A widely known derivative of the quality management maturity concept is the Capability Maturity Model (CMM) for software, with five identified stages: 'Initial', 'Repeatable', 'Defined', 'Managed' and 'Optimizing' (Paulk et al 1993; Hefley et al 1995). Shapiro (1992) when explained the evolution of the product development process stated that "every company that really improves the new product development process goes through evolutionary stages. Some do it faster than others and with fewer detours, but fast or slow, every company that gets to world class must evolve through these stages to get there".

In the field of environmental management, defining maturity stages can help describing the typical behavior exhibited by a firm at various stages of management maturity (Fraser et al 2002).

2.5.2 Environmental Management Classifications

Despite all the methods and tools available to improve companies' environmental management, companies are at different stages of maturity or have different strategies. During the last two decades, many researchers have studied why some firms respond to ecological issues, while others do not even comply with the existing regulation (Bansal and Roth 2000; González-Benito and González-Benito 2006).

There have been several studies defining different types of environmental strategies among companies (Sharma and Ruud 2003). The first author who came up with a classification model to describe the increasing importance of environmental concerns for business policy and strategy was Petulla (1987). Since then, many researchers have characterized corporate responses to environmental management. Some authors have made a classification that identifies a development in time (Lee and Rhee 2005) while others present typologies representing that companies may have different strategies when improving environmental management.

Table 2 gives a chronological overview of some of the environmental management maturity models in the literature. It includes the different stages for each model and represents the relation among the different studies.

Table 2. Previous environmental management models

Study	Designation of maturity stages					
	Indifferent	Defensive	Offensive		Innovator	
(Steger 1993)						
(Hunt and Auster 1990)	Beginner	Fire-fighter	Concerned citizen	Pragmatist	Proactivist	
(Roome 1992)	Non-compliance	Compliance	Compliance plus		Commercial and environmental excellence	Leading edge
(Ford 1992)	Inactive: Ignores	Reactive: Responds	Proactive: Anticipates		Hyperactive: Provokes	
(Borri and Boccaletti 1995)	Passive	Active	Proactive			
(Venselaar 1995)	Reactive	Active	Proactive			
(Andersen et al 1997)	Unprepared	Reactive	Anticipatory		High integration	
(Azzone et al 1997)	Passive	Reactive	Anticipatory		Innovation	
(Berry and Rondinelli 1998)	Unprepared	Reactive			Proactive	
(Winn and Angell 2000)	Reactive	Unrealized	Active		Proactive	
(Mirvis and Googins 2006)	Elementary	Engaged	Innovative		Integrated	Transforming
(Jabbar and Jabbar 2009)	Reactive	Preventive			Proactive	

Nevertheless, these classifications do not explain in depth how a company can reach and surpass these stages. The work to date is still incipient, and it does not give a detailed definition of each stage nor does it describe how to move forward from one stage to the next.

Jabbour (2010) concluded that these stages approach does not fully explain the environmental management evolution within organizations. This author stated that there are factors theoretically belonging to different stages that can coexist in an organization. The researcher also discussed the importance of developing a “structured, well-defined classification system” for environmental management evolution.

On the other hand, there has been an initiative of using these type of classifications in practice. The e+5 program⁶ aimed to help companies in the implementation of an environmental management system through 5 stages regarding the ISO 14001.

It has not been presented in the previous table as there it has not been found any paper regarding these maturity stages. Moreover, the last company that joined the program did it in 2005 and since that moment there has not been any movement. Currently, companies should not get stuck in the environmental systematization but improve in the different environmental aspects of the company trying to innovate in the competitive atmosphere that surrounds them.

2.6 SYSTEMIC THINKING

The development of systems thinking has to do with the ability to see the world as a complex system, in which we understand that “everything is connected to everything else” (Sterman 2000). Within a system, as it could be the environmental management system, there are interrelated actions, which often

⁶ <http://www.observatorioambiental.net/programaemas5.php>

take years to affect on each other. We tend to focus on isolated parts of the system, and the only way of understanding the system is through a holistic view, contemplating the whole, not any individual part of the pattern (Senge 1990). Companies would then act in consonance with the long-term best interests of the system as a whole (Sterman 2000).

It is necessary to construct a structure relating all these parts of the system to understand it as the structure of a model explains the behavior (Forrester 1969). When constructing the structure or model, as Richmond (2001) stated, three aspects are fundamental. The first one is the “10,000 Meter Thinking”, looking at the system as if you were in a plane with a sunny day. In this way, the system could be observed as a whole but with little detail. The second aspect proposed by this author is the “System as Cause” meaning that the model should only contain those elements whose interaction is capable of generating the problem that we are studying. Last but not least, the “Dynamic Thinking” that provides behavioral dimension gathering information from the events that had already happened to see the pattern of which they are a part since the model needs to have a dynamic view, rather than only a static view.

Consequently, to study the environmental management evolution of companies, it is fundamental to have a broad vision of the problem and first of all gather all the related information and see why previous studies did not achieve the goal that we are pursuing.

A modeling tool that is gaining in popularity for its flexibility and structural focus is System Dynamics (SD). System dynamics was developed in the 50-60 years by Jay Forrester (Forrester 1961). SD can be applied to any dynamic system, with any scale of time and space (Sterman 2000). This tool provides a better understanding of the system variables behavior to better appreciate the overall operation. For this reason, the use of this tool is interesting to better understand how a complex system works. SD encourages not focusing on the isolated events but rather on the behavior patterns that these events lead to (Forrester 1961; Repenning and Sterman 2001) capturing the whole picture and creating understanding on the difficulties for an effective environmental management. This

high aggregation perspective makes it easier to analyze the structure of environmental management and to demonstrate that in a wider perspective the environmental management evolution of every industrial company is caused by the same structure, even if at first sight it could seem very different.

2.7 PROBLEM DEFINITION

As it has been pointed out, all the environmental classifications are general and do not deepen into each of the stages. Moreover, some authors agree that they are insufficiently reckoned within organizations (Jabbour 2010; Kolk and Mauser 2002). Companies are not able to identify the necessary steps that they would need to take into account to improve their environmental management in an orderly way. As a consequence; companies do not have a specific reference model where they can support if they want to improve and go further towards environmental excellence.

For this reason, it is necessary to develop an environmental management maturity model (EMM Model) to help companies in assessing their environmental management and not only to guide them from one stage to the next one but also to explain the reason of the environmental management evolution. Apart from maturity stages, environmental management elements should appear in the model and it should have a wider perspective as it has been presented in the objective section in **Chapter 1**.

The EMM Model will be developed for industrial companies, focusing this research on this type of companies. As some companies have more than one plant or more than one strategic business unit (SBU) and each of them can be in a different maturity stage, this model should be applied to each of the SBUs in each of the plants.

As it is presented in **Chapter 5**, the EMM Model will have a sequential order taking into account that it is an “ideal” path for the environmental management evolution within companies, but it does not mean that all the companies will have to follow these proposed stages. Moreover, the EMM Model developed in the

thesis should take into account comments that some authors have made about previous models. Jabbour (2010) pointed out that some factors may coexist in one organization and it is something that it has not been visualized in any of the previous models. On the other hand, Kolk and Mauser (2002) stated that having environmental indicators may help to improve “the greening of the business”.

RESEARCH METHODOLOGY



In this chapter the research methodology is presented. It includes the different steps that have been followed during this study explaining the suitability of the methodology. The research methods and tools that have been used are: Literature Review, Semi-Structured Interviews, Group Model Building (GMB), Causal Loop Diagrams (CLD), Surveys, Case Studies and a Simulation Model.

3.1 INTRODUCTION

This study includes three main steps: defining the research gap, model development and iterative improvement, and the final validation. All these steps with the corresponding research methods have been discussed below.

The research gap identification phase has been carried out through literature review to identify the research gap and define the objectives of this thesis. In the model development phase an iterative process has been carried out, improving the model thanks to different methods. First of all, semi-structured interviews among 19 Basque companies were carried out. Afterwards, with the information obtained in the interviews, two Group Model Building (GMB) workshops were accomplished with six environmental experts and the first version of the EMM Model was developed. For the construction of this model, the System Dynamics (SD) methodology was used, in particular Causal Loop Diagrams (CLD). To validate this first model and to improve it, a survey among Spanish and Italian companies took place, obtaining a second version of the model. This second version was again adjusted after a survey and semi-structured interviews among UK companies, obtaining a third version of the model, which was considered the final EMM Model. Finally, the last step was the final validation that was accomplished through three deep case studies conducted in the Basque Country and a simulation model.

The starting point of each of these steps is the result of the previous step. In **Figure 2**, the different steps are presented and the order that has been followed is indicated by numbers.

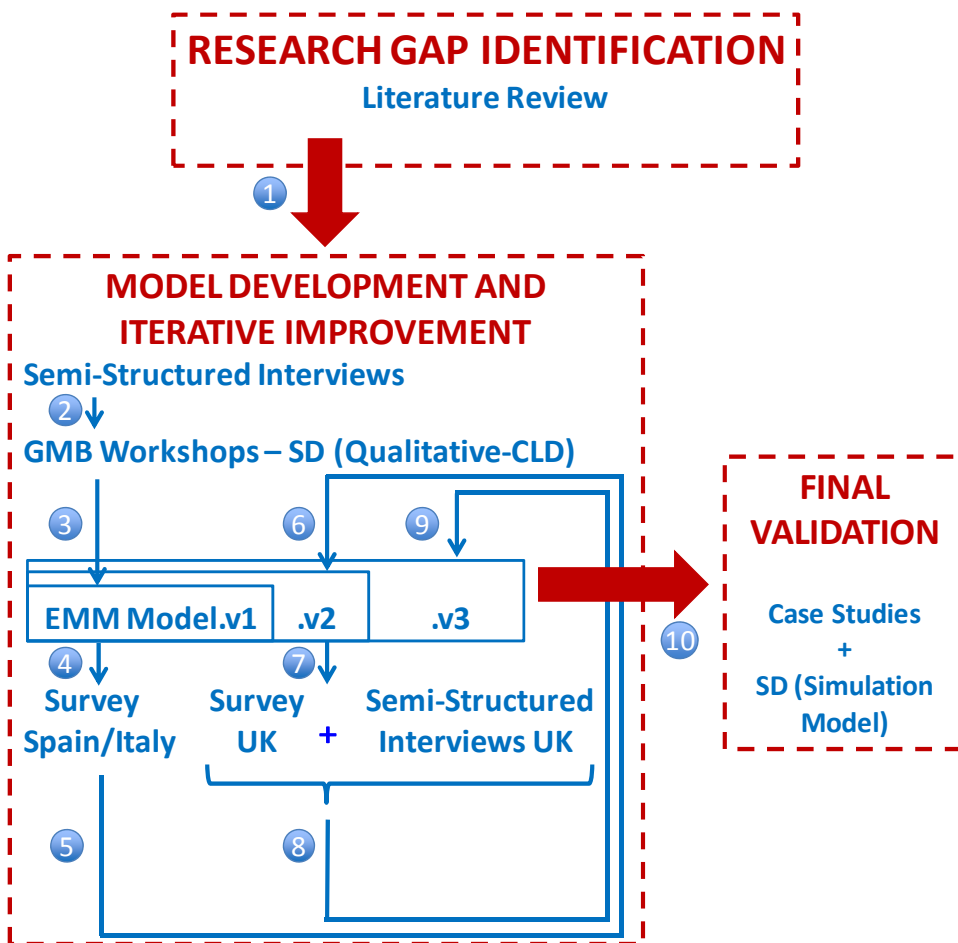


Figure 2. Research methodology

3.2 RESEARCH GAP IDENTIFICATION. LITERATURE REVIEW

To identify the research gap and the corresponding objective of this thesis, a deep literature review was carried out.

A literature review is an analysis of the relevant available research and non-research literature on the topic being studied (Hart 1999). The selection of

available published documents from many sources on the topic helps to form the basis for a goal. It should contain a clear search and selection strategy (Carnwell and Daly 2001). The literature review provides a comprehensive background for understanding current knowledge and highlighting the significance of new research.

Keyword searches are the most common method of identifying literature (Ely and Scott 2006). As a first step to get the general information about the problem, the following keywords were considered: “environmental management”, “environmental activities”, “environmental tools”, “environmental models”, “environmental management evolution” combined with “companies”, “enterprises” and “organizations”. As it might be observed, alternative keywords with similar meaning have been used to elicit further information (Younger 2004).

Once the gap was identified and the objective was described, the literature review was focused on the objective, so the keywords used were: “maturity models”, “environmental maturity models” and “system thinking” all combined with previous general keywords.

All this literature review has been mentioned in Chapter 2.

3.3 MODEL DEVELOPMENT AND ITERATIVE IMPROVEMENT

The literature review was followed by some semi-structured interviews among Basque companies to gather as much information as possible from the practice business point of view.

Moreover, two Group Model Building (GMB) workshops were carried out with environmental experts and the first version of the model was developed. This model relies on System Dynamic (SD) methodology, specifically on Causal Loop Diagrams (CLD). This first version of the EMM Model was validated and improved with a survey among Spanish and Italian companies. Once the second

version of the model was developed, a survey and seven semi-structured interviews were carried out among UK companies obtaining the final version of the model.

A detailed explanation of this iterative process is explained in **Chapter 4**, with the results obtained from the different methods which updated and improved each of the EMM Model versions.

3.3.1 Semi-Structured Interviews among Basque Companies

The qualitative interview is the most common and one of the most important data gathering tools in qualitative research (Myers and Newman 2007). Interview is defined by Frey and Oishi (1995) as “a purposeful conversation in which one person asks prepared questions (interviewer) and another answers them (respondent)”. This is done to gain information on a particular topic or a particular area to be researched and to gain rich information about the experiences of individuals (DiCicco-Bloom and Crabtree 2006). That is why after analyzing the state of the art and taking into account the objective of this research, interviews were conducted with environmental managers from nineteen enterprises among different industrial sectors in the Basque Country. It was fundamental to know what was happening in the reality among companies as the objective of this research is to construct a useful model for companies’ environmental management.

The interviews were semi-structured meaning that they had open-ended questions, allowing the respondents to provide a more detailed answer to the question if the interviewer thinks so. These firms were selected as a convenience sample, taking into account their self-assessed stage of environmental management. Some of the companies were starting with environmental management issues and others were quite advanced. Therefore it was possible to define a preliminary classification of the different maturity stages. The study included 19 firms from different sectors such as chemical, automotive, railway, elevators, and electrical equipment. The average face-to-face interview lasted around 75 minutes. The interviews were based on several questions that were previously prepared to extract as much information as possible. These set of questions can be found in the **Appendix 1**. The objective of these interviews was

to understand how environmental management has been deployed in each enterprise and the consequent factors that affect environmental management. All these factors are presented in Chapter 4.

3.3.2 GMB Workshops with Environmental Experts

3.3.2.1 GMB Usefulness

To assist in the synthesis of the interview results, two Group Model Building (GMB) workshops were conducted with a panel of six environmental management experts. Group Model Building is a methodology for capturing information in collaboration with a group of people who are experts in the problem at hand (Vennix 1996). It is a very suitable method to collect all the necessary information (Andersen et al 2007). As Creswell (2000) states credible data also come from close collaboration with participants throughout the process of research.

For the construction of the model, it was necessary to identify which experts could contribute with their knowledge to the problem under study. The participants included environmental managers of different enterprises, environmental consultants and academics with experience in environmental projects.

When collecting the information raised by the experts, the GMB methodology uses different exercises (Chapter 4).

With all this information the first version of the EMM Model was built which consisted of several maturity stages and for each of these stages the description, policies, indicators, Behavior Over Time (BOT) graphs and CLD representations were developed. For the development of this first version System Dynamics (SD) and Causal Loop Diagrams (CLD) were also used.

3.3.2.2 System Dynamics (SD). Causal Loop Diagrams (CLD)

This research looks to models of process maturity as an organizing principle. While staging is a useful construct, the true value of a maturity model comes when it is tied to processes and causal analyses that help organizations move forward and understand why they follow the proposed evolution (Sarriegi et al 2005).

System Dynamics (SD) (Forrester 1961; Sterman 2000) is a modeling methodology that focuses on analyzing the underlying structure that generates the behavior of complex systems. This way, the structure of the model can be directly compared to descriptive knowledge of the real system structure.

SD includes both qualitative and simulation modeling tools. Qualitative modeling results very suitable when modeling at the most generic stage. Simulation modeling becomes helpful when capturing important aspects such as delays, non-linear relations, etc.

To represent the structure of the model, causal loop diagrams (CLD) have been used, which is a qualitative tool used in System Dynamics (SD). A CLD consists of variables connected by arrows denoting the causal influences among the variables. These arrows are called causal links. Each causal link is assigned a polarity, either positive (+) or negative (-) to indicate how the dependent variable changes when the independent variable changes. On the one hand, a positive link means that if the cause increases, the effect increases, and if the cause decreases, the effect decreases. On the other hand, a negative link means that if the cause increases, the effect decreases, and if the cause decreases, the effect increases. Regarding loops, the important ones are highlighted by a loop identifier that circulates in the same direction as the loop to which it corresponds. If the feedback effect reinforces the initial change, it is a reinforcing loop (+); if it opposes the original change, it is a balancing loop (-) (Sterman 2000).

Not all these loops affect all the different maturity stages. Some of them appear in the first stage and others do not affect environmental management until the last stage. With the companies' and GMB experts' information, the evolution of the

environmental management has been analyzed and classified according to the different maturity stages that have also been identified.

3.3.3 Surveys

Using the first version of the model, a survey was carried out among Spanish and Italian companies. After analyzing the responses, a second version of the model was developed. This second version was used for the survey among UK companies.

A survey involves the collection of information from individuals, through mailed questionnaires, telephone calls, personal interview, etc., about themselves or about the social unit to which they belong (Rossi et al 1983). Researchers often distinguish between exploratory, confirmatory, and descriptive survey research (Malhotra and Grover 1998). In this research the surveys were confirmatory to validate the preliminary model. Confirmatory (or theory testing) survey research: takes place when knowledge of a phenomenon has been articulated in a theoretical form using well-defined concepts, models and propositions (Malhotra and Grover 1998).

An important issue is how the questions should be formulated to collect information on a specific concept. The language must be consistent with the respondent's level of understanding; otherwise the researcher might get unreliable and biased responses (Dillman 2007). Once the questionnaire is built, a pilot test should be done to test whether the questionnaire accomplishes the study objectives (Dillman 2007).

3.3.3.1 Spain and Italy

The standardized EMS with the greatest global impact has been the ISO 14001:2004 (Bernardo et al 2009). In terms of the number of certifications, Spain and Italy are in the third and fourth position respectively after Japan and China, which means that they are in the top two positions among the European countries (ISO 2011). What are the characteristics of environmental management evolution

in Spanish and Italian companies? This first survey was focused on these two countries to validate and complete the first version of the developed model.

The sampling frame was based on an on-line list of Italian and Spanish companies that was randomly sent to 588 companies. The on-line survey was opened by 325 firms and completed by 129. As 59 questionnaires were significantly incomplete they were deleted, obtaining a final sample of 70 firms, 29 Italian and 41 Spanish, which corresponds to a global response rate of 12%.

The questionnaire had five parts (**Appendix 2**). In the first part the proposed maturity stages were defined and respondents were asked to order the different maturity stages in ascending evolutionary stages. The stages were ordered alphabetically to avoid influencing respondents, and there was the option of marking some stages as parallels, deleting others, or adding additional ones for ranking.

The second part of the questionnaire focused on activities and actions that take part in each maturity stage and the apparent intensity of their importance. The respondents were asked to consider the importance of ten factors for each maturity stage, ordered by a four-point scale. New factors could have been added as well.

The third part was to know if companies could position themselves in one of the mentioned maturity stages. The fourth part was an open ended question about the incentives and obstacles towards attaining an environmental certification. The last part consisted of general information about the companies.

All the answers were analyzed and the model was updated, obtaining a second version of the EMM Model.

3.3.3.2 United Kingdom

The second version of the EMM Model was moved to the United Kingdom. After Spain and Italy, United Kingdom is the third state with the highest number of ISO 14001 certifications in Europe (ISO 2011).

First of all, an online survey was carried out to ascertain whether UK corporate representatives agree with the conceptual model previously presented and to identify the most proactive companies that wanted to provide detailed information about their organization.

The survey was conducted among companies in the UK that were randomly selected among LinkedIn environmental groups. The questionnaire had to be completed online and the link of the questionnaire was sent to 273 corporate practitioners, obtaining a total of 55 answers that corresponds to a response rate of 20.2%.

The survey was structured in two main sections (**Appendix 3**). The first one was focused on the companies' environmental management evolution. Companies were asked if they agreed with the maturity stages' order and they had the possibility to write any comment, especially if they did not agree.

The second question was to identify in which of the stages they currently were. The third one was to identify if they have passed through all the previous stages until reaching the present stage. The fourth question in this section was about the factors that have been important for the evolution of the environmental management in their company.

The second section consisted of general questions about the company, to characterize the responses.

3.3.4 Interviews among UK companies

Once the UK survey was conducted, the answers were analyzed to identify the proactive companies that wanted to collaborate in further research. It should be

highlighted that one general question of the survey was related to future collaboration.

A total of seven semi-structured interviews were conducted in August and September 2012, with most lasting about an hour. Six of the interviews were face-to-face while one was done by phone. It enabled in-depth insights into the views of corporate representatives (Patton 2001), and allowed to gain thick, contextual information regarding the way in which the companies within the sample progressed through the different maturity stages. Questions were open ended to allow deeper exploration of issues and to allow respondents own experiences to emerge freely (Appleton 1995; Aira et al 2003; Ingram 2008). Another advantage of this qualitative method is the control over the interview process when questions which may be misunderstood can be clarified by the interviewer (Appleton 1995).

The interviews started with several questions about the interviewee's background. Afterwards, the EMM Model was presented as well as the description of each of the maturity stages. Consequently, all interviewees were asked to describe some milestones that the company has followed to reach each of the stages. This main part was supported by the interview structure, which was designed on the basis of key aspects identified from the literature review as well as the survey to assist with interviewing (Gordon et al 2012). This structure is presented in **Appendix 4**.

All interviews were tape-recorded and then transcribed for analysis. The researchers also made field notes after each interview highlighting aspects of key significance. The use of audio tapes ensured identical replication of the interviews which facilitated the subsequent analysis reducing the error of collecting data incorrectly (Louise Barriball and While 2006).

3.4 EMM MODEL FINAL VALIDATION

Once the final version of the model was developed, the validation proceeded. Case studies and a simulation model have been used to validate and improve the

EMM Model. The following is a more detailed explanation of the use of these methodologies during the validation step. A detailed explanation of this validation process is explained in Chapter 6.

3.4.1 Case Studies

As the development and improvement phase has been iterative the idea was to validate the EMM Model through different case studies to demonstrate that this model represents the path that companies should follow towards environmental excellence. These case studies were much more exhaustive than the semi-structured interviews among UK companies, as they lasted several days and we talked to different people inside the same company.

Case studies explore and study real-life phenomenon through detailed contextual analysis of a limited number of events or conditions, and their relationships (Zainal 2007). The essence of a Case Study is that it illuminates a decision or set of decisions: why they were taken, how they were implemented, and with what result (Yin 2009). In this way, the specific evolution of the environmental management within some companies has been studied.

Case studies have helped raise the level of confidence in the robustness of the method and supports previous results (Yin 2009). Regarding the category, it can be confirmed that descriptive case studies were chosen as they are the ones that better fulfill the objective of this final step of the research. They describe the natural phenomena which occur within the topic that is being studied, trying to answer “what” and “how” questions (Zainal 2007). Answers that respond to that type of questions were needed for this research as the main idea was to identify in each of the companies what they have done until reaching the current environmental management maturity stage and how they have done it.

For the objective of this research the most appropriate companies to analyze are proactive companies as they are the ones that can provide the necessary information to validate all the maturity stages and to identify the milestones that have taken them to the highest maturity stages. Moreover, it should be taken into

account that a company that it is in the last stage is because it has been doing the right things at the right moment, so that is why it is important to identify an appropriate company that has all this features to validate the different steps that have followed before reaching the final stage.

Once the companies were selected, we contacted them to explain the objective of the research. They were explained that after getting all the needed information they were going to be provided with a detailed report of their environmental management evolution. The dates were set for each of the companies with the corresponding people. An interview guide was prepared which listed the questions and issues that needed to be explored. These questions were grouped into the different maturity stages (**Appendix 6**). Before each interview the purpose of the study was re-explained as well as the expected duration and a tape recorder was used.

In total, three case studies were carried out in the Basque Country. The studied companies were from different sectors: railway sector, elevation sector and chemical sector. They were selected due to their mature environmental management.

3.4.2 System Dynamics (SD). Simulation Model

A simulation model was developed to validate the Causal Loop Diagrams (CLD) representation. As it has been explained in **Chapter 2**, the structure of a model explains the behavior of the problem.

Thanks to the experience of the experts that took part in the workshops, the Behavior Over Time (BOT) graphs were available. As a consequence, the main purpose of this validation step was to build a simulation model starting from the causality model to simulate it and compare the simulations obtained with the graphs represented by the experts in the workshops. Consequently, if the behavior of the different variables matches, it could be said that the causality model represents correctly the behavior and the reasons proposed by the experts.

For this validation phase Vensim System Dynamics simulation software has been used (Eberlein and Peterson 1992). The simulation model has been represented with stocks and flows. Stocks are accumulations and are represented by rectangles. They are altered by inflows and outflows, increasing or decreasing the stock. The flows are represented by arrows with a valve. As an example of these terms, it could be said that “the inventory of a manufacturing firm is the stock of product in its warehouses and it is increased by the flow of production and decreased by the flow of shipments” (Sterman 2000).

EMM MODEL DEVELOPMENT AND ITERATIVE IMPROVEMENT

This chapter explains the different steps that have been followed in the EMM Model development phase. As it has been explained, this research has been carried out in an iterative way, improving the EMM Model continuously until reaching the final version. The methods that have been used are: semi-structured interviews among Basque companies, two Group Model Building (GMB) workshops, a survey among Spanish and Italian companies, a survey among UK companies and semi-structured interviews among UK companies. The corresponding results of these methods are presented in this chapter.

4.1 INTRODUCTION

As it has been previously explained in the objective, the EMM Model should be divided into maturity stages and each of the stages should have several components (Table 3).

Table 3. Components of the EMM Model

	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6
Description						
Agents involved						
Policies						
Indicators						
Tools						
CLD						
BOT						

The model has been created, updated and completed according to the information obtained from different methods. It has been an iterative process, improving the model each time (Figure 3).

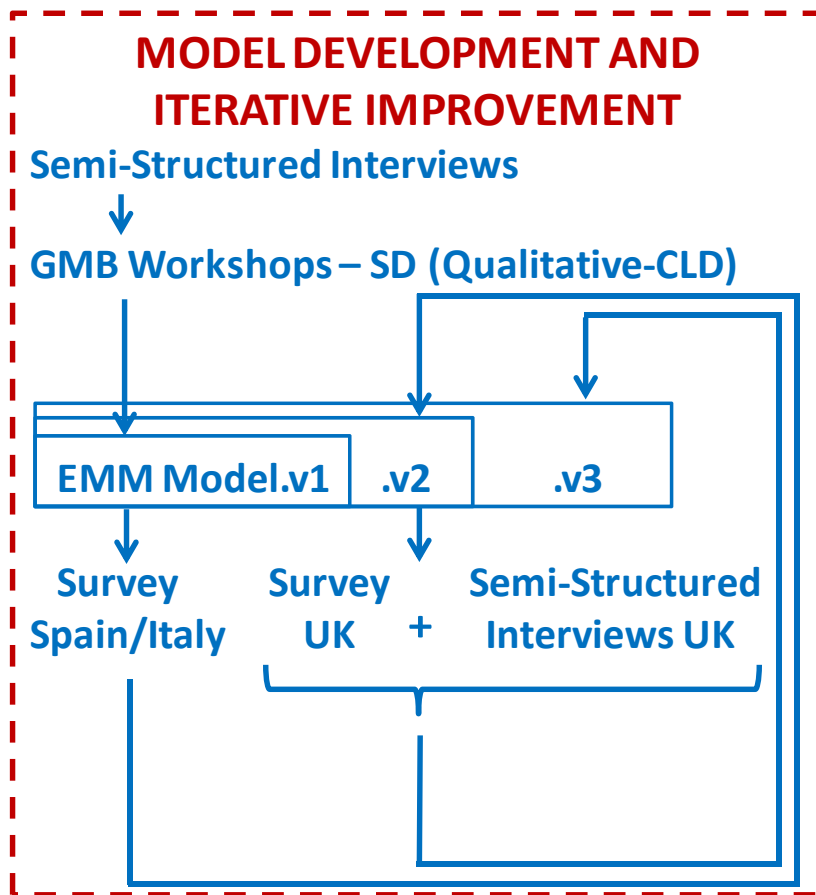


Figure 3. Model development and iterative improvement

First of all 19 semi-structured interviews were carried out among Basque companies obtaining a first proposal about how environmental management was evolving within companies. Afterwards, two Group Model Building (GMB) workshops took place to get as much information as possible about environmental management within companies. This information was used to develop the first version of the model. Once the first version was developed, it was validated and updated with the information collected from the survey among Spanish and Italian companies, leading to the second version of the model. This second version was validated and completed with the information obtained from the survey and semi-

structured interviews among UK companies. Consequently, the final version of the EMM Model was obtained. This final model is presented in the next chapter.

What follows is a description of each of the methods that were used during the model development and improvement phase. The corresponding results and discussion are also presented.

4.2 SEMI-STRUCTURED INTERVIEWS AMONG BASQUE COMPANIES

As it has been previously explained, the first step of the model development was the conduction of semi-structured interviews with environmental managers from 19 enterprises operating in the Basque Country. We included firms from a variety of industry sectors with different environmental management profiles. The industry sectors included chemicals, automotive, railways, elevators and energy devices.

The interviews were conducted in person, with each interview lasting an average of 75 minutes. The main objective was to understand how environmental management has been deployed at each interviewee's company and to identify common factors among its evolution. The interviews were based on a set of questions that were previously prepared to obtain as much information as possible. This set of questions can be found in **Appendix 1**.

After the semi-structured interviews it could be observed that each company was at a different maturity stage, so the idea of building a model with different maturity stages was confirmed.

Every company perceived its environmental management approach as "different from the rest". This happened because companies focus on the specific aspects of their own management programs, rather than on general characteristics. Our research demonstrates that in fact all companies have many aspects in common.

Many different factors explain the evolution of the environmental management within a company. Each factor may be assigned a different value at different companies. Nevertheless, it is not necessary to quantify the exact value that companies assign to particular factors. Rather, it is more important to understand how the significance of these factors may be evolving over time and hence, how the environmental management evolution happens.

Several key factors that explain the environmental management evolution at companies were identified. As the main factors the following ones can be highlighted (as described in Table 4):

- environmental legislation,
- environmental impact of the company,
- company green image/market share improvement,
- process implementation,
- economic benefits,
- top management commitment,
- training of employees, and
- external communication on environmental issues.

Table 4. Factors that affect environmental management at companies

Factor	Description
Environmental Legislation	<p>Environmental regulations and legislation impose norms that force companies to follow specific rules. All companies have to comply with applicable environmental requirements and must make significant efforts to reduce their environmental impacts to a level that the law considers acceptable. When companies fail to do so, they can be penalized.</p> <p>This variable measures the evolution of the environmental legal requirements that every company has to fulfill.</p>
Environmental Impact	<p>This factor measures the real environmental impact of the company (compared to the acceptable level of impact as indicated by the applicable regulations). As a company increases its environmental improvements and innovations, its environmental impact decreases.</p>
Company Green Image/ Market Share Improvement	<p>Many enterprises now see enhanced environmental management as an opportunity to surpass their competitors and increase their market share.</p> <p>This variable evaluates the market share improvement. With the adoption of green products, processes and services, their green image improves.</p>

Formalization/Process Implementation	This factor measures how the systematization of environmental management changes over time. Companies start with a low level of environmental management formalization, going through different maturity stages until they reach environmental excellence.
Economic Benefits	This variable measures the benefits produced by environmental improvements that the company carries out. Because of these changes, the company can gradually reduce its use of natural and energy resources, which means costs savings.
Top Management Commitment	This variable measures how firmly a company's top management is committed to environmental issues. When a company starts to implement its environmental management program, top managers usually are not very committed. Once the results of the program become visible, their commitment increases.
Training	This factor assesses how well workers are trained to use new environmental equipments or carry out new procedures that are being implemented. Appropriate training helps workers commit to environmental issues, ultimately leading to a reduction in the company's overall environmental impact.
External Communication	This variable measures how the company communicated with external stakeholders on environmental issues.

All these factors interrelate and combine to create the structure of environmental management within a company. By analyzing the structure of

environmental management, it becomes easier to understand companies' behavior. Consequently, these factors were necessary to create the structure of the environmental management maturity model.

4.3 GROUP MODEL BUILDING (GMB) WORKSHOPS

Once the environmental management factors were identified two Group Model Building (GMB) workshops were accomplished to get the needed information and start developing the EMM Model.

To obtain the information raised by the experts, the GMB methodology uses different exercises. For this research the exercises were carried out during two single day workshops. In the first exercise, the stakeholders involved in the environmental management were identified and they were classified according to the interest and the influence in the research problem. In the second exercise, the policies that may affect the evolution of the environmental management were identified and grouped into six stages. In the third one, the indicators associated to the different stages were established. Finally, in the last exercise, which was done during the second day, the expert groups developed the graphs associated to the possible evolution of the indicators when the environmental management matures.

4.3.1 Stakeholders Identification

The stakeholders that were identified by the experts are represented in **Figure 4**. All of them have been ordered according to their interest and influence in a company's environmental management. Consequently, this exercise helped to identify the most important stakeholders that needed to be considered in the EMM Model.

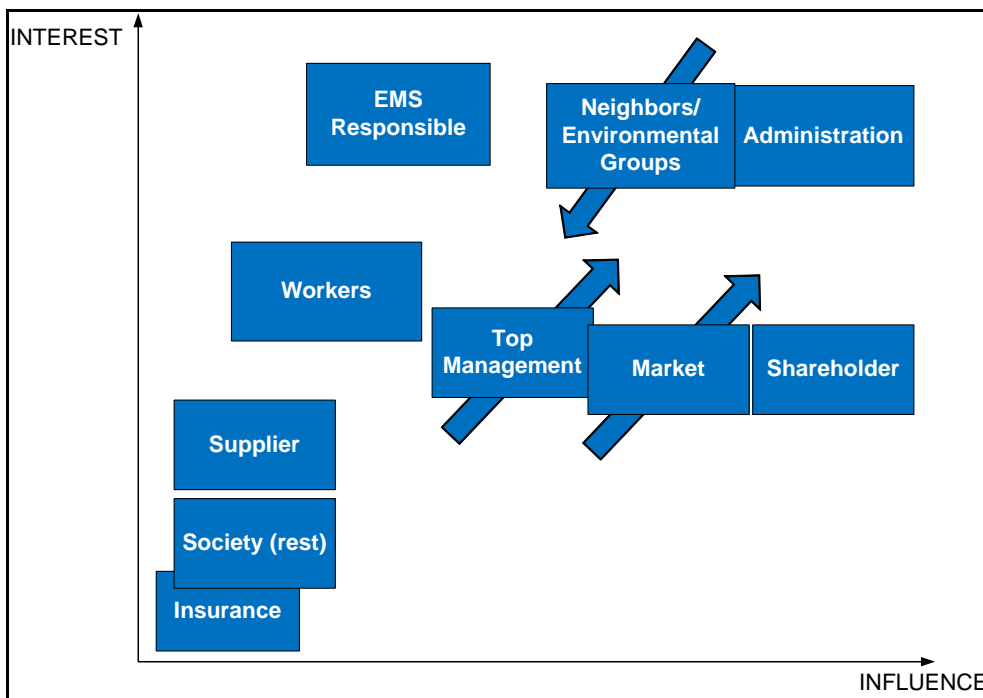


Figure 4. Identification of stakeholders

The Insurance companies may force to fulfill environmental requirements. However, their interest in environmental aspects is still very limited and their influence very small. Another identified stakeholder is the Society. In this stakeholder market is not included. For this reason, the interest and influence that may have in a specific company is quite low. The companies' suppliers have a low-medium interest in the environmental management and a limited influence. As a consequence, all these previous stakeholders are not considered in the EMM Model.

On the other hand, workers have a medium interest in the company's environmental management and their influence is quite low as they do not take part in strategic decisions. The Environmental Management System (EMS) Responsible has a high interest in having an excellent environmental management, but his influence is not very high. The Top Management does not present too much interest and the influence in environmental aspects is not very high.

Nevertheless, as the environmental management matures in the company, the Top Management will also have more interest and more influence (Figure 4). Market has a medium interest but it is increasing over time, and the influence is quite high as the company has to answer to their requirements. The shareholders have a medium interest but the influence is very big as they bring capital to the company. As it can be observed, those with the greatest interest and influence in a companies' environmental management are the Neighbors/Environmental Groups and the Administration. Due to these stakeholders the applicable environmental laws are defined and the company should fulfill the corresponding requirements, otherwise companies could be penalized.

Consequently, all the stakeholders with medium or more interest or with medium or more influence will be considered in the EMM Model taken into account that not all the stakeholders are very relevant since the beginning of the environmental management evolution but that they gain importance during the different maturity stages.

4.3.2 Policies Identification

In this exercise the experts identified those policies that could be implemented to improve environmental management. Once identified the different policies, they were grouped into six packages that were subsequently sequentially ordered, according to the temporary order in which they are implemented in the companies (Figure 5). These six groups are: Law Fulfillment, Training, Systematization, Costs reduction, Eco-Innovation and Green Company. It should be pointed out that this is already a preliminary classification of the different maturity stages.

The first group and, therefore, the first stage, is Law Fulfillment. Any company, the first step that takes regarding environmental issues is due to legal requirements. In this stage, the policies that are implemented are the end-of-pipe solutions, which are all those solutions implemented at the end of the productive processes. Some of the solutions might be the water treatment, the equipment to reduce the atmospheric emissions and the noise reduction.

The second stage is the workers' Training stage. Training is provided to all the workers that need to know how the company's equipments are effectively used and to successfully implement the environmental management measures that the company is taking.

The third stage is the environmental management Systematization. Once some environmental measures have been taken, the company starts to formalize the system and, in some cases, it obtains a certification so the company has an external recognition of its EMS. The objective is to have all the relevant environmental aspects identified and monitored.

In the fourth stage, the companies are looking for Costs Reduction. To achieve this costs minimization, some of the policies that are implemented are the water cycle, materials and energy management. It is also necessary the investment in maintenance to ensure the greatest usefulness.

The fifth stage reflects the company's eco-innovation activities. In this stage environmental tools are used to innovate in products, processes and/or services so they can differentiate themselves from the competitors. Among these tools we can find the Eco-design and the Life Cycle Assessment (LCA), the carbon footprint and the ecological labeling.

Finally, the sixth stage is called Green Company. During this stage, the different involved stakeholders are informed about the measures and the progress that take place so the company starts to get known as green. Therefore, the company's green image starts to develop and the market appreciated the company's environmental measures. The objective of this state is to capitalize the efforts done until the moment.

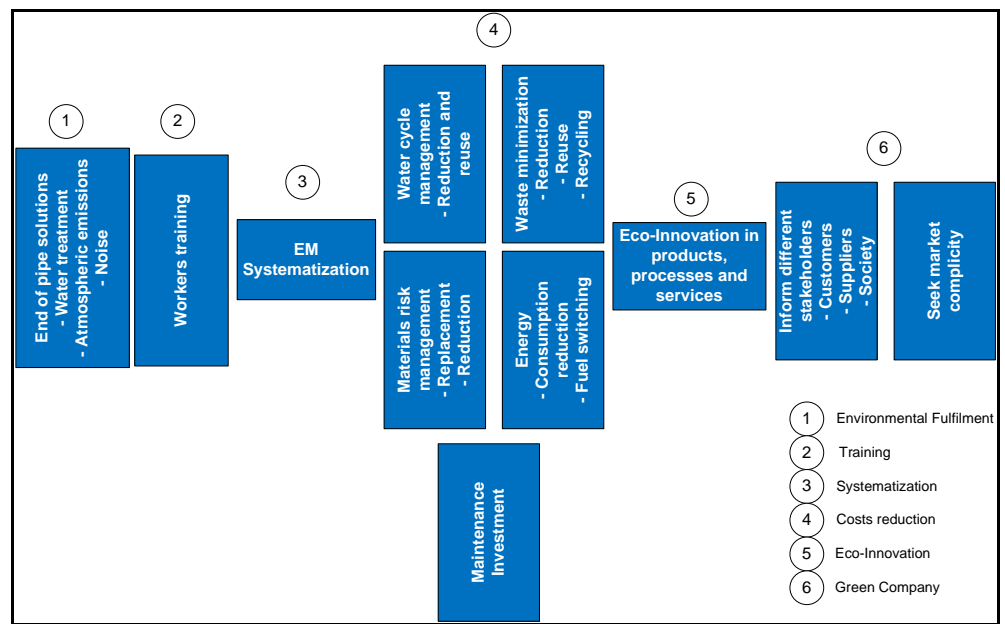


Figure 5. Identification of policies

4.3.3 Policies' Indicators

For each of these six stages, several indicators have been identified and they have been grouped into indicators, those that reflect the amount of effort required to reach the stage; and into results, those that estimate the policies' implementation consequences (Table 5).

Table 5. Identification of indicators

Stages	Inductors	Results
1	- Investment in end-of-pipe actions (Euros). - Environmental requirements.	- Environmental impact. - Requirements fulfillment.
2	- Training hours provided.	- Requirements fulfillment.
3	- Working hours dedicated to environmental management.	- Certification status.
4	- Investment in BAT (Best Available Techniques).	- Consumptions. - Environmental impact.
5	- Environmental tools (labeling, LCA, CO ₂ footprint).	- New green products, processes and services.
6	- External communication.	- Press impacts. - External recognition (prizes...).

In the first stage, Law Fulfillment, the indicators defined as inductors are the investment in end-of-pipe actions; that is to say, the money invested for environmental end-of-pipe actions; and the environmental law requirements. As a result, the environmental impact produced and the requirements fulfillment are measured.

In the second stage, Training, the hours provided are measured. As a result of this stage, the suggested indicator is the environmental requirements fulfillment.

In the third stage, Systematization, the working hours dedicated to environmental management are measured and as a result the certifications status is measured, i.e. it is important to check if certifications that require higher environmental improvements are being achieved.

The fourth stage is focused on Costs Reduction. In this stage the main indicator is the investment in Best Available Techniques (BAT). As a result, the effect in consumptions and the environmental impact are measured to check that they really improve.

The fifth stage is focused on Eco-Innovation. The indicator indicators are the environmental tools, such as eco-labeling, eco-design and life cycle assessment. As a result, the number of new green products, processes and/or services are recorded.

In the last stage, Green Company, the external communication to the different stakeholders, regarding the different environmental actions that have been taken in the company, is measured. As a result, the impacts generated in the press are measured as well as the recognition of the company's environmental excellence.

4.3.4 Behavior Over Time

In this exercise carried out during the second day workshop, the experts graphed some of these indicators over time, to appreciate their evolution (Figure 6). Some indicators were not plotted as they did not provide extra value to the graph. It is the case, for example, of the consumptions, as they are strongly related to the investments done in the BAT to reduce these consumptions. Similarly, the press impacts and the external recognition are implicitly linked to the external communication.

This graph represents the approximated behavior of each of these indicators over time. The six stages correspond to the previous identified ones. This graph is useful to understand better what is going to happen with the company's environmental management if appropriate policies are implemented in each of the stages.

As it has been previously mentioned, the first stage corresponds to law fulfillment, when the first cause of environmental improvement is legislation. There needs to be a big investment in end-of-pipe equipment to fulfill the law. This investment keeps constant during this stage. Initially, the environmental impacts are high, but they begin to diminish when there is some implemented equipment. It is further observed that legal requirements increase over time due to the implementation of new regulations.

In the next stage, the environmental requirements grow, the investment in end-of-pipe equipment decreases, as the biggest investment has already taken place and the requirements fulfillment grow and are approaching to environmental requirements. For this reason, the impacts diminish. In this stage, there are many training hours provided to the workers, so they are able to do their work taking into account the new environmental measures that are being implemented with the introduction of new equipment.

In the next stages, the environmental requirements grow little by little and the requirements fulfillment is maintained. This fulfillment is due to environmental improvements that are carried out which help reducing environmental impact at the same time. The implementation of new equipment starts decreasing little by little as it is not necessary to invest so much in new equipment. As a consequence this indicator becomes constant representing the necessary investment for the maintenance of the equipment.

It is in the third stage when there are more hours dedicated to the formalization of environmental management. Though, it also reflects that there are peaks throughout the evolution of an environmental management system due to the introduction of specific environmental measures. It is in this stage when companies can achieve some accreditations. In the fourth stage, the investment in Best Available Techniques (BAT) takes place. These technologies help the company in being as efficient as possible, trying to diminish the environmental impact at the same type that achieves economic benefits. These investments remain constant over time; though they have some rises when new investments take place to implement new technologies.

On the other hand, in the fifth stage there are new tools to become more innovative and companies might increase the number of green products and processes and consequently, they can get accreditations for their green products.

In the last stage the real external communication takes place where the environmental improvements are announced to the different stakeholders and

customers and society start to recognize the company as a green company, meaning that it is seen as a reference company in environmental issues.

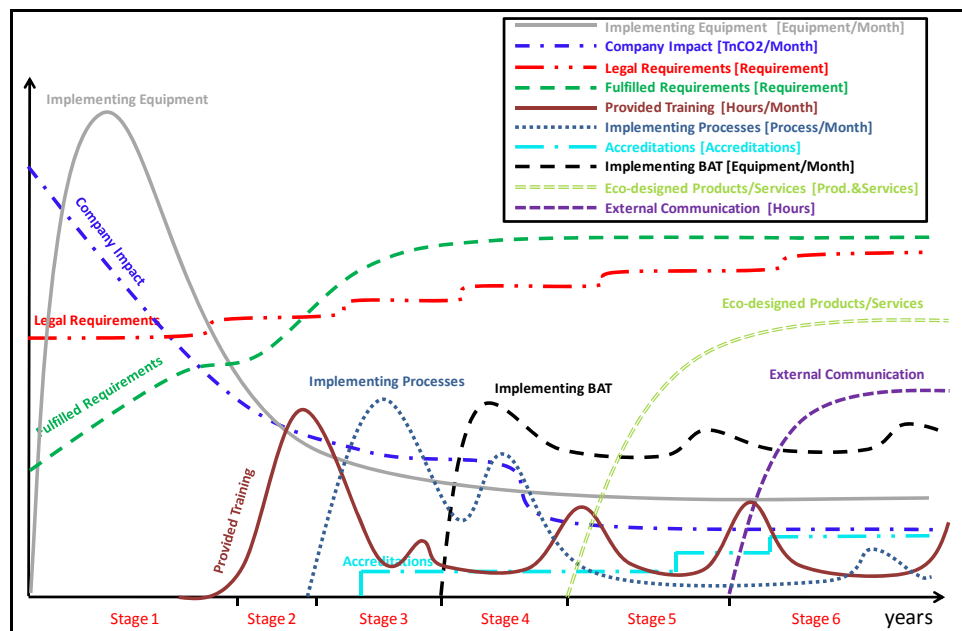


Figure 6. Indicators BOT

4.3.5 Summary of Main Results

All the results obtained from the two day workshops were fundamental to develop a first version of the Causal Loop Diagram that represented the structure of the environmental management evolution within companies.

As a consequence, with all the information from the semi-structured interviews among Basque companies and the two day workshops, the first version of the EMM Model was created. In Table 6 it can be observed the different parts of the first version model.

Table 6. Parts of the EMM Model version 1

For each stage
Description
Policies
Indicators
BOT
CLD

Comparing this model with previous environmental models (Hunt and Auster 1990; Borri and Boccaletti 1995; Venselaar 1995; Azzone et al 1997; Berry and Rondinelli 1998; Winn and Angell 2000; Jabbour 2010), it could be highlighted that no previous models has gone deeply into studying the companies' environmental management evolution, identifying some policies, indicators, BOT and CLD to better explain each of the stages that companies should follow towards environmental excellence.

Some of the stages' names were slightly changed to better represent each of the definitions (Figure 7). "Law Fulfillment" was replaced by "Legislation Fulfillment", "Costs Reduction" by "ECO²" to better represent the idea of not only ecological benefits but also economic benefits and "Green Company" by "Leading Green Company" to reinforce the idea of being a reference company in environmental aspects.

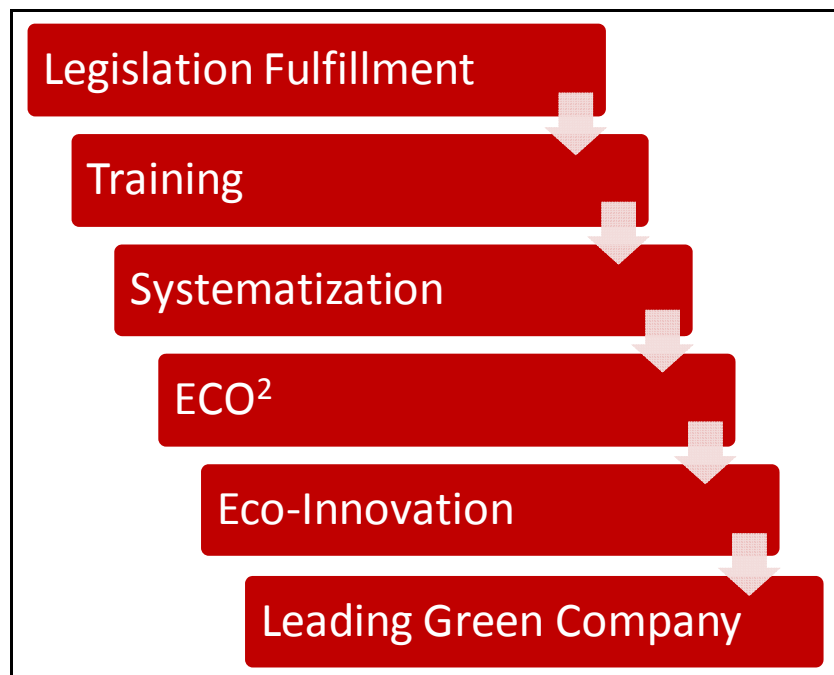


Figure 7. Maturity stages' order in EMM Model v1

4.4 SURVEY IN SPAIN AND ITALY

This first survey was carried out in order to validate the preliminary model about the evolution of environmental management within firms.

Once the questionnaire was developed, a pre-test was done in close cooperation with an experienced environmental consultant. This pre-test led to some minor changes in the questionnaire to increment its clarity. An online-survey was chosen among different ways to administer the questionnaire for avoiding costs, reducing bias and automating data. The survey was conducted among Spanish and Italian companies, since they are the first European countries in terms of the number of ISO 14001 certifications, as mentioned in the **Methodology Chapter**. Therefore, the questionnaire was translated from the original English version into Spanish and Italian, to make the respondents' task easier. Companies

were randomly selected among Export Company Catalogues and through contacts provided by public bodies in charge of encouraging environmental issues in both countries. The questionnaire had to be completed online and the link of the questionnaire was sent to 192 Italian companies and to 396 Spanish companies, a total of 588 companies.

Initiatives for obtaining a higher response rate were made, such as mailing the link of the survey with a letter of introduction. It was also pointed out that a post-survey summary was going to be sent with results and conclusions. All participating companies were assured of anonymity when showing the final results.

4.4.1 Survey Content

The survey had 27 questions and it was structured in four main sections (Appendix 2).

The first section discussed the order of the maturity stages proposed in the conceptual evolutionary model. The different maturity stages were defined and arranged alphabetically to avoid influencing respondents with a suggested order. Afterwards, respondents were asked to put the different maturity stages in order, starting from the first one that chronologically appears in the evolution to the last one (Figure 8). The respondents were allowed to add some missing maturity stages, and also to consider some of them parallel in the ranking and delete those that they thought redundant, with the “no” option.

	no	1	2	3	4	5	6	7	8	9
ECO2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eco-Innovation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Leading Green Company	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation Fulfillment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Systematization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Your added Stage 1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Your added Stage 2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Your added Stage 3	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 8. Maturity stages alphabetically arranged

The second section identified the different factors that take part in each of the previous maturity stages. The factors that researchers had previously identified were defined and arranged alphabetically so as not to influence the respondents. Respondents were asked to analyze each maturity stage, indicating the importance, in each of the stages, of the ten different factors. They were also allowed to add some other factors that they considered relevant. In this case, a Likert scale from *Very Low* importance to *Very High* was used. There was also another possibility *No influence*, if they thought that one factor did not have any influence in one of the maturity stages. Consequently, the scale became 1='No influence', 2='Very Low', 3='Low', 4='High' and 5='Very High'. So in spite of being an odd number of possible judgments, it could be considered a Likert scale without a Midpoint, keeping the characteristic of forcing judgments with a polarity (Garland 1991). The results of this part did not provide direct input to the EMM Model and they have been presented in Appendix 2.

The third part was to know if companies could position themselves in one of the mentioned maturity stages.

And the final section consisted of general questions about the company, to characterize the responses.

4.4.2 Response Characterization

Of a total of 588 companies, the link of the questionnaire was opened by 325 firms and answered by 129 of them. As 59 questionnaires were significantly incomplete they were deleted, obtaining a final sample of 70 firms, 29 Italian and 41 Spanish. So the global response rate yielded was 12%. The response rate is connected to the scale of the survey, varying from 10 to 50% in large studies (Nawrocka and Parker 2009).

The majority of survey respondents were exclusively environmental managers (45%), followed by those who were in charge of other tasks (30%) and Chief Executive Officers (25%). Company profile information in terms of company size and market size is presented in Table 7 and Table 8.

Table 7. Firms' size by the number of workers

Number of workers	Number of responses	Percentage
0-10	9	13%
11-50	25	36%
51-250	22	31%
>250	14	20%
Total	70	100%

Table 8. Firms' declared market size

Market size	Number of responses	Percentage
Regional	9	13%
National	25	36%
International	36	51%
Total	70	100%

Most of the companies had between 11 and 50 workers (36% of the respondents) followed by those companies with 51 to 250 workers (31%). Regarding the market, 51% of the firms operated in the international market followed by 36 % that operated in the national one.

It has to be taken into account that this sample does not exactly represent the population as there are much more small enterprises than big companies in Spain and Italy. Nevertheless, it should be taken into account that the sample we are analyzing has not been randomly selected but it has been constituted by all the answers we obtained. With regard to the obtained sample, it represents the fact that it is more common that big companies have their environmental management implemented in their companies (Tilley 2000) and can tell something about the path they have already followed.

4.4.3 Results

The main objective of the questionnaire was to describe the evolution of the environmental management defined by the temporal classification of maturity stages previously identified.

Only a few firms made some proposals for other stages, though all of the proposed stages were defined implicitly in the original maturity stages. As an example of this, one of the firms proposed the stage called “Reached Environmental Certification”, however, the environmental certification was part of the Systematization stage. Consequently, these new proposed maturity stages were not included in the evolutionary model.

In Table 9, the results of this part of the questionnaire are displayed. The different maturity stages were ordered over time according to the opinion of the respondents.

Table 9. Maturity stages' order

Maturity Stage	Position						Response rate
	1	2	3	4	5	6	
Legislation Fulfillment	80%	14%	6%	0%	0%	0%	100%
Training	26%	36%	28%	4%	2%	0%	96%
Systematization	6%	10%	46%	28%	4%	6%	100%
ECO ²	8%	24%	30%	34%	0%	2%	98%
Eco-Innovation	0%	0%	6%	18%	66%	10%	100%
Leading Green Company	0%	0%	0%	4%	20%	76%	100%

As Table 9 indicates in the Response rate column, there were some firms that did not position all the maturity stages. 4% of the companies did not indicate when training appears in the evolution of environmental management within a company. In the same way, 2% of the companies did not position the ECO² stage.

As a result of the analysis of this question, the order of the maturity stages defined previously by the research group could be confirmed (Figure 7). Legislation Fulfillment was the lowest stage, with an agreement of 80% of the respondents. Training became the second stage (36%). Systematization was elected as the third stage (46%). The last stages were ECO² (34%), Eco-Innovation (66%) and Leading Green Company (76%).

Some of the answers were really clear while others were a bit more confusing. In the Training stage, 36% agreed that this should be the second stage. Nevertheless, 26% of the respondents stated that this stage should be the first one and 28% stated that it should be in the third place. On the other hand, the respondents did not completely agree with the order of the ECO² stage. 30% of the answers pointed the third position while 34% pointed the fourth position. These two stages needed further study. As future methods were going to be used to improve and complete the model, these stages were going to be studied.

4.4.4 Summary of Main Results

As our survey confirms there is a similar evolution in the environmental management within companies. As it has been explained, the order of the stages is really clear in some of the stages and not so clear in the case of the Training stage and the ECO² stage.

The names of some of the proposed six maturity stages have been slightly changed as well as the description after this survey to better explain the environmental management evolution (Figure 9).

The results of the survey indicated that companies did not completely agreed on the order of the Training and this might be because the name and meaning of the stages were not the appropriate ones. Consequently, Legislation Fulfillment has been replaced by Legal Requirements. In this “new” stage, companies identify the applicable requirements and implement end-of-pipe solutions to start diminishing their impacts. On the other hand, Training has been replaced by Responsibility Assignment and Training; meaning that in this second stage, companies should assign responsibilities to carry out corresponding environmental measures as well as give technical training on the equipment implemented in the previous stage. In this way after this second stage, legislation would be fulfilled.

The other name that has been changed is the Eco-Innovation which has been replaced by Eco- Innovative Products and Services. The main purpose of this change is to clarify that in this stage companies start to focus on their products and services but not so much in their processes, as they have been improving their processes since the Systematization stage.



Figure 9. Maturity stages' order in EMM Model v2

Consequently, as it has been observed in the results section, firms tend to start with the implementation of environmental management in their company due to legal requirements. Consequently, the new environmental equipment and procedures, that the company has to implement to fulfill the law, need to be taught to the employees. When the environmental measures are completely implemented in the organizations' activities, firms go through the systematization stage. Thanks to the process efficiency, not only do the environmental aspects become visible but also economic issues. The companies that want to go further decide to innovate with products and services where the environmental aspect is central. The last stage to reach is to be recognized as a green company and to be a reference for other companies.

4.5 SURVEY AND SEMI-STRUCTURED INTERVIEWS IN THE UK

4.5.1 Introduction

As it has been previously mentioned in the **Methodology Chapter**, the objective of this part of the research was to explore how proactive companies have moved forward in the UK and to identify the different steps that they have followed to reach each of the maturity stages sketched out in the model. The research design mainly focused on proactive companies because these can be expected to have passed through the majority of the six maturity stages and could provide more information. The main purpose was to confirm and complete the identified policies and indicators in the workshops as well as some tools that can help companies in each of the stages.

Consequently, this study aimed to explore the environmental management evolution within proactive companies in the UK. First of all, an online survey was accomplished to ascertain whether UK corporate representatives agree with the conceptual model previously presented and to identify the most proactive companies that were willing to provide detailed information about their organization. After the survey, a sample of proactive companies was identified based on the online survey and semi-structured interviews were carried out to identify the milestones for each of the maturity stages.

4.5.2 Online Survey

The survey was structured in two main sections (**Appendix 3**). The first one was focused on the companies' environmental management evolution. Respondents were presented with the second version of the EMM Model, and were asked whether they agreed with the order of maturity stages. This was followed by a free-text field to give respondents the opportunity to provide comments on the evolutionary model, especially if they did not agree. The next questions were to identify in which of the stages they saw their company at that

moment, whether their company had passed through all the previous stages until reaching the present stage and about the importance of several factors during their environmental management evolution. The second section of the survey consisted of general questions about the company, to characterize the responses.

Once the questionnaire was developed, a pilot was carried out with a number of academics and corporate practitioners in the field. This pre-test led to some minor changes in the questionnaire in order to improve its clarity. An online-survey was chosen among different ways to administer the questionnaire as it is cost-efficient, reduces bias and lends itself to the automatization of data (Forza 2009). The survey was conducted among companies in the UK that were randomly selected among LinkedIn environmental groups. As the main objective was to focus on proactive companies, it was considered that most of these companies would be part of innovative social networks such as LinkedIn environmental groups, being aware that this may lead to a response bias. The questionnaire had to be completed online and the link of the questionnaire was sent to 273 corporate practitioners, obtaining a total of 55 answers that corresponds to a response rate of 20.2%.

Initiatives for obtaining a higher response rate were made, such as mailing the link of the survey with a letter of introduction explaining who the researchers were and the purpose of the research project. An e-mail contact was also given if anyone required more information. It was also pointed out that a post-survey summary was going to be sent with results and conclusions. Furthermore, all participating companies were assured of anonymity when showing the final results.

4.5.3 Semi-Structured Interviews

Once the UK survey was conducted, the answers were analyzed to identify the proactive companies that volunteered to collaborate in further research. One of the general questions of the survey was related to future collaboration in this topic. Only 38 companies answered to this question, with a total of 24 willing to

collaborate. Out of those 24 companies, 17 companies positioned themselves in the last three stages of the model, so they were contacted for collaboration.

A total of seven semi-structured interviews were conducted with respondents of self-declared proactive companies in August and September 2012, with most lasting about an hour. Six interviews were face-to-face while only one was done by phone. The qualitative interview is the most common and one of the most important data gathering tools in qualitative research (Myers and Newman 2007). It enabled in-depth insights into the views of corporate representatives (Patton 2001), and allowed to gain thick, contextual information regarding the way in which the companies within the sample progressed through the different maturity stages. Sample selection followed the rationale of a multi-case study design, i.e. the aim was to create a diverse sample with regard to company size, sector affiliation, customer base and position in the value chain. This allowed us to identify trends and patterns across the sample in terms of how different types of organizations progressed.

Questions were open ended to allow deeper exploration of issues and to allow respondents own experiences to emerge freely (Appleton 1995; Aira et al 2003; Ingram 2008). Another advantage of this qualitative method is the control over the interview process when questions which may be misunderstood can be clarified by the interviewer (Appleton 1995). A loose interview structure was designed (Appendix 4) on the basis of key aspects identified from the literature review as well as the survey to assist with interviewing (Gordon et al 2012). All interviews were tape-recorded and then transcribed for analysis. The researchers also made field notes after each interview highlighting aspects of key significance. The use of audio tapes ensured identical replication of the interviews which facilitated the subsequent analysis reducing the error of collecting data incorrectly (Louise Barriball and While 2006).

The interviews started with several questions about the interviewee's background. Afterwards, the evolutionary model was presented as well as the description of each of the maturity stages. Consequently, all interviewees were

asked to describe some milestones that the company has followed to reach each of the stages.

4.5.4 Results

Out of the 55 companies that answered the survey, 78% of the respondents agreed with the order proposed in the maturity model. Four of these companies mentioned that this order is the one that companies ought to follow, but that they experienced a different progression path (typically leaving out one or more specific stages) within their own companies. On the other hand, 22% of the companies disagreed. All these data are presented in Table 10. Most of the companies that did not agree with the order, did not comment the reason for the disagreement. However, those respondents that provided some comments revealed that their organizations tended to multi-track some of the stages, i.e. to simultaneously pass through different maturity stages. For example, one respondent stated that “Stage 4 [i.e. process efficiency and cost savings] can come at any stage if staff is smart”. Furthermore, several respondents pointed out that even though it is possible to realize some economic and environmental benefits without having their environmental management systematized, these efforts then typically tend to be ad-hoc in nature. In other words, the systematization stage forms an important threshold; without passing through this stage, companies are unlikely to make any significant further improvements in terms of their environmental management evolution. Consequently, the order that should be followed is the one that the model considers. Moreover, these situations of companies that do not follow this proposed order are further studied with the comments obtained in the case studies

To identify proactive companies within the initial sample, respondents were asked to position their companies in one of the maturity stages. Almost 50 % of the companies positioned themselves in one of the two most advanced stages (Table 10). It can be seen that a clear majority of respondents agreed with the order and content of maturity stages irrespective of the stage they perceived their company to be in.

Table 10. Companies' position

	Total number of companies	Agree with the order	Disagree with the order
Legal Requirements	7	7	0
Responsibility Assignment and Training	3	2	1
Systematization	8	6	2
ECO ²	10	7	3
Eco-Innovation	14	11	3
Leading Green Company	13	10	3
Total	55 (100 %)	43 (78%)	12 (22%)

We followed up with corporate representatives who had classified their companies in one of the three last stages, and therefore could be expected to be relatively advanced with regard to their environmental management efforts. Table II provides information on the seven companies that were approached for semi-structured interviews.

Table II. Classification of the interviewed companies

Company	Sector	Market	Size	Maturity Stage
1	Food and drink manufacture	Globe	>250	6
2	Office products	UK and Northern Ireland	51-250	6
3	Plastic stationary products	UK	51-250	6
4	ICT	Globe	>250	6
5	ICT	UK	0-50	5
6	Building	England	>250	6
7	Engineering, ICT	UK	>250	4

Each representative of the above companies talked about the evolution that his or her own company has followed in environmental management presenting specific milestones. Focusing on the respondents' comments, what follows is a more detailed description of the specific actions occurring within the six different maturity stages.

Legal Requirements

Several respondents agreed that environmental legislation formed the basis of their environmental management efforts. For example, the building company respondent (company 6) stated that "image is a big part in construction; nobody wants to be the company that has been prosecuted". At this stage companies "identify applicable laws" and do "an assessment of the current situation" so they

could know which measures to take if they want to adhere to all relevant regulations.

For all companies within the sample, compliance was stated to be a significant and time-consuming challenge, and appeared to be a key driver for their initial environmental management engagement.

Responsibility Assignment and Training

As it was described in the evolutionary conceptual model section, the main objective of this stage is to name an environmental management responsible that will manage the equipment previously implemented, assigning the necessary responsibilities and giving the necessary training to workers. This will lead to the fulfillment of all legal requirements, or depending on the sector of most of the legal requirements.

The food and drink manufacturer (company 1) mentioned that one of the first actions of the company's newly appointed Environmental Management Director was to assign responsibilities and to identify training needs of all employees in the context of compliance. As one of the ICT company's respondents (company 4) stated, training should "allow people to do their job" and should enable them to be aware of all relevant legislation affecting their everyday activities, and – as far as possible – to anticipate any relevant future regulations in their specific area.

In the first company, the food and drink manufacturer, there were so many problem areas at the beginning that it was a case of identifying what were the easy ones to achieve, what they could do straight away. So, for instance, in the aforementioned company "people who were actually working around the factory needed to do some form of 'emergency spill response' training, whereas that probably wouldn't have been appropriate for people based in the office".

Some of the training tools that environmental managers of these companies use and that might be useful for other companies are power point presentations, new starter inductions, environmental DVDs, e-learning modules, information sharing

in team briefs as well as more informal communication sessions. The plastic stationary products company respondent (company 3) emphasized that as they are a “small” business, they do not have any formalized training programs; however, the respondent stressed that the company has created a culture in which employees are expected to learn things on their own, through the internet or through their internal and external networks.

Systematization

The vast majority of the companies developed the management system with a view to achieving ISO 14001 certification. Nevertheless, some of the respondents pointed out that a more informal management system had already been in place before the company aimed for formal accreditation. Only when customers started asking for environmental credentials, these companies decided to get formal accreditation. Irrespective of formal accreditation, the systematization of environmental management and the development of an environmental management system form the focal point of their activities in this context: “an EMS is a fundamental; it is the basics of what you need to be doing” (company 4).

As the construction and engineering companies mentioned (companies 9 and 10), companies should integrate all relevant aspects into the same process and organizational structure, and employ key performance indicators (KPI). And as it is the case of all the interviewees, companies might progress towards ISO 14001 accreditation.

ECO²

In this stage, companies pointed out the importance of encouraging people to start focusing on resource efficiencies, for example with regard to “quantities of water that are being used and waste production” (company 1). Moreover, all respondents stated that in this stage more general training activities focusing on a number of overarching topics are provided for all employees, in order to create a more general sense of awareness of the companies’ activities in this context.

Consequently, companies started to implement easily achievable energy saving measures, e.g. getting employees involved in “switching the PC off at night, turning the lights off at night” (company 2). The food and drink manufacturer pointed out that the kilns in the factory were being indirectly heated using hot water boilers. In the meantime, these activities have in some cases led to significant investments in order to progress further in terms of resource efficiency. In the case of the food and drink manufacturer, a direct firing system has been acquired, which represents a best available technique (BAT) and is far more efficient than the previous heating system. The project cost them about £1.1 million and the payback turned out to be less than nine weeks. The office products company (company 2) replaced the lighting with ambient light detection and presence detection, which in turn resulted in £20,000 electricity savings. Other companies, such as the plastic stationary products company (company 3) made some clear savings selling waste products and reducing utility bills as well.

As one of the respondents pointed out, the fact that the company started to actively measure and manage its resource use in this stage brought about almost immediate improvements (company 7).

One respondent emphasized that the systematization stage forms a necessary condition for further improvements of corporate environmental management, and thus for reaching the ECO² stage. He remarked that “the situation is a bit like saying you are going to run a business without accounts, well you can make lots of money doing it, you might have a good nose for it, but ultimately if you can look at financial statements and look at management accounting you will probably do a better job” (company 7). Whilst companies may engage in environmental activities that come along with economic benefits, these activities tend to be ad-hoc and part of a piece-meal approach without a preceding formalization and systematization of environmental management activities.

Eco-Innovative Products and Services

Manufacturing company respondents mentioned a range of product innovations their companies had introduced. No set pattern emerged with regard to the way in which these innovations emerged; however, several respondents pointed towards general awareness of environmental issues among the workforce as crucial prerequisites for various types of product innovation. In other words, the fact that these companies passed through the preceding environmental management stages put them into the position to actively search for new types of eco-innovation.

One of the appropriate tools for this stage is the life cycle assessment tool to develop eco-innovative products. For example, one of the ICT company respondents said that every product “needs, and it is mandatory, to go through a design for environmental process”. This process consists of analyzing the life cycle of the products from an environmental perspective, with a primary focus on reducing energy consumption throughout the product life cycle.

One of the green innovations that the respondent of company 1 mentioned was the introduction of a new ingredient that permitted to reduce the baking time in commercial buns by a couple of minutes, resulting in significant energy savings for its customers.

Leading Green Company

The clear majority of the companies that responded to have reached this stage have gained recognition for their environmental management activities in different competitions such as the “Sunday Times” best green companies award, the “Green manufacturer of the Year” award or the “Business in the Community” award. Entering some of these competitions was linked to significant amounts of effort and paper work required for the application process as well as audits linked to the awards. Another important milestone indicating external recognition as leading green company was that some of these companies received significant amounts of

media coverage. Likewise, a number of respondents perceived the publication of environmental reports as indicative of their companies having reached this stage. In contrast, those respondents who saw their own companies being positioned in stage 4 or 5 did not report any external communication.

In **Table 12** an overview of milestones identified by the interviewees is presented. The overview shows that a number of milestones appear to form central parts of environmental management evolution within our sample. Most notably, this refers to activities to ensure compliance with relevant regulation, the development of an environmental management system and the realization of initial efficiency-gains linked to energy use, waste generation or water use. In addition, six out of the seven companies reported specific product innovations resulting in sometimes significant environmental performance improvements. Furthermore, all respondents who saw their company having reached the 'Leading Green Company' stage associated this with specific environmental management awards their companies had been presented.

Table 12. Summary of the milestones identified in the interviews

Stage	Comments	Companies
1	Assessment of current situation.	1, 6
	Identify applicable laws and any relevant future legislation.	1, 5, 6, 7
	Primacy of legislation. Establishing general sense of obligation to society.	2, 3, 4
2	Identify training needs. Train according to responsibilities.	1, 4, 5
	Start with the easy problems.	1
	Power Point, DVDs, Talking, E-learning modules...	6
	Induction provided for new starters.	6
	Choose a legal compliance system.	2
	Team briefs, communication sessions.	3, 7
3	Develop an EMS. Systematize all aspects of operations.	1, 2, 3
	Certify with ISO 14001.	1, 2, 5, 6
	Understand the objectives, the vision and the policy.	4
	Measure and understand firm performance in relation to objectives. Focus on KPIs.	4, 6
	More holistic perspective. Development of organization-wide processes, increasing systems perspective.	6, 7
4	Encourage people.	1, 3
	Replace lights. Presence detection. Use more natural light.	2, 4, 5
	Use low energy light bulbs.	
	Measure.	2

	Reduce utility bills, energy costs, waste production, water consumption...	3, 4, 6, 7
5	Change a component/material of the product that makes it greener. Design from an environmental perspective. Life cycle assessment.	1, 2, 3, 4, 5, 6
	Identification of best practice within sector or other industries.	3
6	Aiming for/ applying for/ winning sustainability/ environmental management related awards.	1, 2, 3, 4, 6
	Press coverage linked to environmental management activities	1
	Environmental reporting.	3

4.5.5 Summary of Main Results

Respondents perceived the model as a logical sequence of maturity stages and confirmed that their companies progressed along these lines. The responses also revealed that each of the maturity stages is associated with a number of milestones, i.e. key policies that at least several of the companies undertook as part of progressing through the different maturity stages. Consequently, this model provides useful guidance for those companies that aim to further develop their environmental management efforts and strive towards environmental management excellence.

It is important to point out that the order of maturity stages was confirmed as crucial by companies within the sample. For example, whilst companies might arguably be able to achieve certain efficiency gains or even process or product innovations without any prior training or systematization, respondents highlighted that these improvements then tend to be anecdotal and incremental in nature rather than forming part of a more holistic, well-managed improvement path.

One of the common characteristics of the most proactive and advanced companies was the commitment and involvement of top management. All of these companies pointed out that senior management was pivotal for these companies' continued engagement in environmental management, again confirming previous studies in this context (Hunt and Auster 1990; Banerjee et al 2003).

In summary, the responses may therefore help to confirm the order of the stages and complete the previously identified policies and indicators as well as the identification of some appropriate tools for each of the stages, obtaining the third and last version of the model. It should be pointed out that in this last model the boundaries have been delimited. The model has been focused on the internal aspects, on what the company should do to improve its environmental impacts, regardless of the customers or society demand. The only external aspect that has been considered is the legislation as all companies the first thing they should do regarding environmental management is fulfilling the law.

4.6 CONCLUSION

The model has been developed and improved with each of the methods that have been carried out until obtaining the last version of the EMM Model that is presented in Chapter 5 (Figure 10). The methods used have been quite different and have been applied in different countries to get a diverse sample.

Despite there are several companies under the study that have not exactly followed this path, they agree that this is the most efficient way of reaching the environmental excellence.

Method	Results	Model Version
Semi-Structured Interviews among Basque companies (19)	<ul style="list-style-type: none"> • Factors. • Confirm that companies are at different maturity levels. 	EMM. v1
2 GMB Workshops (6)	<ul style="list-style-type: none"> • Stakeholders. • Policies. • Indicators. • Initial CLD. • Maturity Levels. • BOT. 	
Survey Spain/Italy (41+29)	<ul style="list-style-type: none"> • Factors Validation. • Maturity Levels validation – update names. • Improve CLD. 	EMM. v2
Survey and Semi-Structured Interviews among UK companies (55+7)	<ul style="list-style-type: none"> • Specific milestones. • Policies extension. • Indicators extension. • Possible tools for each level. 	EMM. v3 – FINAL MODEL

Figure 10. Iterative model improvement process and corresponding results

EMM MODEL. FINAL VERSION

5

This research explains that the environmental management evolution is quite similar among companies. The previous chapter has presented how the environmental management maturity model (EMM Model) has been developed. Consequently, this chapter presents the model that explains how this evolution happens and why it happens. At first the whole EMM Model is explained which is divided into six maturity stages: Legal Requirements, Responsibility Assignment and Training, Systematization, ECO², Eco-Innovative Products and Services and Leading Green Company. Afterwards, for each of these stages the objective, the agents involved, the policies, the indicators, the Causal Loop Diagrams (CLDs) and the Behavior Over Time (BOT) graphs are explained.

5.1 EMM MODEL

The EMM Model defines a sequence of six maturity stages companies pass through from their initial efforts in environmental management towards the achievement of environmental excellence. Since the first semi-structured interviews that were accomplished among Basque companies, six maturity stages were defined. The names of the stages have slightly changed over the research as it has been explained in **Chapter 4** until concluding that the suitable names for the maturity stages are: Legal Requirements, Responsibility Assignment and Training, Systematization, ECO², Eco-Innovative Products and Services and Leading Green Company.

The order of the maturity stages has also been confirmed through the fact that the surveys and the semi-structured interviews demonstrated that passing through the initial stages of the model could be seen as necessary preconditions for the ability to reach later stages such as “ECO²” or “Eco-Innovative Products and Services”. The time that a company might spend in the six stages until it reaches environmental excellence might vary depending on the sector and resources among other reasons.

It should be highlighted that the EMM Model has been developed for industrial companies, as all this research has been focused on this type of companies. If a company has more than one plant or more than one strategic business unit (SBU), this model should be applied in parallel to each of the SBUs, as each SBU or each plant can be in a different maturity stage.

Each stage represents a generic characterization and could be applied to any industrial company. The specific requirements for any particular company will vary according to the size of the company, the type of business, etc. It should be highlighted that when the company progresses to the next stage, it does not mean that it has to forget about previous stages, but that it should at least maintain what it had already achieved.

For each of these stages, the EMM Model presents:

- **Description.** The model presents a description of what the objective of each of the stages is, so the companies could have clear where to focus on.
- **Agents involved.** The progression of the involvement of the agents in the company is fundamental. Consequently, we have given importance to present the agents that should be involved in each of the stages.
- **Policies.** The actions that companies should take to complete each of the stages have been exposed, so companies could know exactly what steps they should take to reach the objective of the stage.
- **Tools.** Some tools have been presented to help companies during the progression through each of the stages. Some of the tools might be general for diverse topics, while some others are environmental tools for specific stages.
- **Indicators.** When the company implements a policy, it is fundamental to have some indicators so it can measure the way is progressing. Consequently, a list of indicators has been presented.
- **Causal Loop Diagram (CLD).** To better understand how a company's environmental management evolves, the structure of the evolution of each of the stages has been represented with Causal Loop Diagrams (CLDs), so the cause-effect of the main factors that take place in each of the stages can be appreciated. Consequently, companies may realize how important is to introduce some factors in the environmental management, and how these factors may affect others. The policies and indicators previously mentioned help to go through the different loops.

- **Behavior Over Time (BOT) graphs.** The representation of some of the indicators through graphs it is a good way to show companies how some indicators may evolve through the different maturity stages if companies follow the proposed policies in this model. Not all the indicators appear in the BOT, as not all of them add value as it has been mentioned in the previous chapter. This representation was done during the Group Model Building (GMB) workshops with the environmental experts.

The whole EMM Model is presented in **Appendix 5**. The following is a more detailed explanation of each of the parts of the model for each of the stages.

5.2 STAGE 1. LEGAL REQUIREMENTS

5.2.1 Description

The first thing that a company should do is to understand exactly what the legal requirements that it should fulfill are. It is fundamental to identify the laws that the company is breaking or in danger of breaking.

As most of the firms, which collaborate in this research, did regarding environmental legislation, a company should first do an assessment of where it actually is. It needs to establish what legal requirements are being fulfilled in the company, what legal requirements are not being fulfilled and hence, what the gaps are. Moreover, companies have to make sure that they are aware of any coming legislation for their businesses; they need to have the latest information and know what they need to be complying with.

Regarding the measures that companies implement to fulfill the law, they start with end-of-pipe solutions what derives many times in new equipment investments to prevent companies' excessive impacts.

5.2.2 Agents Involved

In this first stage there should be one person in charge of all the legal aspects that apply to the company. This person might be in charge of all the new environmental laws that appear and are applicable to the company. It is important to highlight again that the EMM Model is valid for each SBUs in each plant of the company. So when we are referring to a “company” in the dissertation, we are focusing on each SBU in each plant.

5.2.3 Policies

The different policies or actions that each company needs to take into account in this stage are the following ones:

- **Identify legal requirements.** Companies in this stage need to identify legal requirements, whether international, national, state, province, departmental or local. They need to make sure that they have access to all the applicable environmental requirements. Moreover, all companies need to have the activity license to work legally. In the Basque Country, the application of activity licenses is regulated by Law 3/98 General of Environmental Protection and at the state level is regulated by the Decree 2414/1961. The objective of the activity license is to verify that the conditions of the company are the proper ones to protect the environment. These environmental legal requirements are related to the following aspects⁷:
 - Waste. Hazardous waste, used oils, inert industrial waste, waste similar to urban waste and packages should be controlled within the company. For all this type of waste,

⁷ The classification of the environmental aspects has been based on a guide from Ihobe for Basque companies. *Manual Práctico de Tramitaciones Administrativas Ambientales para la Industria Vasca*: <http://www.ihobe.net/Publicaciones>

there are some limits that each company, depending on the sector and the situation of the company, has to fulfill.

- Atmospheric emissions. Companies need also to look at the atmospheric emissions requirements. Any industrial company can generate pollutant emissions to the atmosphere. If any of these emissions is generated from an emitting source with duration of more than 5% of the working day, the corresponding emitting source will be considered as potentially polluter and will need to fulfill some legal requirements.
 - Discharge of waste water. Any type of action that involves a damaging alteration in the water quality needs administrative approval.
 - Chemical and fuel storage. Among the legal requirements that need to fulfill this type of storage, there are some that are administrative procedures, others are technical obligations and others are revisions and inspections that need to be done periodically.
- **Estimate legal environmental aspects.** Once all the legal environmental requirements have been identified, it is necessary to estimate whether the company is fulfilling the laws.
 - **Implement end-of-pipe actions.** When the environmental aspects have been estimated in the company, it is necessary to implement some end-of-pipe actions. This will result in equipment investment in most companies. One of the studied companies stated that at the beginning of its environmental management, they invested in filters in the oven to manage atmospheric emissions as this was the main emission point in the plant.

- **Document and identify the level of compliance.** After the end-of-pipe actions have been implemented it is necessary to identify the level of compliance and document it. It is essential to know if more equipment is necessary to fulfill some legal environmental requirements.

5.2.4 Indicators

There are several indicators that can measure the evolution of the environmental improvement in this stage. Investment in end-of-pipe equipment measured in the country's currency indicates that the company is acting positively to legislation requirements. Another indicator is the environmental requirements, to know how demanding the legislation for each company over time is. Each of these environmental requirements might have a different unit of measure. The environmental impact of the company should also be measured according to the unit of measure appearing in the requirements. As a last indicator the level of compliance could be measured comparing the requirements with the current impacts of the company regarding those requirements.

In the following table the indicators with the possible measures for each of them are presented (Table 13).

Table 13. Some Legal Requirements indicators

Indicator	Measure
Investment in end-of-pipe equipment	- (€/ turnover)
Environmental Requirements	<ul style="list-style-type: none"> - Amount of greenhouse gasses emissions permitted. - Total amount of waste generation permitted. - Total amount of water drainage permitted. - Amount of permitted emissions of other substances under regulations.
Environmental Impact	- Measure the above mentioned requirements within the company.
Level of Compliance	<ul style="list-style-type: none"> - Number of violations. - Amount of fines.

5.2.5 Tools

There are several tools that may help to achieve this stage. There are different legislative self-assessment tools that can help companies to evaluate their level of compliance. The different laws applicable to each company may help the company to know exactly what the legislation is requiring. There are also measure systems that may help to measure the different impacts that the company is generating regarding the legal aspects. The decision to choose a measurement system will depend on the type of pollutant that the company wants to analyze among other factors.

Many organizations offer help in the identification of environmental aspects, e.g. Ihobe, an environmental management public company in the Basque Country. Other companies offer their help through software that may notify the company

when new applicable environmental requirements come out. Another thing that companies could do is to hire waste managers so all the waste in the company is managed and the legal requirements with regard to these aspects could be fulfilled. One of the most common tools is the technological equipment as technology could help companies to reduce environmental impacts.

5.2.6 CLD

In this first stage the behavior is quite simple and hence, it can be explained with a structure of a single loop (Figure II).

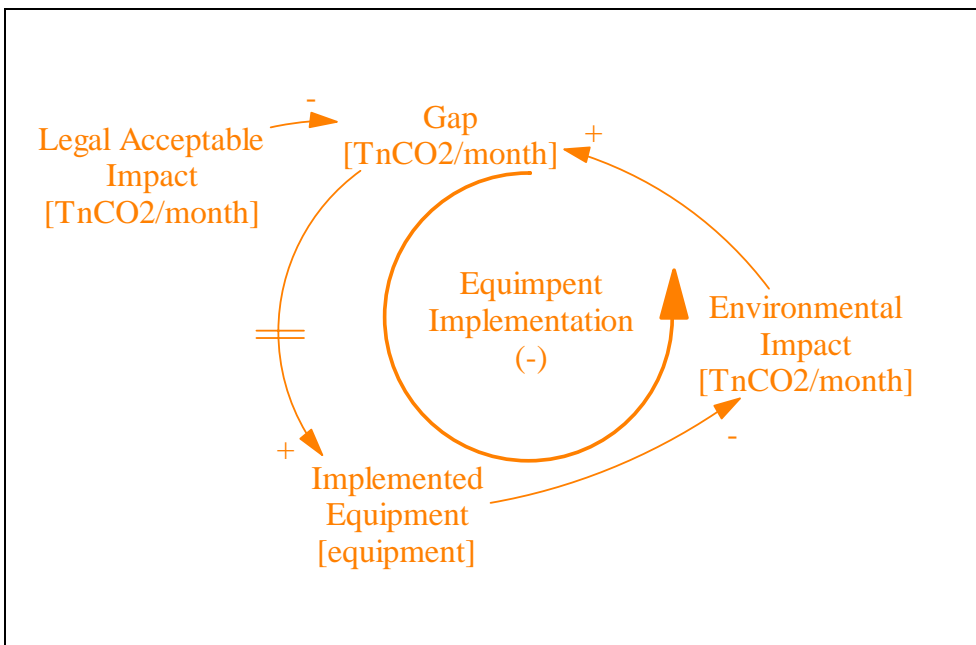


Figure II. CLD of Legal Requirements

The first stage proposes that when legal requirements increase, the *Legal Acceptable Impact* will be lower and consequently, the *Gap* is bigger. In turn, this drives to the implementation of new equipment and hence the *Implemented Equipment* increases. This will lead to a reduction of *Environmental Impact* what will

make the *Gap* becomes lower. As a consequence, at this early stage, a balancing loop, called *Equipment Implementation*, is activated. As it could be observed, the variables related to the impact are measured with tones of CO₂ per month, to cover in a general way de impact produced by the company (Wiedmann and Minx 2007). On the other hand, the *Implemented Equipment* is measured by the amount of equipment that has been implemented within the company.

5.2.7 BOT

Figure 12 shows how the factors that take part in the CLD evolve over the first stage. As it has been previously explained with the balancing loop the company fulfills major legal requirements implementing some end-of-pipe solutions through the investment in equipment. This will lead to a decrease in the company's impact and as a consequence the company will be closer to fulfill the applicable legal requirements and hence, less investment will be needed.

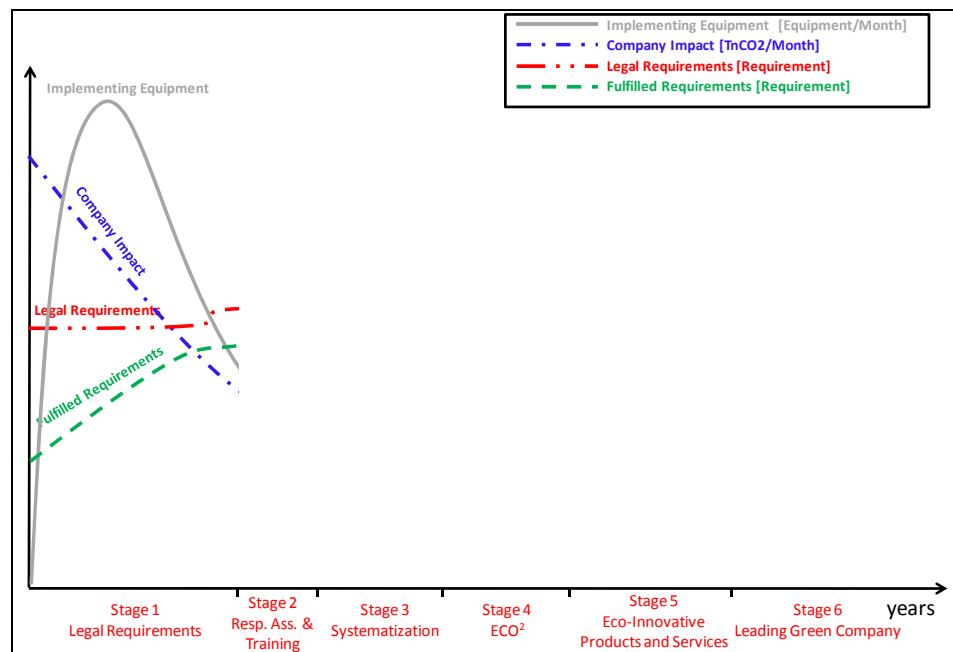


Figure 12. Legal Requirements BOT

Observing the BOT graph it could be seen that the company starts to invest in new equipment to fulfill the legal environmental requirements. These demands might increase over time as well. When the company starts to manage its environmental management, the impact of the company is quite high but it diminishes when the company invests in new equipment. It is further observed that the number of fulfilled requirements starts to grow. The duration of this stage might vary depending on the company. For some companies, this stage might be quite short in time, as they may not have many environmental impacts and they will not need to invest too much in new equipment.

5.3 STAGE 2. RESPONSIBILITY ASSIGNMENT AND TRAINING

5.3.1 Description

Once the applicable law is identified and some end-of-pipe equipment has been introduced, there needs to be an environmental management responsible and consequently some responsibility assignments will take place. As a consequence, some training is needed to teach the workers how the new equipment should be efficiently used.

5.3.2 Agents Involved

With new equipment, and workers that need to be taught, an Environmental Responsible is necessary. Depending on the size of the company it can be an environmental responsible person or an environmental responsible team. In this stage, someone needs to be in charge of the environmental management that takes place in the company. Sometimes, this person might be the same as the quality responsible.

5.3.3 Policies

The different policies that companies should take into account to progress in this stage are the following ones:

- **Name an environmental management responsible.** As it has been said it is necessary to name an environmental management responsible who is going to be in charge of the environmental practices that are being taken in the company.
- **Define a legal adjustment plan.** The environmental management responsible needs to define and document a legal adjustment plan to fulfill all the legal requirements. Consequently, it is necessary to identify the causes of the different environmental impacts caused in the company that could have not been solved with the equipment previously implemented. Once the causes are identified, the company needs to define some actions that should be taken. One example is the waste management in the company as not only equipment is necessary, but also people need to be committed.
- **Assign responsibilities, duties and resources.** For each of the actions it is necessary to assign responsibilities, duties and resources, so the actions could be carried out in the most effective way. Some of the companies stated that it was fundamental to assign responsibilities to guarantee that legal requirements were fulfilled in the different emission points.
- **Provide training.** Before implementing the necessary measures, it is important to train the workers so they have the necessary skills to carry out the environmental measures that are being planned. One of the studied companies confirmed that they had different types of training: one for the people responsible of the technical areas and other more specific for the workers in the factory.

- **Implement actions.** The corresponding measures should be applied to fulfill the law requirements.
- **Check the results.** Once all the actions have been implemented, it is necessary to analyze the results and see whether the results are the expected ones or not.

5.3.4 Indicators

There are several indicators that may help to describe the evolution that the company is achieving within this stage. One indicator measures the hours dedicated to training for environmental issues. These hours could be measured with regard to the total hours of training in the company. Furthermore, it would be significant to have the number of people trained with regard to the total number of workers in the company. Moreover, it could be very useful to look at the environmental tasks/actions assigned to job descriptions compared to the total amount of tasks in the company.

5.3.5 Tools

Different tools might help companies to advance in this stage. There are several basic management tools such as brainstorming, flow chart and fishbone chart that might help companies to identify possible causes of different environmental impacts. For providing training or specific internal communication to the workers notice boards, specific courses or panels for the work place might help.

5.3.6 CLD

As part of the advancement to a more mature stage of environmental management, an environmental manager responsible is needed and workers may be trained in skills to fulfill their environmental responsibilities (Wee and Quazi 2005).

It is worth highlighting that previous loops continue working in the following stages. In the second stage, *Responsibility Assignment and Training*, there are three new variables influencing the behavior: *Technical Training*, *Needed Management Tasks* and *Assigned Management Tasks* (Figure 13).

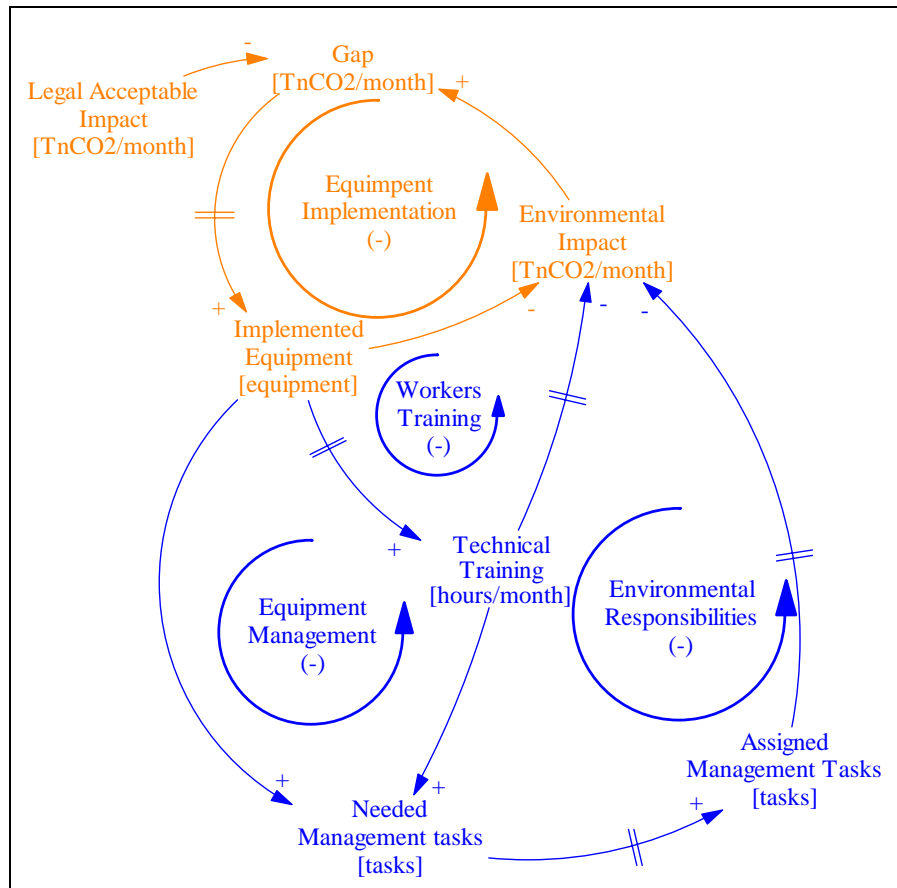


Figure 13. CLD of Responsibility Assignment and Training

It can be observed, that in this second stage, the environmental impact is reduced by four different causes which corresponds to the four balancing loops: the impact is reduced by having more equipment (*Equipment Implementation*), by using better the equipment (*Equipment Management*), by giving training to the

workers (*Workers Training*), and by managing the training and equipment correctly (*Environmental Responsibilities*).

As the number of *Implemented Equipment* increases, *Technical Training* is needed. Workers need to be trained to make the most of the implemented equipment. Due to this training the *Environmental Impact* will decrease as well, obtaining a balancing loop called *Workers Training*. This *Technical Training* is measured in hours per month to reflect the time devoted to environmental training.

The *Technical Training* and the *Implemented Equipment* lead to an increase in the *Needed Management tasks* what will lead to the assignment of some management tasks, what will also lead to a decrease in the *Environmental Impact*.

As a consequence, three balancing loops derive from the introduction of the three variables are being activated: *Workers Training*, *Equipment Management* and *Environmental Responsibilities*.

5.3.7 BOT

Figure 14 shows how the indicators of the first stage and new indicators that appear in the second stage evolve. This behavior derives from the balancing loops of the CLD.

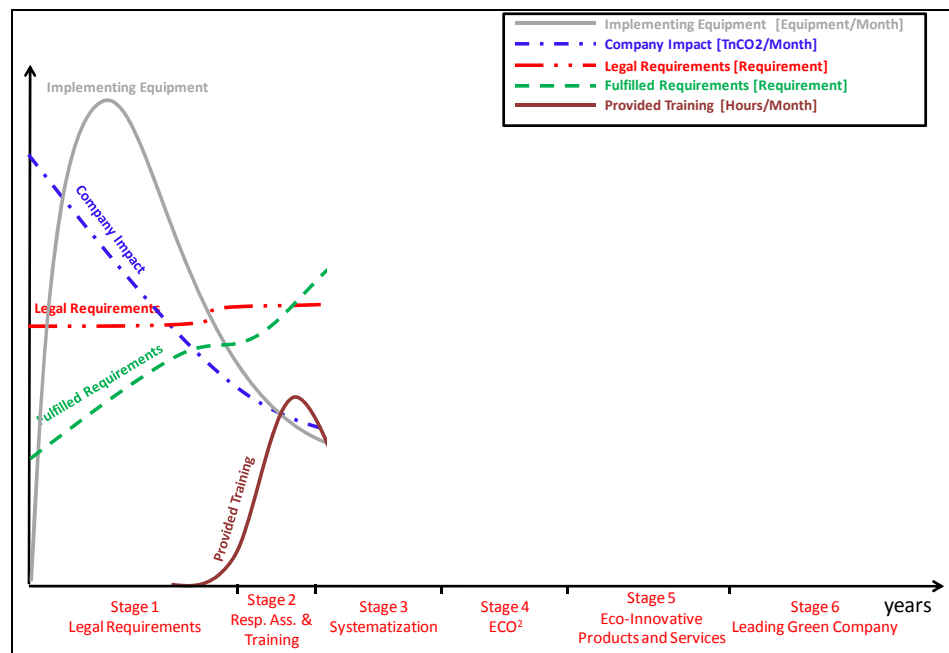


Figure 14. Responsibility Assignment and Training BOT

In this second stage the external demands might increase or remain constant. The end-of-pipe equipment investment decreases as the biggest investment has already been done and the compliance with requirements keep increasing thanks to training provided to workers and to the assignment of an environmental responsible. In this stage the company fulfills with all or most of the legal requirements, this will depend on the sector. Consequently, the company's impact decreases.

5.4 STAGE 3. SYSTEMATIZATION

5.4.1 Description

Once the law is fulfilled and companies are aware of any coming legislation so they can carry out as soon as possible any necessary measures, systematization is needed. Companies should know that to reach the systematization state, they need

to identify what their environmental objectives are, their vision and their strategy. The objectives are related to the different environmental aspects that they want to improve. They need to build a new infrastructure so that allows them to measure and understand, week by week, month by month, how they are performing comparing their objectives.

5.4.2 Agents Involved

In this stage the Top Management begins to engage with environmental issues but not in a proactive way. The person that it is really involved at this stage is the Environmental Manager responsible. He/She takes the responsibility of achieving the environmental formalization in the company.

5.4.3 Policies

What follows is a group of policies or actions that companies may take into account to have their environmental management systematized. These policies have been sustained by the ISO 14001⁸.

- **Document and systematize.** All the environmental steps that are being carried out in the company need to be documented, in this way formalization can start.
- **Environmental Policy.** The company needs to define, document and communicate an environmental policy with the following characteristics:
 - **Define.** The Top Management should define the company's environmental policy. This policy should include the commitment to improve the environmental performance

⁸ ISO standards: www.iso.org

within the company in a continuous improvement way. This statement does not ensure that the company will improve continuously since this moment but that it commits to do several improvements apart from the legislation requirements. There needs to be also a commitment to fulfill the different environmental requirements. Moreover, in this environmental policy should also appear the objectives and goals that the company wants to achieve.

- Document. The policy should be documented, implemented and maintained.
- Communicate. There is also a need to communicate the policy to all the company's workers and make it available to the public.
- **Planning.** Before achieving some improvements there needs to be a planning step where the environmental aspects are prioritized, the necessary resources are estimated and the measurement plan is organized among other steps.
 - Identify environmental aspects. The company has to analyze and identify what are the environmental aspects of its activities, products and services. These aspects might be the use of raw materials and natural resources; the use of energy; the energy emitted, e.g. heat, radiations and vibrations.
 - Identify aspects with significant impacts. Once the environmental aspects have been identified, it is necessary to make a classification of those aspects and determine which ones have or could have significant impacts over the environment. Afterwards it is necessary to define the environmental objectives and goals coherent with the

environmental policy and the resources that are going to be applied.

- **Implementation and operation.** There needs to be a procedure about the different steps that should be followed when implementing a new action in the company.
 - Internal communication procedure. The company should formalize how the internal communication needs to be, and what are the different steps that they need to follow to communicate the different environmental measures that are being taken in the company.
 - Documents control. All the documentation needs to be controlled and updated periodically.
 - Operational control. The company needs to identify and plan those operations related to the significant environmental impacts.
 - Emergency plan. In case of an emergency, the company needs to have a preparation and response plan.
- **Verification.** There also needs to be formalization regarding the control of the implemented measures.
 - Assign responsibilities, duties and resources. Each time there is an action there needs to be responsibilities assignment and it needs to be formalized. It is also necessary to determine the duties that each responsible should have as well as the resources that are going to be assigned.
 - Workers training. Workers need to be trained in environmental aspects. A record of all the training done in the company is required.

- Track and measure. All the operations that could have significant environmental impacts need to be tracked and measured.
 - Identify non-compliances. Once the actions have been tracked and measured, the non-compliances should be identified to take corrective actions and preventive actions not to happen again.
 - Records control. All records carried out in the company need to be legible, identifiable and traceable. They are supposed to be used by the workers in the company.
 - Internal audit. An internal audit to check whether the actions objectives have been fulfilled and the results are satisfactory is needed.
- **Revision.** The Top Management should revise periodically the internal audits' results, the external complaints, the environmental performance, the objectives and goals compliance level, the corrective and preventive actions state, track the resulting actions from previous revisions and look for improvement recommendations.
 - **Formalize future steps.** All the steps that are carried out from now onwards need to be formalized.

5.4.4 Indicators

Several indicators may help to analyze the progression of the improvement in this stage. Hours devoted to environmental management could be a measure expressing the importance of environmental management for the company. This indicator should not be measured in isolation as it has not got sense to compare the hours devoted to environmental management in a small company and in a big company.

Consequently, these hours should be related to the total hours that are being worked in the company. Another useful indicator is to look at the certifications of the company. Some certifications are more demanding than others and one company having EMAS might express that it is quite environmentally friendly. Most of the studied companies had the ISO 14001 certification. The company could also use the indicator of the number of documented and/or certified processes compared to the total number of processes.

5.4.5 Tools

There are different tools that might help companies in this stage. The ones that appear in the model are just some examples of the tools that companies may use in some of the aforementioned policies. Templates are very useful when talking about systematization. Companies should have some templates to carry out the actions, where the corresponding responsibilities, duties and the estimated times should appear. Another important tool might be the process map which describes the flow of activities of a process which might help to make clearer some of the processes that the company should follow. Pareto chart might also be useful to represent the different environmental aspects to afterwards prioritize them. It is represented in descending order by bars, and the cumulative total is represented by a line. Control chart might also be very useful in the verification policy as it helps to graph the behavior of different processes and look whether there are many variations and check if corrections are needed. Some procedures, reports and records are also useful when systematizing. There are also systematization guides that may help companies to follow specific steps to formalize their environmental management. For example, these guides could be found in environmental management system standards. Furthermore, defining basic indicators may help companies to control and check if the expected results are being achieved. More specifically, environmental impact assessment (EIA) and strategic environmental assessment (SEA) could be used in this stage to analyze the environmental impact in the company in a systematized way.

5.4.6 CLD

There is a point in the company's environmental evolution in which a company starts to systematize good environmental practices. The trigger at this stage is the increase in the *Assigned Management Tasks* that requires the adoption of formalization of the company's environmental management resulting in the implementation of green processes (Figure 15).

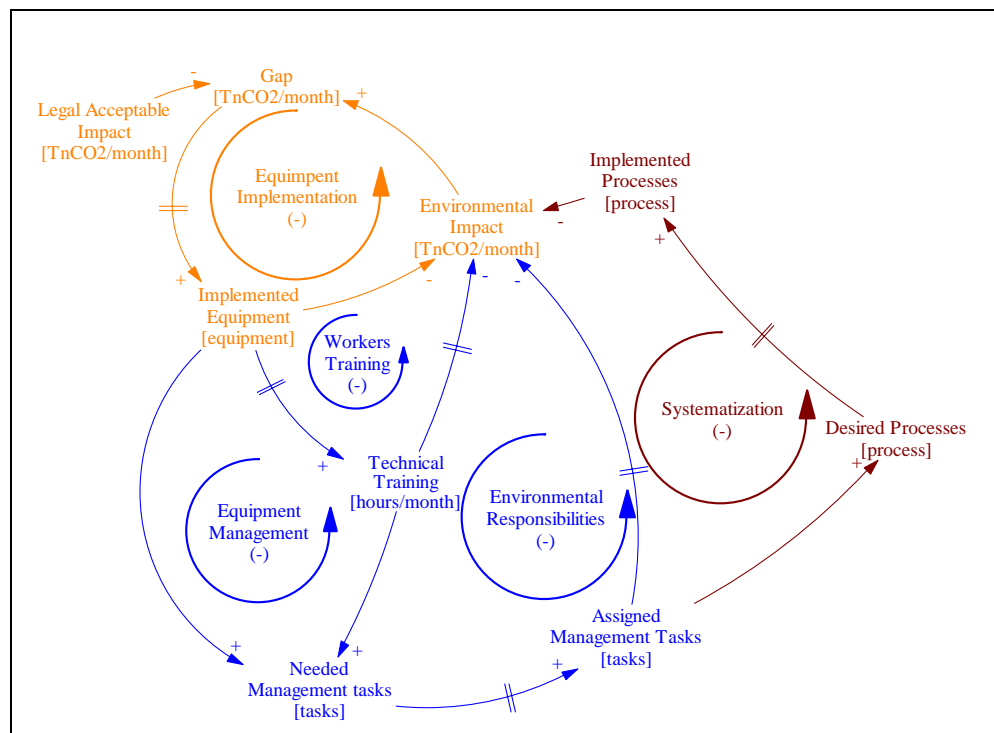


Figure 15. CLD of Systematization

As the *Assigned Management Tasks* increase the *Desired Processes* in the company will increase at this stage of maturity. This will lead to more *Implemented Processes* which will lead to a decrease in the *Environmental Impact*. These two new variables are measured by number of processes.

In addition to the previous four improvement mechanisms we have a fifth one now, which is called *Systematization*. Sometimes this *Formalization* can be seen in the form of certification, such as ISO 14001 (Coglianese and Nash 2002), EMAS or local recognition.

5.4.7 BOT

In Figure 16 two other indicators have been graphed apart from the previous ones: implementing processes and accreditations. The loop, Systematization that starts working in the CLD leads to an increase in the number of processes that are being implemented each month in this stage and as a consequence companies will be able to achieve some certifications.

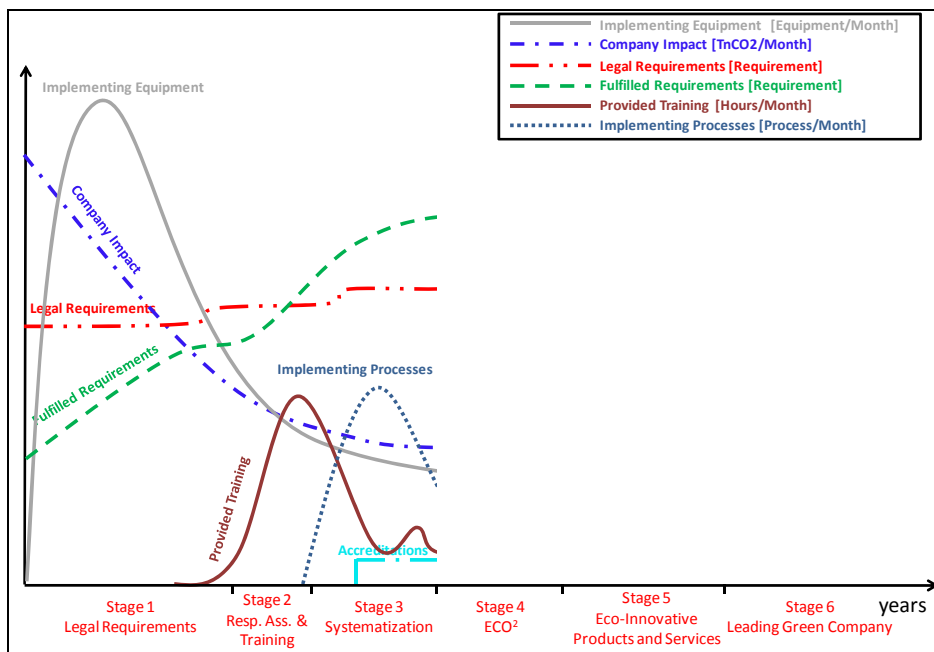


Figure 16. Systematization BOT

External legal environmental requirements slowly grow and the fulfilled requirements increase surpassing the legal requirements. This legal requirements compliance is due to the process implementation and hence, the environmental

impact continues decreasing. The provided training decreases and only will increase when new environmental measures are implemented because workers will need to be trained again.

It is also usually in this stage when the company may certify its environmental management system obtaining an accreditation.

5.5 STAGE 4. ECO²

5.5.1 Description

In the next stage the company goes beyond the systematization. The company does not see the certification only as a “requirement” but also it sees it as the right thing to do. It is in this stage when companies realize that there are quite significant environmental benefits from a well-run environmental management system. They enter in a continuous improvement cycle. This fourth stage is called ECO² because at this point companies obtain ecological and economic benefits (Suzuki et al 2010).

5.5.2 Agents Involved

The involvement of the top management and the commitment of the company’s workers are really fundamental in this stage. Welford (1992) highlights the importance of the commitment from the Chief Executive as well as from the whole workforce. When the employees are committed to environmental issues, companies could start to implement easily achievable energy measures, e.g. getting employees involved in switching the PC off at night, in turning the lights off at night and other actions that are not possible without the collaboration of all the workers.

5.5.3 Policies

Several policies that companies should take in this stage have been identified. Some of the policies have been completed with the Ekoscan⁹ standard, as it also looks for economic benefits.

- **Top Management Commitment.** At this stage there needs to be a serious commitment of the Top Management. At this point the Top Management should firmly be involved in environmental issues, they need to take into account environmental improvements not only because of external pressures but because they really think it is the right thing to do.
- **Implement continuous systematization.** Formalization should be implemented in a continuous improvement way. There needs to be completely integrated in the daily activities, and not only improve certain environmental aspects when the auditor of the certification comes.
- **Identify critical processes.** When trying to improve certain environmental aspects initially in a process, it is better to identify the most critical ones and seek to improve them. These critical processes could be the generation of unnecessary waste, the excessive consumption of raw materials, energy and water, the inadequate use of containers and packages and the inefficient transport.
- **Prioritize environmental aspects.** It is also necessary to prioritize the different environmental aspects according to several factors. One factor might be the impact, i.e. the amount of one specific aspect in the whole company. It is also very important when prioritizing to take into account the most dangerous environmental aspects. The economic

⁹ www.ihobe.net

costs are also quite essential as every company looks for lower costs. In some companies the energy consumption is really high, so diminishing this consumption will lead to significant savings.

- **Define objectives.** Once the critical processes have been identified and the environmental aspects have been prioritized, the objectives for improvement need to be defined.
- **Define indicators.** The company also needs to define some indicators and measure them in accordance to the objectives previously defined, so the indicators could afterwards be compared.
- **Design actions or solutions.** Each of these objectives need to have some specific actions and some responsible in charge of the actions to ensure that they are carried out correctly.
- **Implement actions or solutions.** Afterwards the actions need to be implemented to obtain the expected results. The case of one of the studied companies was to change all the plant lights using Best Available Technology (BAT).
- **Control the results.** After the actions have been implemented, it is necessary to control the results, look at whether the indicators have improved, and think if further actions need to be implemented to achieve the expected objectives.
- **Encourage workers' participation.** It is really important to encourage workers to participate in new actions or solutions that may improve environmental aspects while reducing some costs. In one of the studied companies an important campaign was launched to commit workers in being more efficient.

5.5.4 Indicators

There are some indicators that may help to assess how the company is doing in this stage. The number of environmental audits, both internal and external, indicates the level of continuous improvement adopted in the company. To achieve some economic results, best available technologies (BAT) are needed in the company so all the processes are as efficient as possible. This investment might indicate how well the company is doing. Looking whether if the technology the company has is relatively new could also indicate the investment they do in new technology that may help them to be more efficient, more environmentally friendly and to save costs. Another fundamental indicator is the consumptions. The company needs to measure the consumptions of the different resources that are being used, such as water, energy, etc. These measures should be relative and each company needs to define to which aspect these consumptions should be related so the comparison from month to month or from year to year makes sense. It is important to consider this comment since some companies compare the total consumption from month to month and a reduction of this consumption does not necessary mean that the company has improved, as the main reason of this reduction can be a decline in the production during some months. One possibility is to measure the consumptions per products manufactured. Another important indicator is the estimated economic benefits due to the result of environmental improvements. As it has been mentioned before, in this stage it is really important the workers' participation and commitment. One way of measuring this aspect is counting the number of suggestions made by the workers and consequently, the number of workers that have sent these suggestions.

5.5.5 Tools

To follow these policies and to complete the whole stage, companies may use several tools. Companies may organize a competition of ideas where all the employees could participate giving ideas to improve certain environmental aspects. Some of the interviewed companies stated that is good practice to involve workers and consequently employees feel they are part of the company. Usually the winner has a prize depending on the proposal. Another useful tool is eco-

efficiency, which is based on the idea of using fewer resources for producing goods or services and creating less waste and pollution. Recycling and reuse are tools very useful for this stage. It is important to reuse all the possible materials and recycle those ones that cannot be reused in the company to improve the environmental aspects. Another important tool is the SWOT analysis to evaluate the Strengths, Weaknesses, Opportunities and Threats. Through this tool the company may analyze what should be the actions that the company needs to take to be environmentally friendly and to reduce its costs.

5.5.6 CLD

As it has been described, this fourth stage is called ECO² because at this point companies obtain ecological and economic benefits (Suzuki et al 2010). As there are more and more improvements, companies will start to achieve operational savings (Figure 17).

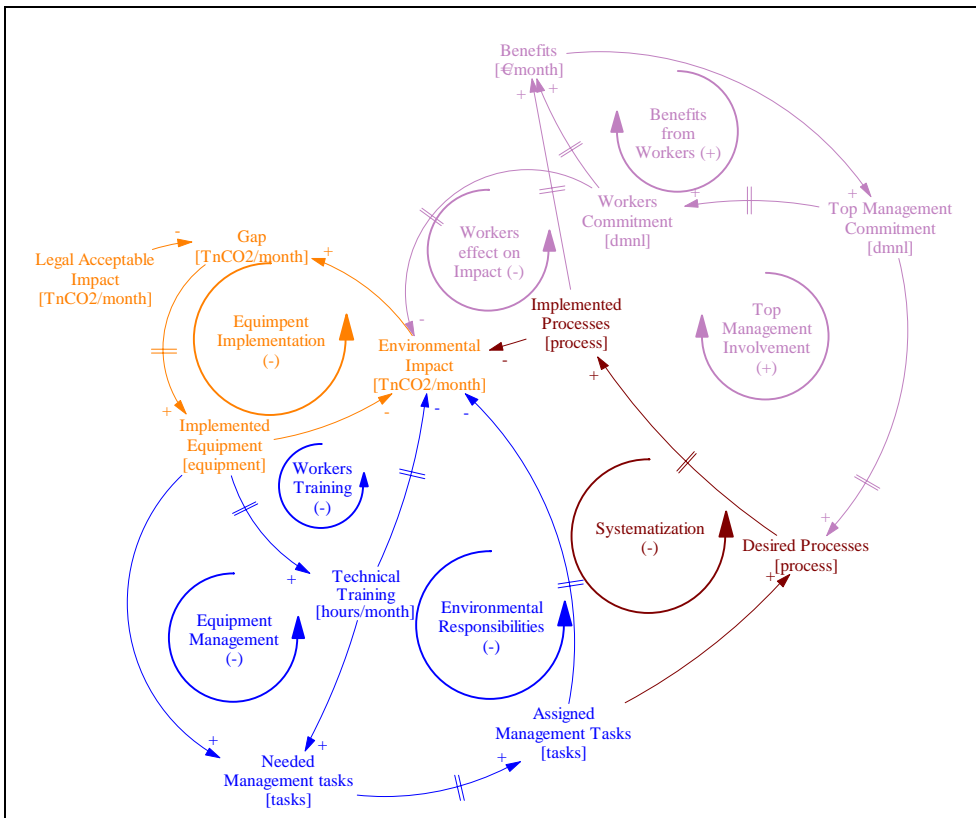


Figure 17. CLD of ECO²

In this stage, as the *Implemented Processes* increase the economic *Benefits* will increase which will lead to higher *Top Management Commitment*. When the top management is more committed to environmental issues, the *Desired Processes* will increase and the number of *Implemented Processes* will also increase.

Consequently, a new loop is activated. In this case, it is a reinforcing loop called *Top Management Involvement*. It is the first reinforcing loop in the environmental management evolution. It is since this stage that the company becomes proactive and starts to get out some benefits from the environmental management.

The second reinforcing loop in this stage is called *Benefits from Workers*. When the Top Management is committed to environmental issues it will make workers to be committed as well, basically through internal communication. Govindarajulu and Daily (2004) stated that employees who feel committed to environment may provide opportunities for improvement. As a consequence, this *Workers Commitment* is reflected in the economic *Benefits* growth, i.e. if workers are committed to environmental issues, they will propose new environmental improvements that will lead to some economic *Benefits*. These *Benefits* will lead to an increase in the *Top Management Commitment*.

On the other hand, there is a balancing loop called *Workers effect on Impact* and it represents that when workers are committed, thanks to their actions, the *Environmental Impact* of the company will be lower.

5.5.7 BOT

Figure 18 shows the evolution of previous indicators and a new one: Best Available Techniques (BAT) investment. As it has been seen in the reinforcing loops in the CLD, the Top Management Commitment increases in this stage; hence, the top management will invest more in BAT.

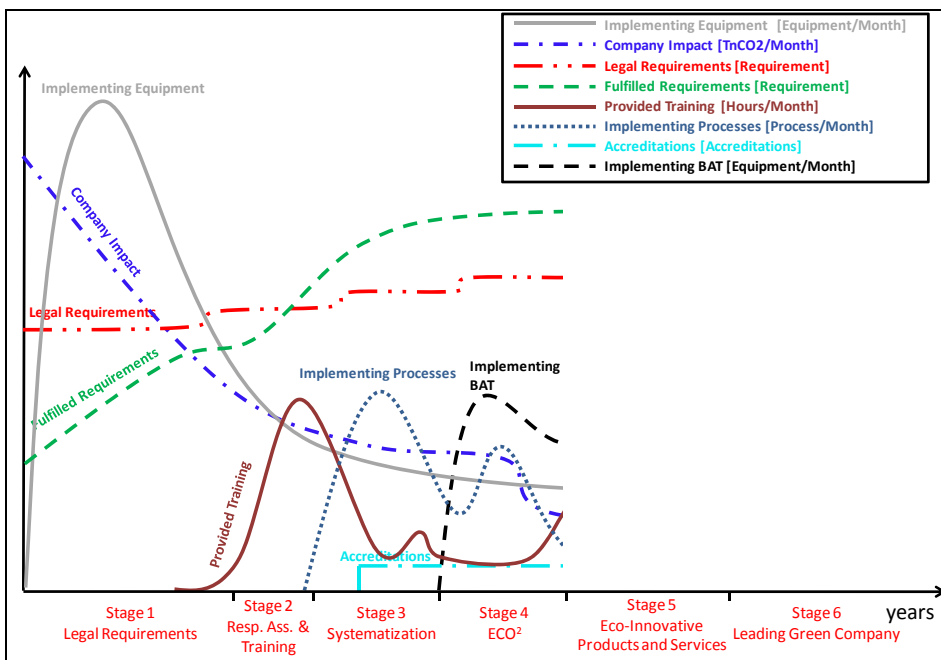


Figure 18. ECO² BOT

As it has been mentioned before, at this stage, through the involvement of the workers, the top management commitment and consequently through process improvements, companies get some economic benefits. Some of these economic benefits are due to the investment in Best Available Techniques (BAT). This investment will remain quite constant over the next stages, although it slightly increases when big investment are done to get some new technology.

5.6 STAGE 5. ECO-INNOVATIVE PRODUCTS AND SERVICES

5.6.1 Description

Once companies have achieved the systematization stage and have begun realizing operational savings, the company may recognize the value of new green

products and services for the activities of the company. As a consequence, they will need to design products and services that minimize the environmental impact (Wee and Quazi 2005). There are different types of software and models to help companies in the acquisition and management of the product life cycle (Yang et al 2007). In this stage companies tend to be quite proactive so they innovate and consequently they gain more customers.

5.6.2 Agents Involved

The agents within the company that actively take part in this stage are the development people and designers and the commercial people. The new green products and services are conceived by the development people and designers so they are fundamental for this stage. Moreover, the commercial people are in charge of selling these new products and services.

5.6.3 Policies

For completing this stage there are several policies or actions that companies may follow:

- **Identify market demands.** When creating a new green product or service it is fundamental to identify what the market demands or what it will demand in a future time. The clients of one of the interviewed companies dedicated to the design and manufacture of electrical devices, as they are operating in the building sector, were very strict demanding green devices. As a consequence, this company needed to innovate in their products. It is also important to define the market, if it is going to be the traditional market or if it is going to be extended to a wider market.
- **Define objectives.** Once the market is defined and the demands are identified, it is time to define the objectives of the consequent innovation(s). What do you want to achieve out of new green

products or services? This question is the one that the company has to make itself before creating new products or services.

- **Identify environmental aspects.** To create a new product or service, it is fundamental to identify the environmental aspects and impacts from the raw materials acquisition to the final disposal. Analyzing the whole life cycle of the product or service, all the environmental aspects and impacts that the product bears within it can be identified.
- **Cooperate with customers and suppliers.** There needs to be a close cooperation with customers and suppliers. If the idea is to make a product as environmentally friendly as possible taking into account all the materials and operations carried out in the whole life cycle, customers and suppliers need to cooperate.
- **Identify the most significant aspects.** When identifying all the environmental aspects and impacts that the product bears within it, they need to be assessed to identify the most significant ones.

5.6.4 Indicators

Several indicators may help to measure how the company is doing towards completing this stage. The first indicator gives information about the number of eco-innovative products and services that the company has achieved. The best way to measure this is to look at the percentage of green products or green services that the company has among the total range of products or services that the company offers to the market. One of the companies stated that in 2012 almost the 60% of their products were eco-designed. Consequently, it is also useful for the company to measure the turnover that offers these eco-innovative products and services compared to the total turnover as well as the number of new customers due to these green products and services. Other company mentioned that nowadays 20% of the company turnover corresponds to the eco-designed products and they expected to increase this rate in the following years. Another useful indicator is to

measure the amount of products with certified environmental labeling compared to the total number of products.

5.6.5 Tools

Different tools support the companies that want to complete this stage. The eco-design is the most common tool for this stage as its name suggests. This tool guides the company when designing a new product that is going to take into consideration environmental aspects. As part of this tool it could be considered another tool that is the life cycle assessment (LCA). It has been previously mentioned, since it is very useful to identify all the environmental aspects and impacts that the product has during its whole life cycle. There are different LCA software that help the company to describe all the life cycle and detect those environmental aspects with the greatest impact. Eco-indicator 99 is one of the most widely used impact assessment methods in LCA, which allowed the environmental load of a product to be expressed in a single score¹⁰. The companies that have been studied during this research and that have used LCA to eco-design their products, have created their own LCA software. Benchmarking could be a helpful tool to know the best practices of other companies regarding eco-innovation and identify those practices that could be considered in the company.

5.6.6 CLD

As it has been previously mentioned, during this stage companies recognize the value of new green products, processes and services to the activities of the company. We propose that the introduction of these innovations results in companies obtaining additional benefits (Figure 19).

¹⁰ www.pre-sustainability.com/impact-assessment-methods

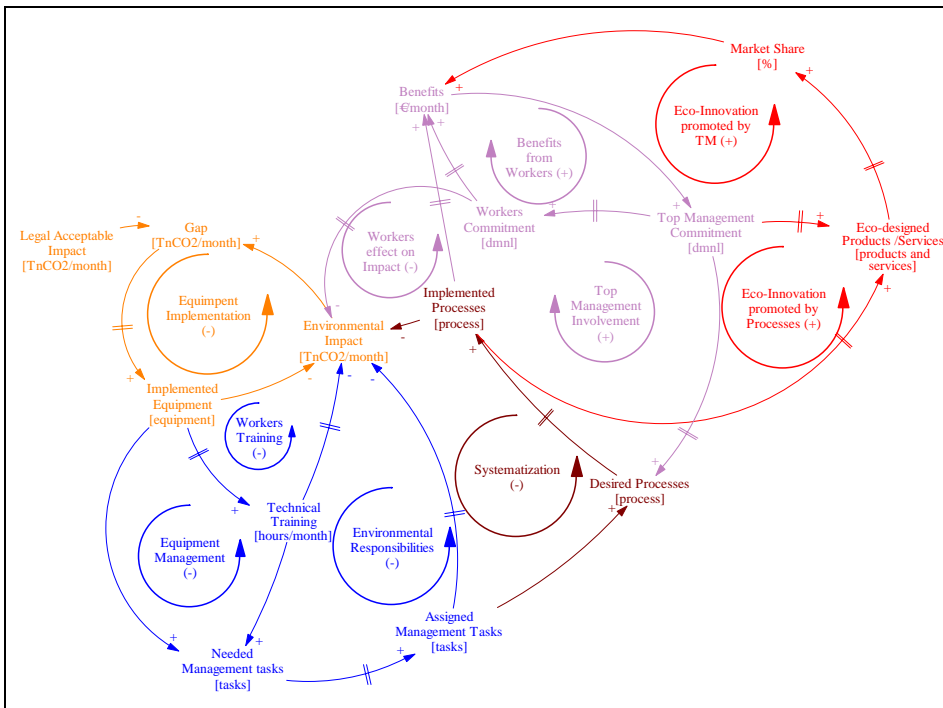


Figure 19. CLD of Eco-Innovative Products and Services

The reinforcing loop at this stage is called *Eco-Innovation promoted by TM* (Top Management). Due to the commitment of the top management, there will be more products or services designed from a green perspective. This will lead to an increase in the variable *Eco-designed Products/Services* and as a consequence, an increase in the *Market Share*, increasing the *Benefits* what will lead to a higher *Top Management Commitment*.

The second reinforcing loop at this stage is called *Eco-Innovation promoted by Processes*. Thanks to the *Implemented Processes* new green products and/or services will be created obtaining as a consequence a higher *Market Share*, what means higher *Benefits* and hence, an increase in the *Top Management Commitment*. The Top Management will then demand more processes, and consequently, the number of *Implemented Processes* will grow.

5.6.7 BOT

Figure 20 represents the evolution of some of the indicators up to and including stage 5. As it has been presented in the CLD, new green products and services are designed and launched on the market.

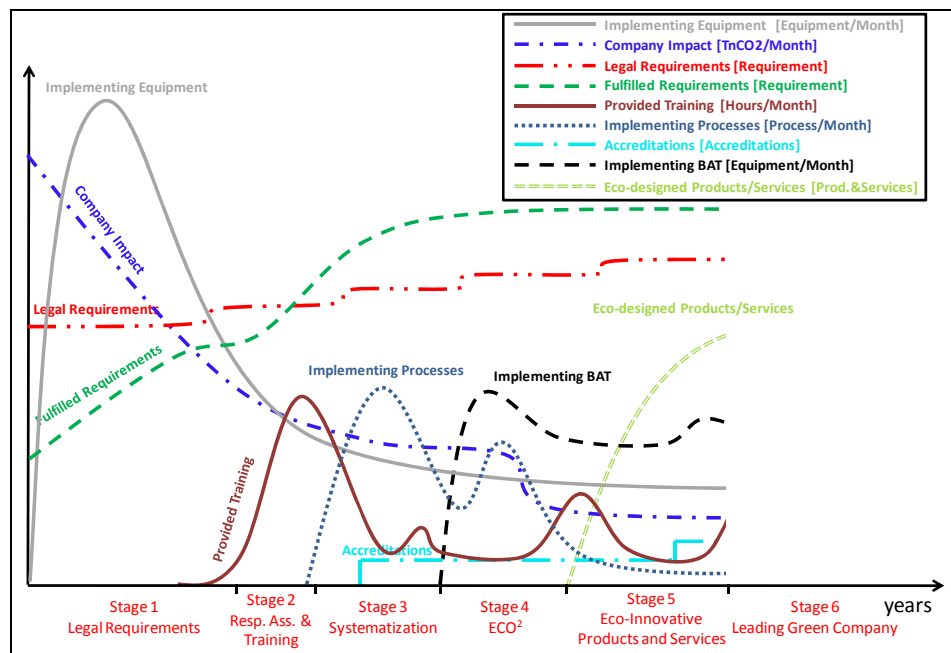


Figure 20. Eco-Innovative Products and Services BOT

It is in this stage when new products and services are being designed and consequently the company could achieve new accreditation, such as ISO 14006.

5.7 STAGE 6. LEADING GREEN COMPANY

5.7.1 Description

Once the stage of eco-innovation has been reached, the company focuses its efforts on becoming a green company. Companies begin to make public their

environmental practices and they compete on environmental issues. In this final stage, the company should be a benchmark for other companies that want to improve their environmental management. Through external communication the whole market becomes aware of the green image of the company. Not only customers, but also competitors look at the company as a reference company in environmental issues.

5.7.2 Agents Involved

Consequently, the person or team that becomes involved in this stage is the communication responsible. This person or team should present all the improvements and innovations that they have been taken over the years.

5.7.3 Policies

There are some policies that companies should take to complete this stage. Some of these policies have been identified in the standard ISO 14063¹¹ that talks about environmental communication.

- **Analyze the situation.** The first thing that the company should do is to analyze the current situation. It is central to identify the issues that concern stakeholders so the communication can be as efficient as possible. Moreover, it is important to identify the media and the different activities that other companies have effectively communicated. It must not be forgotten the identification of opinion leaders and their influence in environmental communication. All this data needs to be collected and assessed before planning the external communication.

¹¹ www.aenor.es

- **Define goals.** Once the current situation is analyzed it is essential to define the goals of external communication or marketing in some cases. These goals need to be related to the environmental aspects of the different activities, products and/or services, emphasizing those green improvements or green innovations that have taken place in the company. Closely related to this is to identify the environmental actions that have been taken and are being taken in the company and the corresponding improvements. With all this information each time the company wants to externally communicate, it needs to define the objective and select what is the information it wants to transmit.
- **Define geographic scope.** Not only is important what to transmit and what is the objective but also it is necessary to identify who the receiver of the message is going to be. For that reason it is a key action to identify the geographic scope, describing the receivers of the communication.
- **Make an environmental declaration.** With all the green aspects identified, the company should make an environmental declaration which should be available for anyone that wants to look at it. This action is part of the EMAS certification and that is why not many companies have this certification as they do not want to make public their environmental aspects.

5.7.4 Indicators

There are several indicators that could measure how well the company is doing regarding the external communication and marketing. One fundamental indicator might be the press impacts that could be measured by the number of times the company has appeared in press due to environmental improvements that have been taken in the company. External recognition is another indicator that could be very useful when assessing if the company is regarded as a reference company in matter of environmental management. This could be measured by the number of

mentions by third parties. Another important indicator measures the number of awards or prizes that the company has won regarding environmental aspects. Other related indicators are the number of environmental reports, the number of environmental related advertisements and the participation in environment related conferences.

5.7.5 Tools

To move forward in this stage, companies might use several tools. In the model that has been previously presented, these tools have been grouped into written communication/marketing or oral communication/marketing.

In the written communication or written marketing there have been several tools that may help companies. Some of these tools might be the use of the website, where they could inform the different stakeholders about the green improvements or green innovations that are being carried out in the company. Another tool is the environmental or sustainable annual reports where the company is transparent presenting all the environmental aspects of the company (Koehler and Chang 1999). The Global Reporting Initiative¹² (GRI) guidelines could be widely used to produce sustainability reports. Brochures, letters, e-mails or newsletter could be also used to externally communicate the environmental issues of the company. Information statements about the product or service are becoming widely used such as eco-labeling (Dudley et al 1997). If a product is eco-labeled means that it fulfils some environmental aspects. In this way people buying a product can select one specific brand because as it is eco-labeled, it assures the consumer that it has been created taking into account environmental aspects. The posters and exhibitors in different places could help the company to transmit specific environmental issues to make aware the stakeholders how important the environment is for the company. Articles and other type of media and press could be a good way to reach many people.

¹² Global Reporting Initiative (GRI): www.globalreporting.org

Oral communication and oral marketing can be another way of transmitting the environmental issues of the company. Public meetings or public conferences are a good way to be known as a green company. In many cases, when the company is doing the right things, they will be called to present their experience in environmental forums and the company needs to take advantage of these opportunities. One of the studied companies mentioned that they were called to participate in an eco-design meeting and present what they had done.

Interviews in the media could be a way to reach more people and make the company known. Furthermore, open-door events, information days, on-site guide visits and videos are not only a way to show the product or service that the company offers but also to make people aware that the company is completely committed to the environment. There are more and more “meal” meetings among companies, and it is always a good option to show the stakeholders that the environmental aspect is a fundamental part of the strategy of the company. Cooperation projects regarding environmental aspects are another useful tool to demonstrate what the company cares about. Sustainability agreements and environmental awards could also demonstrate that companies are following the right path regarding environmental issues.

5.7.6 CLD

The structure of this last model adds three new loops to the previous ones (Figure 21).

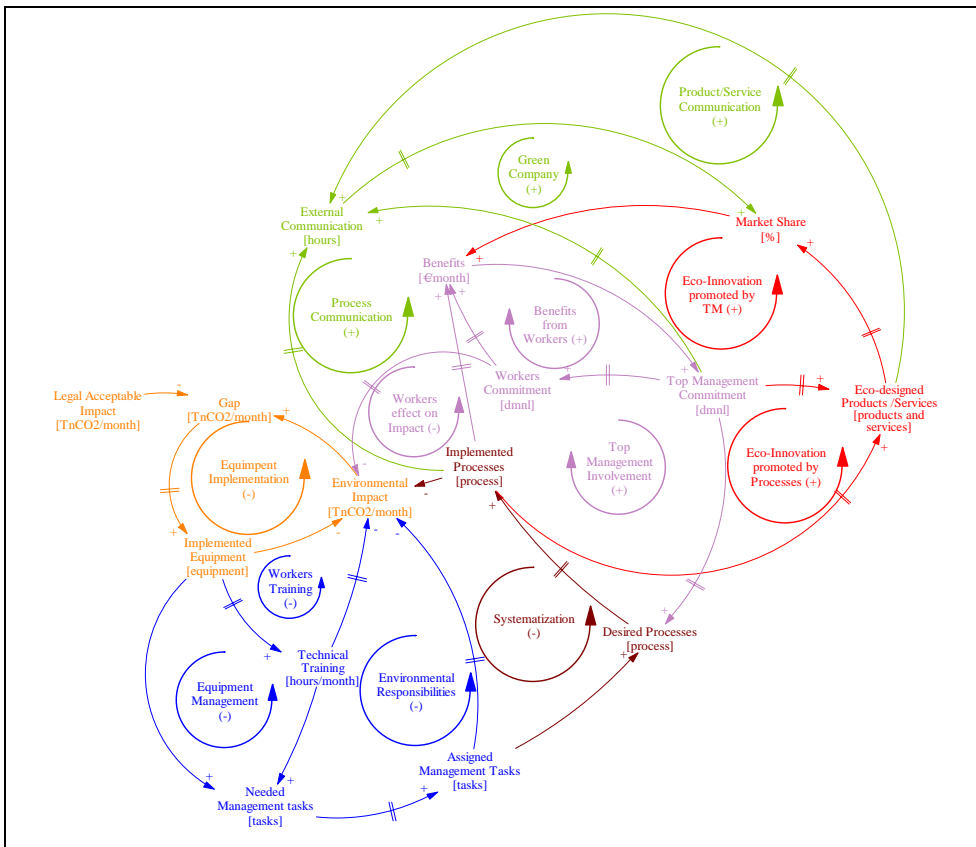


Figure 21. CLD of Leading Green Company

The *External Communication* will be due to three important aspects in the company: the *Implemented Processes*, the *Eco-designed Products/Services* and the *Top Management Commitment*.

When there are many *Implemented Processes*, the *External Communication* increases and this will lead to an increase in the *Market Share*, what will result in *Benefits growth*. Consequently, the *Top Management Commitment* will increase due to the earnings growth and they will desire more processes leading to an increase in the *Implemented Processes*. This reinforcing loop is called *Process Communication*.

The second reinforcing loop is called *Product/Service Communication*. When there is a high number of *Eco-designed Products/Services*, the *External Communication* will grow as the communication responsible will communicate externally the new green products or processes. Thanks to the *External Communication*, the *Market Share* and hence the *Benefits* will increase. As a consequence, the *Top Management Commitment* will increase and will demand more green products/services, leading to an increase of *Eco-designed Products/Services*.

Finally, the last reinforcing loop is called *Green Company*. When the *Top Management Commitment* is high, it will apply more resources to *External Communication*. This communication will reach more customers and consequently, the *Market Share* will increase. This will lead to more *Benefits* what will increase the *Top Management Commitment*.

5.7.7 BOT

Figure 22 represents the evolution of some of the indicators over all the maturity stages. Moreover a new indicator is being introduced as a consequence of the reinforcing loops presented in the CLD. This indicator is the green external communication.

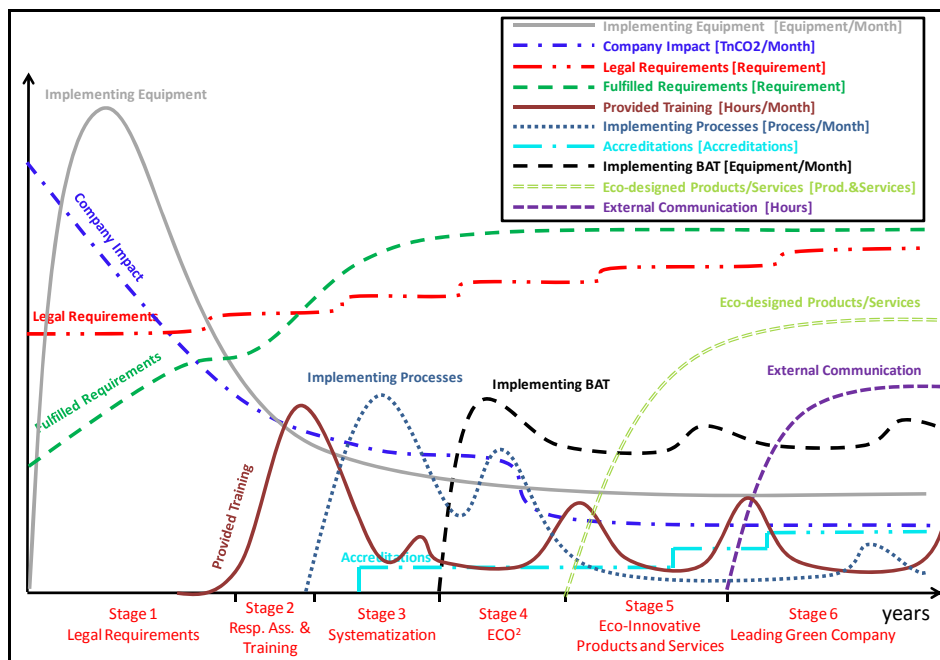


Figure 22. Leading Green Company BOT

As it has been previously mentioned, stage 6 starts with green external communication. The environmental process improvements and products and services improvements are made public. Consequently, customers, society, competitors and other stakeholders start recognizing the company as a leading green company.

5.8 COMMENTS ON THE MODEL

5.8.1 Comparison with Previous Studies

As it was pointed out in Chapter 2, many authors (Borri and Boccaletti 1995; Venselaar 1995; Berry and Rondinelli 1998; Cramer 1998; Jabbour and Jabbour 2009; Jabbour 2010) used the terms Reactive, Preventive and Proactive to designate different maturity stages:

- **Reactive Stage.** In this stage the company mainly moves forward due to external requirements.
- **Preventive Stage.** The company looks for effective strategies through improvements in processes, e.g. reusing, recycling, etc.
- **Proactive Stage.** The company moves forward introducing environmental objectives in the strategy of the company, and this leads to a competitive advantage.

Comparing previous studies with the developed model in this research, it can be said that the three first stages, Legal Requirements, Responsibility Assignment and Training, and Systematization correspond to a reactive stage because the company is responding to external demands such as legislation requirements and market demands regarding systematization as many companies obtain a certification because their clients demand it.

The fourth stage, ECO², correspond to a preventive stage, where the company looks for improvements in processes reaching a continuous improvement cycle that leads to environmental and economic improvements.

The last two stages correspond to a proactive stage where the whole company is committed to environmental issues, propose new environmental products and/or services and afterwards the company communicates all the environmental improvements that have been taken over the last years within the company. Consequently, it leads to a competitive advantage (Figure 23).

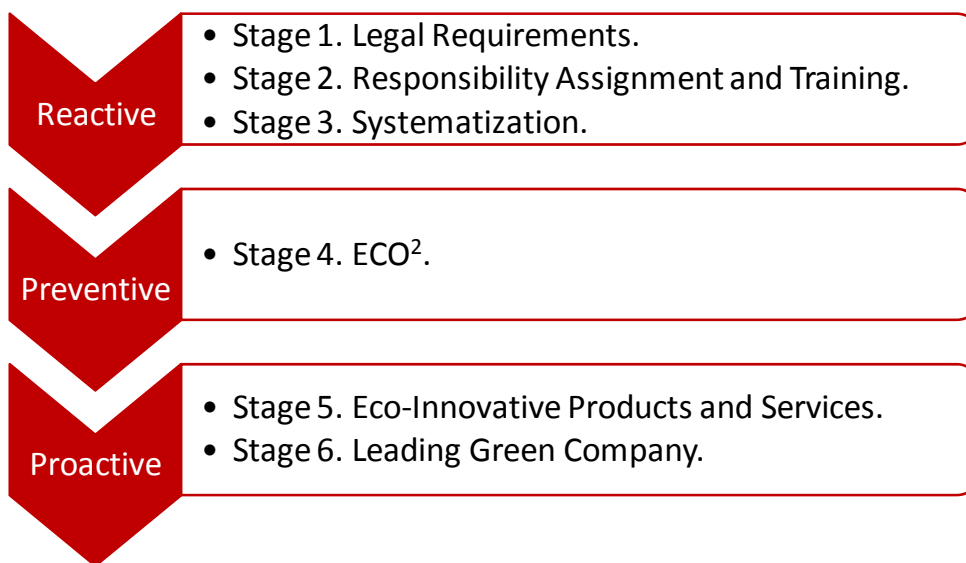


Figure 23. Maturity stages

As it has been mentioned in the **State of the Art Chapter**, Jabbour (2010) stated that all the different factors related to the environmental management can coexist in an organization and that the “union of variables theoretically belonging to different stages shows the non-linearity” of the environmental management evolution. With the proposed maturity model this statement is taken into consideration, as the company that improves its environmental management, adds new factors to the previous ones, so all the factors can coexist. Consequently, a company that reaches the last stage does not mean that it only cares about external communication but it also cares about all the previous stages.

Moreover, in response to Kolk’s comment (2002) the EMM Model presents indicators and policies so companies can reach each of the stages more easily.

5.8.2 Reasons for Following the Proposed Order

It should be mentioned that there are some companies that have not exactly follow this path in their environmental management evolution. However, it has been contrasted through this research that this is the most efficient way of

improving the company's environmental management, mainly because companies that have progressed in their environmental management in another order, they afterwards realized that they should go back again to previous stages.

This might be because there was lack of information on how companies should evolve towards environmental excellence in the most effective way. The previous models were very general and did not specify the steps that companies should follow to reach each of the proposed stages.

However, some comments must be taken into account when looking at EMM Model. Firstly, it should be pointed out that some companies the first thing they want to do regarding environmental management is to achieve a certification. It has been demonstrated that companies that start with the systematization process to get a certification they have to go back and start identifying legal requirements and giving some training and assigning responsibilities before doing all the formalization in the company.

Furthermore, it should be highlighted that not all the companies have a long process of legal requirements identification as they may not have big environmental impacts so it is quite easy for them to fulfill with all legal requirements and hence, they do not need to make big investments in equipment. So they just go through the first stage quite quickly, but they recognized that identification and fulfillment of legal requirements should be in the first place in the environmental management of a company.

On the other hand, it is also essential to highlight that there are some companies that might think that they can start obtaining some benefits before the systematization is in place in the company. It is definitely possible, however, there are some evidences that companies with all their environmental management systematized they will have it easier to find improvements and get benefits out of it.

Moreover, there are some companies that start innovating in their products in a green manner before having their processes improved. This is not very coherent if the company wants to show a green image in the outside. Some companies have

realized about this “problem” and they have gone back to improve their own processes. Nevertheless, it is possible to start improving the processes at the same time that you do some improvements in the products or services. So the ECO² and Eco-Innovative Products and Services stages could be parallel in some companies.

FINAL VALIDATION. CASE STUDIES AND SIMULATION MODEL

This chapter explains the different methods that were carried out to validate the final environmental management maturity model (EMM Model). The particular results obtained in each of the methods and the corresponding discussions are presented. Three case studies carried out in proactive companies in the Basque Country are presented to validate most of the model. The main objective of the case studies was to explore the evolution of the environmental management of three different companies to demonstrate that the most appropriate way to go towards environmental excellence is the one presented in the EMM Model. To complete the validation, a simulation model has been developed to demonstrate that the Causal Loop Diagram (CLD) structure presented in the model represents the Behavior Over Time Graphs (BOT) proposed by the experts.

6.1 CASE STUDIES

As it has been mentioned, three case studies have been carried out as part of the validation process. Contrary to the semi-structured interviews, in the case studies an exhaustive study has been carried out in each of the companies, interviewing different people. A focused interview guide was prepared which listed the questions and issues that needed to be explored. These questions were grouped into the different maturity stages (Appendix 6). Three important companies regarding environmental issues were selected from different sectors: railway sector, elevation sector and chemical sector. In the following sections the environmental management track record for each of the companies is presented to validate the path that the model is recommending.

6.1.1 Case 1. Railway Sector

The railway sector company is one of the internationally market leaders. This company is aware of the need to preserve the environment. According to the United Nations Environment Program, the railway is one of the key sectors to achieve a sustained economic and social growth, consistent with the stabilization of the climate¹³. In this transition to a clean development, this company is working on the improvement of transport energy costs, reducing at the same time the railway footprint. The company is certified with the ISO 14001, which corresponds to the certification of their environmental management system. As a reference company in the railway sector, it was decided that it was an interesting case to study to get the information about its environmental management evolution.

Five sessions were accomplished during this case study with different people in the company (Table 14). The information that was obtained during these sessions was contrasted with the web page information.

¹³ www.pnuma.org

Table 14. Sessions and people involved in the railway company

Session	Function within the organization
S1	Prevention service coordinator. Environmental management responsible.
S2	Maintenance and general services of production facilities responsible.
S3	Eco design responsible.
S4	Oven section maintenance responsible ¹⁴ .
S5	Environmental communication responsible.

Since the beginning of the 70's, this company has identified the corresponding legal requirements. Nevertheless, in these first years there were not many environmental requirements. The legal environmental requirements reached its culmination with the Royal Decree 833/1975¹⁵. With this law the control of the atmospheric emissions started, particularly the emissions quantity and the air quality around the plant. Consequently, the company looked at the corresponding limits, measured the plant levels and in case of being above the standards, the company worked on diminishing the emissions in quantity and improving them in quality, optimizing in the best possible manner the machinery and raw materials selection.

Another important law was the RD 833/1988 in which the activities of production and management of hazardous waste were classified and regulated.

¹⁴ It is in the oven section where more energetic consumption takes place.

¹⁵ BOE: *Boletín Oficial del Estado* www.boe.es

With this regulation the Basque Country Government demanded its community companies an authorization for hazardous waste management. This implied that companies should make an application to carry out activities with hazardous waste, identify the waste and declare the hazardous waste. In the 80's and 90's there was not a specific environmental management department within the company, but the Department of Investment Developments managed among other issues the hazardous waste and the environmental impact of the new investments. However, not only did the company focus on laws of the Basque Government but also world, European, Spanish and local laws.

The sanctions and penalties are not very known within this company as it has had little problems with legal aspects. They have never had any sanction for discharge to rivers or for atmospheric emissions. At the end of the 90's there were several big investments in the company:

- **Filters in the oven doors.** This project consisted of the purification of the diffuse emissions in the steelworks because when the ovens were opened there were high volumes of polluting emissions. Specifically, 3,000 filters were placed as well as a measurement equipment to make more complete controls.
- **Canopy in the oven.** Another important milestone was the placement of a canopy in the oven, just to continue with the control of the emissions in the steelworks. The aim was to suction the diffuse emissions. This was a project of 3,000,000 Euros for an improvement of a 5% in the elimination of diffuse emissions in the industrial activities.
- **Water collector.** An investment was done for the separation of fecal waters and industrial waters. It was needed to full up the flooring, so it was done during the summer time.

With these three important actions, the main sources of impact were managed: atmospheric emissions and water separation. In this company the impact has been

diminishing over the years. However, with the implementation of the big measures as the previous ones, the biggest impact reductions took place at that time.

When the environmental issues started to being managed, people responsible for a project, area or department were in charge of its own environmental aspects and they taught the workers in a practical manner to facilitate their work. Once the section of environmental management was created in 2000, different training sessions for people in different departments were established. As time went by, there were more people trained in environmental issues within the company. Some training about particular issues of hazardous waste involved the participation of the security advisor, that by law, the company must have. The security advisor was responsible, among other issues, of the specific hazardous waste. It might be important to highlight that despite the training of environmental issues was strengthened in 2000, it is a clear point in the ISO 9001 (quality standard) so it has been taking place in the company since the 90s.

In the year 2000 the environmental systematization took place. All the systematization in the company is based on the ISO 14001 standard. As the company was excellent in the fulfillment of the legal requirements all the systematization process was really quick. It should be stressed that the company saw the systematization as the logical step after the legal fulfillment. Before obtaining the ISO, a previous diagnosis was done to identify the points that were missing in the company to obtain the accreditation. Despite the legal requirements were all identified, the standard required them a procedure of the identification of the applicable legal requirements. This systematization of legal requirements was outsourced, so another company was in charge of the identification of all this legal requirements in the company since that moment. When a new law came out, there was a transitional period, but it did not take the company too much time to fulfill the new requirements as everything was really well systematized.

The company stated that one of the most important systematized measures was the implementation of internal audits because it was useful for the identification of corrective actions that many times are overlooked on day to day.

The maintenance department is the one that works more with the environmental department to define measurements, to plan them. Moreover it is this department the one that carries out the daily monitoring and collects indicators.

After several years they have internalized the way it should be operating with this certification. Since that moment they have not been catching up with different aspects or documents the previous day of the audit. At this point the company became aware of its own progress because it started to save money. They stated that “moving from spending and investing to saving becomes a strong incentive to keep moving in the same direction”.

The commitment of the top management has been relevant over the years but it has increased when progress was done. At the same time the workers commitment has considerably increased over the years. As a consequence, they have become more proactive in environmental issues. In 2000 and 2001 they only felt the obligation of “listening”. However, nowadays the same workers are the ones that take part in the environmental improvements; they are the ones that ask for intensifications in some issues. The environmental improvements “arise in part from them” and they “progress with them”. Workers are encouraged to save and optimized the use of energy in their work places, e.g. “turning off the equipments when they finish their work shift or they take a break, notifying if there is any gas leak, proposing new improvements for the use of energy in the plant, among other interesting and various forms”. With these measures they achieved great economic benefits; specifically they have been saving 27,000 Euros per year (25% of savings).

One of the aspects that they have being studying during the last years but they have not done it yet is to move from metal halide lamps of 400W in the workshop to LED lamps and they will save 50% of energy. As regards heating, they are looking for the best way to isolate the buildings, to maintain heat inside during winter time and outside during summer time.

Regarding the environmental improvements in the product, it can be said that since the 90s the company has taken into account ecological factors in the design of the products, aspect that was reinforced with the ISO 14001.

It is worth noting that this company has to create a product with the customers' specifications, so there is not quite a lot of space to improve freely. However, they pointed out that they wanted to be prepared for new requirements and they wanted to offer what competitors were not offering. The top management commitment with the environmental aspects in the design was very proactive, so much that the first ideas and impulses emerged from them. Consequently, the eco-design has been more important since 2008. Two specific milestones constitute this fact:

- **Recyclability.** In 2008 a project was accomplished to analyze the recyclability of the products, the materials that were used and the components that took part in the trains. A methodology was introduced to control in the design part the recyclability that will have the final product. It was based on the cycle Reduce-Reuse-Recycle.
- **Life Cycle Assessment (LCA).** In 2010 another project was carried out to study and formalize the environmental aspects of the product during the whole life cycle, "from cradle to grave".

All these improvements in the environmental aspects whether in products, processes or services, are communicated. There are some environmental aspects that are being communicated mainly because the customers require it. Regarding the green communication budget it has considerably evolved during the last 10 years, moving from not having any budget or objective to be essential to communicate green improvements.

One of the main communication tools is the web page where all the advanced, developed and strengthened information is notified. Although it is not a priority they have appeared in press due to environmental improvements, but not so many

times as they could have. Regarding environmental awards they have not obtained any but neither the competitors. However, they have had several recognitions.

It should be stressed that this railway company seeks to be discreet, cautious and practical with its communication to sustain its affirmation of “better do than talk”.

What follows is a graph of the main milestones that describe the evolution of the environmental management in this company (Figure 24). The colors chosen to represent the different milestones are the ones that have been used to represent each of the maturity stages.

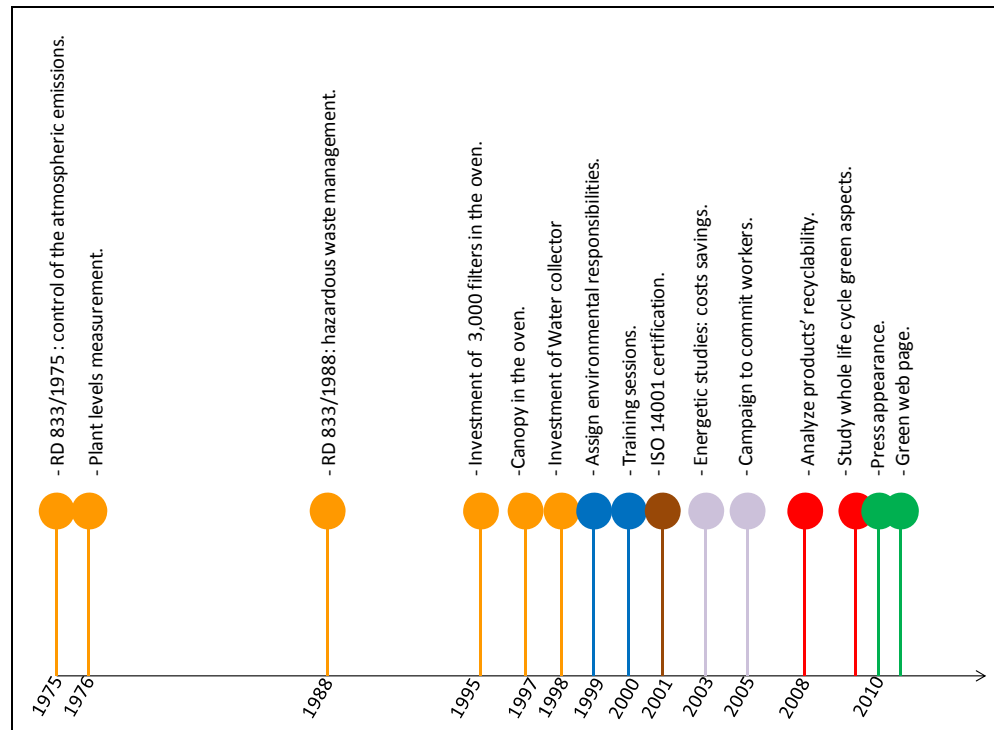


Figure 24. Environmental management milestones in the railway company

6.1.2 Case 2. Elevation Sector

The second case study was moved to the elevation sector. This group consists of several national and international companies that provide a service in more than 85 countries at a global level with more than 4,000 people working. It is the leader in Spain in the elevation sector and it is among the six first companies in the whole world, in terms of turnover. The company is certified with the ISO 14001 and the ISO 14006 which corresponds to the eco-design standard. It has been the first company to be certified with the ISO 14006 in the elevation sector at a global level. This company bets on environmental issues due to the market interest and due to their innovative vocation that leads the company to search for costs reduction and satisfy more and better the customers' expectations.

Nine sessions were carried out during the elevation company case study with different people in the company (Table 15). The information that was obtained during these sessions was contrasted with the web page information as in the previous company.

Table 15. Sessions and people involved in the elevation company

Session	Function within the organization
S1	Marketing and promotion director.
S2	Maintenance responsible.
S3	Quality, prevention and environmental responsible.
S4	New business development responsible.
S5	Management architecture and facilities responsible.
S6	Management architecture and facilities responsible.
S7	Technological innovation services responsible.
S8	Branding and communication responsible.
S9	Service technician.

This company has always identified legal requirements but not in a systematized way. At the beginning they needed “to acquire the activity license and to comply with 4 or 5 things that the law required”.

As a consequence the training was rather low. Only the necessary training was given, especially to the maintenance people and afterwards the maintenance people were the responsible of spreading their knowledge among the rest of the workers that needed that training.

In 2001, the environmental department was created together with the achievement of the certification ISO 14001. Before achieving it, the company identified the requirements still to be met to fulfill the entire norm. Since 2002, there have been audits once a year but the environmental responsible in the company stated that it is increasingly difficult to find aspects to improve as the

biggest measures have already been implemented. The most important aspects for this company are the waste, the consumption (water, light and gas), the paint discharges and the emissions. They have indicators for these aspects so they can control them and they are usually classified according to the risk and/or the cost and they are quantified to study them annually or in less time if they are thinking of introducing a new measure.

Since 2005 the identification of legal requirements has been outsourced, so when a new legal requirement appears that is applicable to this company they notify them. Specifically, every 2 or 3 months they notify the company if there is any new requirement as well as the different supports, advices that might help them. Nowadays they fulfill 100% of the requirements and when a new law appears and they are not fulfilling it, they make deep and quick studies to make the necessary investments as soon as possible.

The systematization has been internalized in such a way that they are not preparing everything and making a lot of changes the day before the audit. All the employees including the top management are really committed to the environmental issues in the company. Nevertheless, it is not easy for them to be proactive as it is difficult to find new improvements, even for the environmental department. They have realized recently that they can improve the environmental impact and achieve significant savings if they teach the people in charge of the maintenance to the customers to drive efficiently to save petrol and consequently improve the impact. They have 1,000 cars in the street during 6 hours a day and it might be an important saving if they could save in 3 years around 10% of the costs, because the initial investment it is relatively low but with interesting economic, ecological, social and marketing impacts.

Regarding the product, in 2008 the company achieved the Spanish certification UNE 150301 of eco-design. They created a tool to analyze the whole life cycle of the company's elevator with the system indicators 99, which is "the one that best meets the company's products and at the same time the one that is more standardized over Europe". When the ISO 14006 appeared in 2011, the recognition and accreditation was almost immediate. So much so that it was the first company

in the elevation sector among the world to get this certification and it was used as an example to move from the UNE to the ISO.

In 2008 the first eco-design products were developed. It can be said that “all the new products since 2008 are eco-designed”. In 2012, 58% of the sold products were eco-designed and for 2013 this rate is expected to be more than 60%. Some of the innovations carried out in the elevators have been the following ones:

- **Elevators’ energy standby.** An important milestone related to the energy aspects in the product design was the one related to the energy consumption during the elevators’ standby as the lights of the elevator are normally switched on 24 hours a day and in a residential building it is only used an overall total of 2.5 hours a day. To solve this aspect, LEDs lights were used to switch on the lights only when the elevator was being used what led to important savings of 125%.
- **Recovery of braking energy.** Another important aspect of eco-design was the one related to the regenerative energy system, that uses the energy that is generated during the brake to transform it into energy that could be used in any other system, either in the same elevator or in the building if it is possible, what also means savings for the final customers.

To prioritize the environmental aspects when eco-designing, “it is important to identify the market objectives, not to be left out of the competitive prizes among other issues”. Regarding the top management commitment, the cooperation and support since the beginning of the eco-design has been fundamental, otherwise “none of the projects would have become possible”.

In 2011 there was a project to analyze the performance and energetic efficiency in the plant and three aspects were found to improve:

- Lighting.
- Heating.

- Compressed air.

In 2012 some actions were taken to improve the energetic efficiency. One of the most important actions that was carried out was the optimization of the lighting with an investment of 130,000 € that is going to be amortized in 8 years, obtaining savings of nearly 40% of the consumption. Moreover, together with this investment, software was implemented to program the on/off lighting.

Nowadays, they are focusing on actions with smaller investments but with more commitment from the workers to save and reduce the environmental impact with measures such as switching off the illumination and the compressed air outside working hours.

The communication of all these improvements that the company has been carrying out has been done constantly since 30 years ago. Nevertheless, the environmental communication 30 years ago nothing has to do with the current communication. Nowadays, in all the catalogues of the company there is always a section of eco-design, energy efficiency and any other factor related to environmental management. The methodology carried out to communicate all the environmental information is through the annual report where all the activities done over the year are explained. This report is distributed to all the clients (around 100 countries), the suppliers, future clients and other important stakeholders in the value chain. From these reports the necessary material is selected to be emitted through catalogues, calendars, brochures, documents for fairs among others.

It is interesting to point out that this company joined the Global Compact¹⁶ to demonstrate society the environmental commitment that they have. To join the compact companies have to fulfill any of the 10 required points and this elevator company is fulfilling all the points.

¹⁶ United Nations Global Compact: www.unglobalcompact.org

The environmental excellent awards do not excel because “it is a company that is more interested in doing rather than talking”. However, the last 4 prizes they have opted to, they have won them. Moreover, they are aware of the importance of communicating and they think they still have a lot more to do.

What follows is a graph of the main milestones that have been described in this case study to represent the environmental management evolution in this company (Figure 25).

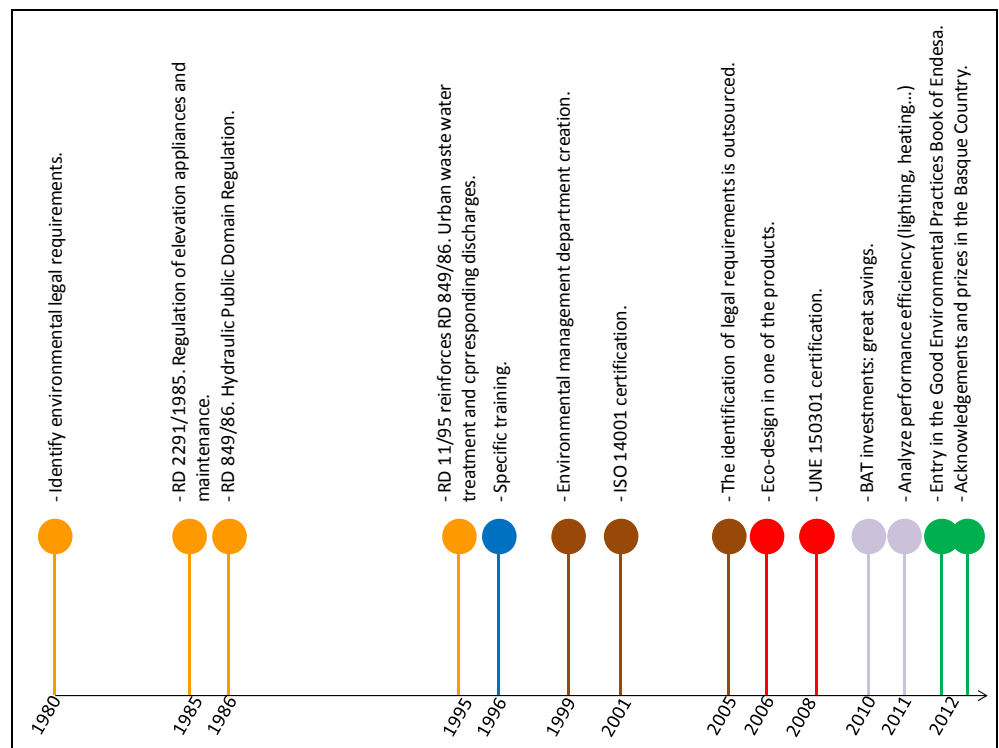


Figure 25. Environmental management milestones in the elevation company

6.1.3 Case 3. Chemical Sector

The third company works on the design, production and market of biological and chemical products. In contrast with previous case studies, it can be considered a small company with less than 50 people.

It is the only company in the Basque Country with all the following environmental certifications: Ekoscan, ISO 14001, UNE 150301/ISO 14006 and EMAS. The environmental certifications among companies in the Basque Country were analyzed and it can be observed that among the 185,454 business premises only 1,405 facilities (0.76 %) have any type of environmental certification¹⁷, either Ekoscan, ISO 14001, UNE 150301/ISO 14006 or EMAS.

As it has been presented, out of all the analyzed facilities, this is the only company that has all the above certifications implemented, and there was great interest in studying what has been their environmental management evolution.

As it was a quite small company it was not necessary to talk to different people in the company but only to the environmental management responsible as he is in charge of all the environmental issues in the company. Three interviews with the environmental management responsible were needed to carry out this case study.

It should be emphasized that this company has been situated in 4 different headquarters. In 1996 the last transfer took place with a vision to reinforce the quality and environmental management in the company. This way all the building and facilities were built taking into account environmental aspects and optimizing the energy efficiency of this new building. Consequently, the way this company started with its environmental management it might differ from the rest of the companies.

In 1997 the company pretended to get the ISO 14001 certification. Several actions needed to be done until achieving the accreditation. The aspect that took

¹⁷ www.ihobe.net

“more work, effort and investment was the related to the environmental legal requirements”. The company did not have all the legal requirements identified so it had a significant difficulty to look for the applicable requirements in the different laws. In 1998 it was decided to outsource this identification so it could be done in a simple, quick and efficient way.

One of the most important aspects that needed some management was the waste characterization, to look if it was a hazardous waste or non-hazardous waste. As a consequence workers needed to be trained in the way they should handle with hazardous and non-hazardous waste, with packages, waste separation, etc. For these training there were two important groups. On the one hand the training was given to the responsible of the technical areas. This training was much more intensive as they needed to know the legal world and the actions that they needed to take to be as efficient as possible. On the other hand, the training was for the workers in the factory, where the specific actions that they needed to take were being taught.

In 1999 the ISO 14001 certification was obtained but not all the legal requirements were fulfilled at that moment. Due to requirements it was needed to have some permissions but as they had already asked for those permissions, there was not any problem in obtaining the certification. The audits were made once a year to see how the fulfillment was and what the possible aspects to improve could be.

With the outsourced company they worked until 2010 when they decided that all this process of identification of legal requirements could be done through software. In this software all the characteristics of the company were introduced so any new applicable requirements were notified to the company. The person in the company in charge of looking if there is any notification does it once a month.

Nowadays they not only fulfill all legal requirements but they go beyond the law. They read law drafts that will appear in a short time to fulfill the possible requirements. Moreover, the evaluation and control of the ecological measures and processes are carried out in a positive an efficient way: at the beginning of the year

some objectives are established, an action plan for those objectives is developed and through weekly meetings a tracking of the actions and measures is done so it could be done in a more complete and continuous way. Some of the environmental indicators that are measured are: waste generation, water consumption and electricity consumption among others.

Another important aspect that has made possible the development and continuous growth of the environmental management in the company is the awareness that has been transmitted to all the workers since 2003, which allows that they participate proactively and hence, the problems can be identified easily and the action and improvement plans can be carried out as effectively and efficiently as possible. “The clue was to be continuously talking about the environmental policies, actions and projects that were taking place or were going to take place in the company until they become part of the jargon of the company.

To identify the aspects that could be improved, a SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis is normally carried out between the company and the auditors.

In 2003 the company was certified with the EMAS standard that has a component of Environmental Declaration. As are companies that show all their environmental performance this certification does not allow having any requirements without being fulfilled.

Until 2008 there was a special emphasis to seek for measures to improve the ecological impact of the facilities and processes, while now the company is more focused on the product and its development. Their policy is to look for products less environmentally dangerous, with less environmental impact. As a consequence it started to work in eco-design issues with a proactive attitude in 2008 and in 2009 the UNE 150301 was obtained, being one of the first companies in the sector to be certified. The software used for eco-design was developed by them to facilitate the analysis of the environmental aspects of different products over the whole life cycle.

For the development of a chemical product they first look at the sector that they want to have some participation or increase the participation. The different products that are available in that sector are studied and then an analysis for improving those products is done, taking special account of the ecological factor. Each time they “mix one substance with another one, the software makes the simulations to know which are all the possible risks and impacts of the mixture”. They are then analyzed and studied to decide if they go ahead with the development process or not.

One important aspect in the chemical sector is that “you can do a product as dangerous as you want; the legislation does not forbid it. What they require is that you inform the user how harmful your product is”. What this company did was to differentiate itself from the rest just in this aspect: trying to develop products as green as possible. Nowadays they have a green product family which is a 20% of the company turnover in 2012 and they want this rate to be 25% in 2013. These green products help them to enter in the “strong countries” of Europe. They had it clear that they needed exclusive, different and absolutely green product, because they already had a normal product. They did not care so much about the prize but about the ecological aspects. In some cases they did not have to look for distributors and/or clients because these ones were looking for the products that this company was offering.

It is important to highlight that all the environmental management development would have been impossible without the support, interest and active participation of the top management.

All these environmental steps have been communicated and recognized several times since 2010:

- 2010. Finalist in the “Fundación Laboral San Prudencio” due to good environmental practices.

- 2011. Participation in the “Bilbao Eco-design Meeting” to talk about their eco-design experience. They also received this year the eco label for the eco-designed products.
- 2012. The OCDE (Organization for Economic Co-Operation and Development) recognized the company’s work and hence, the company’s eco-design case was published among Europe.

The following graph presents the main milestones that have been described in this case study to represent the environmental management evolution in this company (Figure 25).

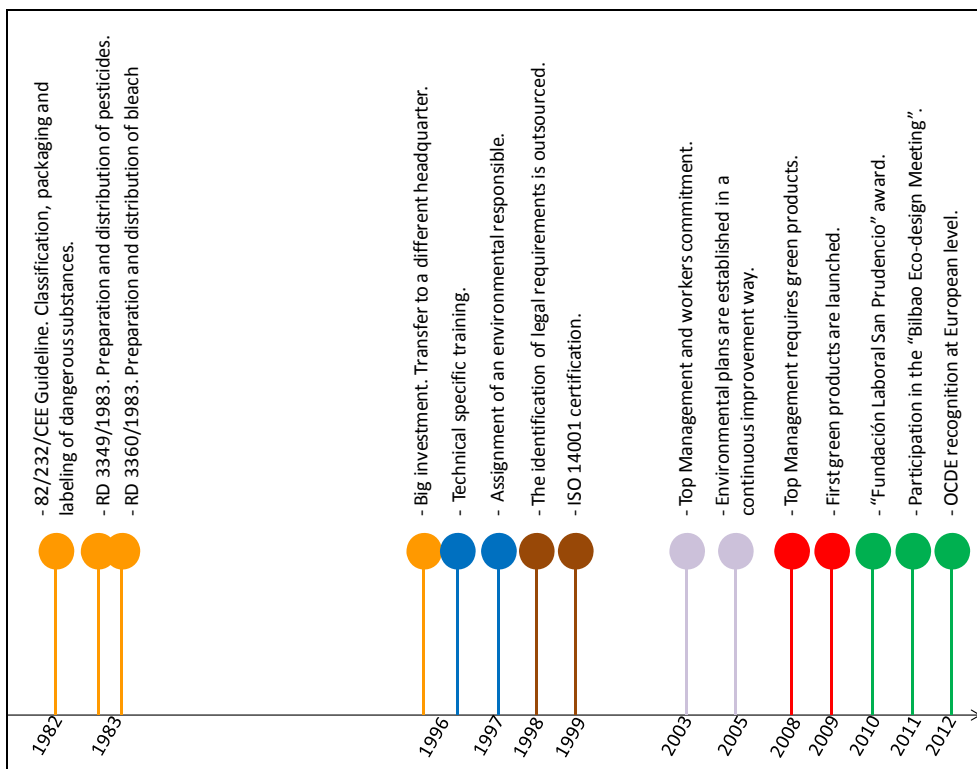


Figure 26. Environmental management milestones in the chemical company

6.1.4 Summary of Main Results

After analyzing the three case studies, it can be observed that the duration of each of the stages in the three case studies is very similar (Figure 27). The stage with the longest duration is Legal Requirements. It should be taken into account that all these durations could be reduced with the EMM Model, as companies will know what to do in each of the stages to move forward without keeping stuck in one of the stages.

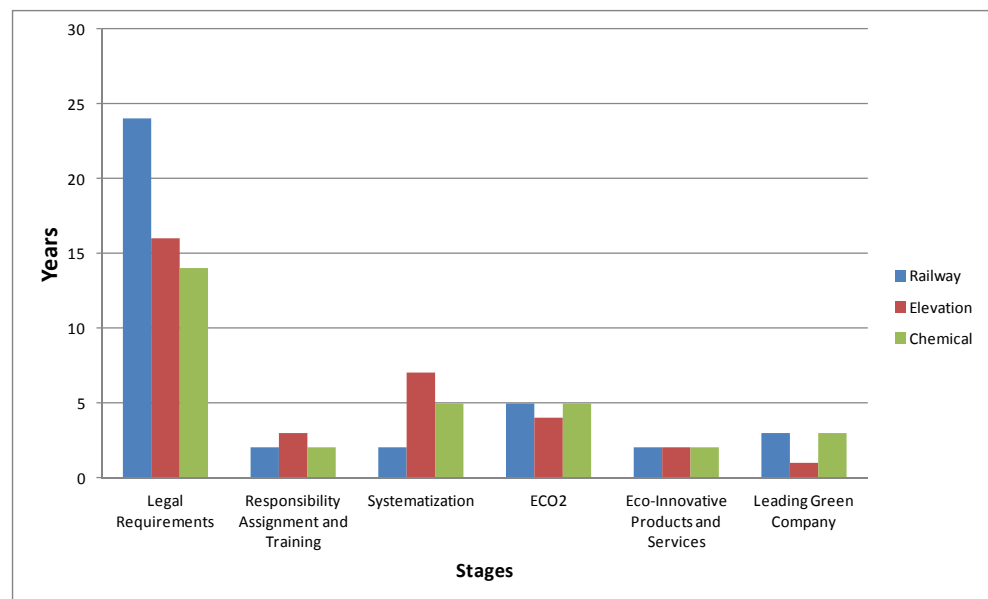


Figure 27. Duration of each stage in the three companies

It might be observed that the evolution and policies taken by these companies correspond to the ones mentioned in the EMM Model. What follows is a table with the main milestones carried out in the companies for each of the described stages in the EMM Model (Table 16). Appendix 7 shows a detailed classification of the milestones identified in each of the companies for each of the stages.

Table 16. Specific milestones in the case studies

	Milestones
Legal Requirements	<ul style="list-style-type: none"> - Identify the corresponding environmental legal requirements (Royal Decree 833/1975, activity license). - Look at the corresponding limits, measure the plant levels (waste characterization...). - Several big investments and measures to manage the main impact sources (filters, canopy, water collector, new building...).
Responsibility Assignment and Training	<ul style="list-style-type: none"> - Assign responsibilities for each project, area or department (involve maintenance people. technical areas...). - Teach the workers in a practical manner to facilitate the work (hazardous and non-hazardous waste, waste separation...).
Systematization	<ul style="list-style-type: none"> - Outsource the identification of the environmental legal aspects (external company, computer tool...). - ISO 14001 certification. - Organize measurements, plan them. Monitor, collect and classify indicators (maintenance department). - Evaluation and control of the ecological measures and processes. - Establish objectives, define an action plan for those objectives and track the actions.

ECO ²	<ul style="list-style-type: none"> - Track the actions in a more complete and continuous way. - Top Management Commitment. - Transmit environmental awareness to all the workers (save and optimize the use of energy), hence, they participate proactively. - Invest in Best Available Technologies (BAT), e.g. move from metal halide lamps to LED lamps. - Consequently, they achieve great economic benefits.
Eco-Innovative Products and Services	<ul style="list-style-type: none"> - Take into account ecological factors in the design of the products and services (recyclability, life cycle assessment...). - UNE 150301/ISO 14006 certification.
Leading Green Company	<ul style="list-style-type: none"> - External communication through the web page, annual report. - Obtain some awards.

There are several aspects that should be highlighted in this section. It can be pointed out that despite all the companies the first thing that they did was to identify the legal environmental requirements; they did not do it in a proper manner until reaching the ISO 14001 certification. This might be because they did not have any environmental path to follow so they just realize that they had to identify legal requirements and fulfill them when they wanted to obtain the accreditation. Nevertheless, through these milestones it could be confirmed the proper order of the three first maturity stages.

On the other hand, it is important to point out that the elevation company introduced eco-innovative products before improving in a systematic way the processes and achieve some economic benefits. Nevertheless, they realized that if they wanted to have a green image and sell green products, they should be green inside the company, so they needed to go back to the ECO² stage.

One of the general comments that was transmitted during the case studies was that big companies had more difficulties in involving the whole company than the small company. This is the case for example of turning off the lights or the computers before going home. It is more difficult to involve the whole company if it is a big company.

Another important aspect to emphasize is that the smallest company has been the one that more green external communication has done among the three. However, all of them agree in the importance of “first do and then talk”, so the communication factor should be at the end of the evolutionary model. Moreover, the three of them think that external communication has become really important and they will need to work harder in this aspect.

Moreover, it is interesting to emphasize the importance that the two first companies give to the maintenance department regarding the environmental issues within the company. They are the ones that measure the indicators and have a control over them. Within smaller companies, such as the chemical one, it is not so common to see this environmental role of the maintenance people, as the environmental management responsible is the one that manages all regarding to environmental issues within the company.

It is important to conclude that these three case studies could be used as case examples of the developed model, so companies can be supported with these cases.

6.2 SIMULATION MODEL

As it has been pointed out in the **Methodology Chapter**, a simulation model has been developed to validate the Causal Loop Diagrams (CLD) representation and consequently, confirm that the Behavior Over Time (BOT) graphs proposed by the experts in the workshops are valid to represent the evolution of the CLD.

For this validation phase Vensim System Dynamics simulation software has been used (Eberlein and Peterson 1992). In **Figure 28**, the structure of the simulation model has been represented with the colors previously used in the

Causal Loop Diagram, to differentiate each of the different stages. As it has been previously explained the representation is with stocks and flows. In **Appendix 8**, all the equations for each of the variables in the simulation model are presented. The model has been calibrated to represent the evolution of an industrial company of about 500 employees. It has been simulated in a period of 5 years, which corresponds to 60 months. It needs to be highlighted that this period of time is different to the case studies' ones as it corresponds to an ideal situation and hence, it can be different depending on the characteristics of the company and how rapidly implements the different policies described in the model.

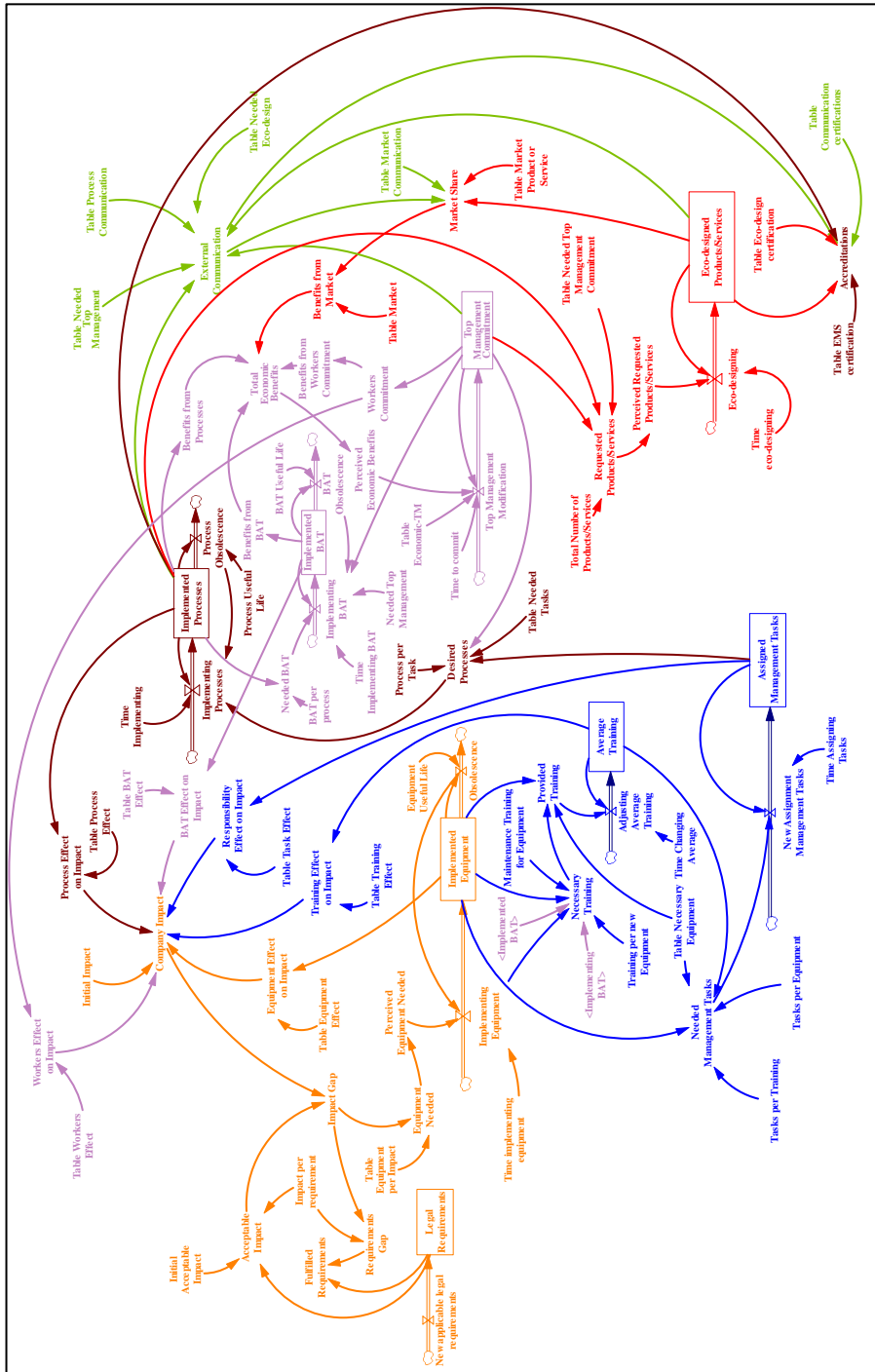


Figure 28. Model simulation structure

The model has been simulated and the variables graphed in the Behavior Over Time (BOT) graphs have been plotted and compared to the ones presented by the experts (Figure 29 and Figure 30). The corresponding variables are:

- Legal Requirements [requirement]. It represents the different environmental requirements that are applicable to the company.
- Fulfilled Requirements [requirement]. It indicates the requirements that the company fulfills.
- Company Impact [$\text{TnCO}_2/\text{month}$]. It measures the impact generated by the company each month.
- Implementing Equipment [equipment/month]. The number of equipment that is being implemented each month is represented.
- Provided Training [hours/month]. The hours provided to the workers in environmental issues are measured each month.
- Implementing Processes [process/month]. The number of processes that are being implemented in the company each month is measured.
- Accreditations [accreditations]. The number of accreditations that the company has regarding environmental issues.
- Implementing BAT [equipment/month]. The best available technology (BAT) to reduce the environmental impact and obtain some costs reductions is measured in this variable.
- Eco-designed Products/Services [products and services]. This variable measures the number of green products and services that have been designed in the company.
- External Communication [hours]. The hours spent in environmental communication are indicated.

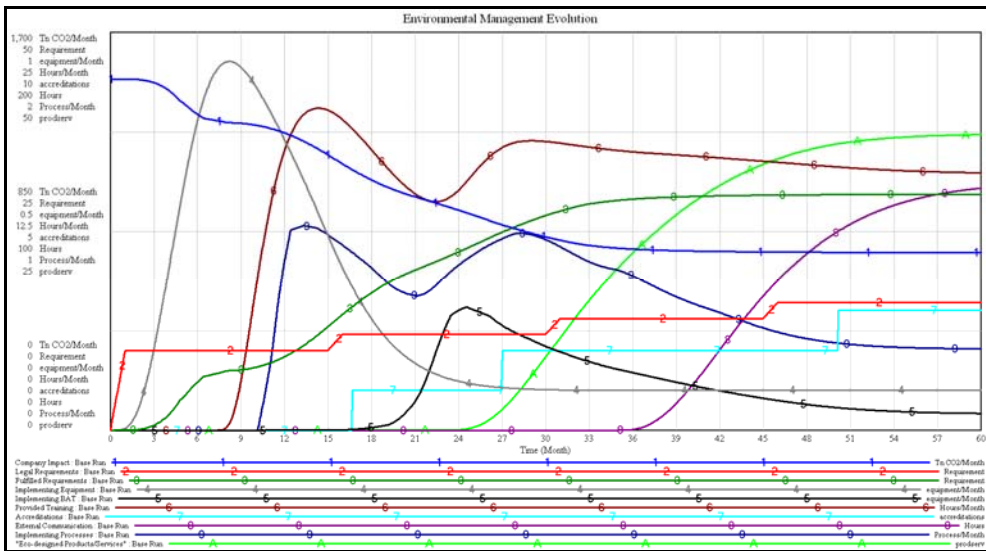


Figure 29. Simulation model BOT

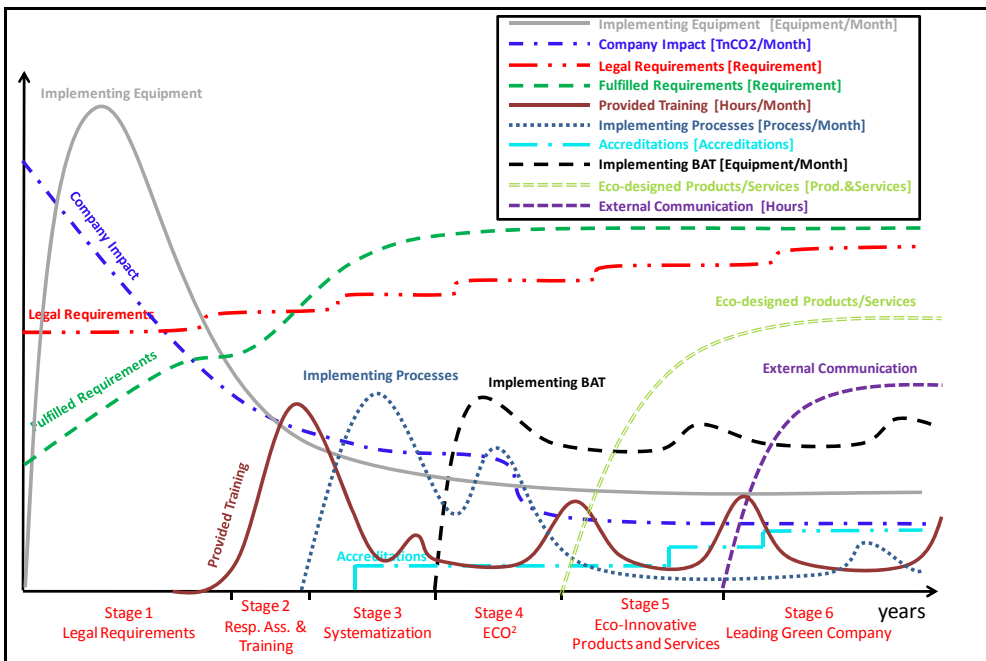


Figure 30. Experts BOT

It can be observed that the simulation model represents the experts' opinion about the behavior of the environmental management in a company. The legal requirements grow each time new laws appear and are applicable to the company. As a consequence the company starts implementing new equipment what will lead to a decrease in the company's environmental impact. As it could be seen the major investment in new equipment is done in the first maturity stage and afterwards it will decrease and remain constant over time, maintaining the equipment of the company.

As it could be observed the environmental impact decreases when new measures are being implemented in the company, this leads to an increase in the legal requirements fulfillment and approximately in the second stage the company will surpass these requirements. This legal fulfillment is due to the environmental management assignment which provides the necessary training to workers, being very high in this second stage and slightly decreases, increasing again if new equipment is introduced.

In the third stage, new processes are being implemented, being this variable quite high but it will increase again in the fourth stage due to the top management commitment. Thanks to the systematization of the processes, the company is able to obtain some certification, so the number of environmental accreditations will increase. In the ECO² stage, the top management applies some resources to the implementation of Best Available Techniques (BAT) what leads to an increase, with some delay, in the provided training, as it has been pointed out before.

In the Eco-Innovative Products and Services stage the company introduces new green products and services what also leads to some certifications, such as, the ISO 14006, increasing the accreditations variable.

Finally, it is in the sixth stage when all the environmental improvements in the processes and the innovations in the products and services are being externally communicated, so the external communication increases.

Consequently, with the graph obtained from the simulation model, it is clear that the CLD structure represents the experts' opinion about the environmental management behavior over time.

CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH

In this chapter the most relevant conclusions of this research are outlined. Moreover, the limitations of the environmental management model are discussed as well as any possible future research.

7.1 CONCLUSIONS

The main conclusions that arise from this research are presented in this section:

- Environmental management is becoming increasingly important not only in big companies but also in small companies as they need to differentiate from the rest of the competitors. Moreover, many of these small companies supply the big companies, so they need to move forward if they want to continue in the same supply network.
- Nowadays, there are many tools that help companies with their environmental management. However, these tools are explained in isolation and there is no indication of which tools should be used depending on the company's current situation. ISO 14001 is one of the most implemented environmental standards that might help companies to implement an Environmental Management System (EMS). Nevertheless, it only indicates what aspects companies should fulfill to obtain the certification and it does not propose the path that companies should follow from the start of their environmental management and after the implementation of an EMS; it does not explain what companies should do to improve their environmental management after the certification.
- The environmental management evolution might be seen as different in each company if we look at the details. Nevertheless, if we look at the environmental management evolution within companies from a wide perspective we can observe many common elements and hence, detect that the evolution is really similar.
- This research proposes an environmental management maturity model (EMM Model) that represents the evolution of environmental

management within industrial companies. Specifically, it should be applied for each SBU in each plant, as they might have different maturity stages. It extends and improves on previous research by adding, in each of the proposed maturity stages, the necessary policies, indicators, explicit causal forces behind the evolution, people involved and Behavior Over Time (BOT) graphs, reaching as a consequence, the objective of this thesis. Consequently, this research goes beyond previous studies that remained at the level of generic categories (Borri and Boccaletti 1995; Venselaar 1995; Berry and Rondinelli 1998; Cramer 1998; Jabbour and Jabbour 2009; Jabbour 2010).

- The research proposal is supported through the use of complementary techniques of grounded theory model-building combined with data review and corroboration through surveys, semi-structured interviews and case studies.
- The EMM Model does not only provide information about how to progress towards environmental excellence but it also explains why the proposed evolution happens.
- The EMM Model might have several uses:
 - The maturity stages and milestones form a logical sequence of events leading to environmental management excellence, and can thus serve to provide guidance for companies aiming to further develop their environmental management activities. As a consequence, companies will be able to follow the proposed model having as a reference the environmental management path of the studied companies. Moreover, this classification helps companies to understand the need for non-technical elements in the process, such as top management commitment and workers involvement.
 - This study will help public policies with respect to getting companies thinking more about their environmental management

strategy. It will help them to guide companies towards environmental excellence.

- The EMM Model might be a good tool for consultants to help other companies that want to improve their environmental management as it provides a technique for assessing maturity stages as well as steps that can assist their ecological advancement.
- This model might also be useful for companies willing to assess and help their suppliers with their environmental management.

7.2 LIMITATIONS

The EMM Model, developed in this research, presents some limitations regarding its applicability. As it can be useful for all type of industrial companies, it is very general and it does not consider the specific characteristics of each company. Moreover, the quantitative part of the model will need further study as this model has been focused on the qualitative part.

Another limitation of the research is that it has not been possible to implement the full model in a company, as this implementation may take quite a long time depending on the company's particularities. However, the validation of the model has been than through surveys, semi-structured interviews and case studies to prove its validity.

7.3 FUTURE RESEARCH

One of the most immediate future works that derives from this research is the development of user-friendly software to guide companies in the evolution of their environmental management. This model might be the basis of the software.

Future research will also do an analysis of the interrelationships among companies and external companies, such as suppliers, as it would extend the boundary of the model to include the effects of strategic partnership and on environmental management.

Another aspect to take into account in future research is the implementation of the whole model in a company that is starting with environmental issues and observe the direct results of the implementation of the model.

On the other hand, as the model is quite general as it wants to enclose almost all type of companies, future research can also focus on specific sectors so the model can be more detailed depending on the sector it is operating.

Moreover, future research should shed light on different trajectories between manufacturing and service firms. In particular, it should explore why some companies appear to get trapped in specific maturity stages and do not aim to develop their environmental management activities further.

And finally it would be very interesting to analyze more systematically the link between underlying drivers, company characteristics and outcomes for the different maturity stages.

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PUBLICATIONS

In this section the publications at conferences, journals and book chapters are presented. A total of 5 publications in journals, 1 book chapter and 8 international conference papers have been accepted during this thesis.

P.1 PUBLICATIONS IN SCIENTIFIC JOURNALS OR BOOKS

Authors: M. Ormazabal and J.M. Sarriegi

Title: Estudio de la Evolución de la Gestión Ambiental en Empresas Industriales

Journal: Revista Electrónica de Medioambiente, vol. 11, pp. 97-107

Place and Date: Madrid, 2011

Indexed in Latindex

Authors: M. Ormazabal and J.M. Sarriegi

Title: Environmental Management: Explaining its Evolution through Maturity States

Journal: Environmental Quality Management, vol. 22 (1), pp. 31-42

Place and Date: USA, 2012

Indexed in Scopus

Authors: M. Ormazabal and J.M. Sarriegi

Chapter: Environmental Management in Industrial Enterprises: A Multiple Case Study

Book: Industrial Engineering: Innovative Networks

Place and Date: London, 2012

Published by Springer

Authors: M. Ormazabal and J.M. Sarriegi

Title: Definición, Dinámica y Alcance de la Eco-Innovación

Journal: Gestión Ambiental, vol. 23

Place and Date: Chile, 2012

Indexed in Latindex

Authors: M. Ormazabal and J.M. Sarriegi

Title: Environmental management evolution: empirical evidence from Spain and Italy

Journal: Business Strategy and the Environment. Online version.
DOI: 10.1002/bse.1761

Place and Date: Asia, 2012

Indexed in ISI Journal Citation Report (JCR)

Impact factor: 1.96 (Q1)

Authors: M. Ormazabal and J.M. Sarriegi

Title: Evolución de la Gestión Ambiental a través de estados de madurez

Journal: Dirección y Organización, vol. 49, pp. 17-26

Place and Date: Madrid, 2013

Indexed in Scopus

P.2 CONTRIBUTIONS TO INTERNATIONAL CONFERENCES

Authors: M. Ormazabal and J.M. Sarriegi

Title: Environmental management model and definition of the different maturity states

Conference: 14th QMOD Conference on Quality and Service Sciences ICQSS

Place and Date: San Sebastián, 2011

Authors: M. Ormazabal and J.M. Sarriegi

Title: Environmental Management in Industrial Enterprises: A Multiple Case Study

Conference: V International Conference on Industrial Engineering and Industrial Management

Place and Date: Cartagena, Murcia, 2011

Authors: M. Ormazabal and J.M. Sarriegi

Title: Evolución de la Gestión Ambiental en empresas industriales a través de estados de madurez

Conference: 50th Conference Tecnun

Place and Date: San Sebastián, 2012

Authors: M. Ormazabal and J.M. Sarriegi

Title: Environmental Management Maturity Models

Conference: 50th Conference Tecnun (Poster)

Place and Date: San Sebastián, 2012

Authors: M. Ormazabal, E. Rich and J.M. Sarriegi

Title: Explaining environmental management evolution through maturity states and behavior over time graphs

Conference: System Dynamics Conference

Place and Date: St. Gallen, Switzerland, 2012

Authors: M. Ormazabal

Title: An evolutionary model of environmental management

Conference: PhD Colloquium - System Dynamics (Poster)

Place and Date: St. Gallen, Switzerland, 2012

Authors: M. Ormazabal and J.M. Sarriegi

Title: Explaining companies' environmental management evolution through maturity states

Conference: CRR, Corporate Responsibility Research Conference

Place and Date: Bordeaux, 2012

Authors: Faye McAnulla, Marta Ormazabal, Ralf Barkemeyer, William Young, Anne Tallontire

Title: Environmental Management Standards as a Driver & Inhibitor of Innovation

Conference: CRR, Corporate Responsibility Research Conference

Place and Date: Bordeaux, 2012

GLOSSARY

In the following chapter a glossary is displayed with some of the used terms and acronyms during this dissertation. Together with these terms and acronyms an explanation is presented with the corresponding significance.

BAT:	Best Available Techniques. They are used to reduce emissions and in this model they are seen as the most appropriate techniques to reduce the environmental impact as well as to have some economic benefits.
BOE:	Official Spanish Gazette (“Boletín Oficial del Estado”). Each time a new Spanish law enters into force, it is announced in this “journal”.
BOT:	Behavior Over Time. Representation of different variables over time.
CLD:	Causal Loop Diagrams. Representation with arrows to denote cause-effect relationships.
ECO²:	It has been designated in the model ECO ² to the third stage, to designate that due to ecological improvements that are taking place in the company economic benefits are being achieved.
Ekoscan:	An environmental management system standard for the Basque Autonomous Region.
EM:	Environmental Management.
EMAS:	European Eco-Management and Audit Scheme. EMAS regulation is a voluntary standard of the European Union for environmental management systems.
EMM Model:	The model developed in this thesis has been designated Environmental Management Maturity (EMM) Model.
EMS:	Environmental Management System.

- GMB:** Group Model Building. Methodology for building System Dynamics models in small groups.
- ISO 14001:** International Standards Organization 14001. It is part of the ISO 14000 series for environmental management. Particularly, it is focused on environmental management systems.
- ISO 14006:** International Standards Organization 14001. It is part of the ISO 14000 series for environmental management. It focuses on eco-design replacing the UNE 150301 standard.
- KPI:** Key Performance Indicators.
- LCA:** Life cycle assessment/analysis. It is a technique to assess all the environmental impacts associated with all the stages of a product, from the raw materials to the disposal.
- Model:** A representation of a real problem. A standard to be imitated. In this case it is a representation of the evolution of environmental management within companies and it can be used as a reference model to be imitated.
- RD:** Royal Decree.
- UNE 150301:** The UNE 150301 is a Spanish certification for eco-design that has been annulled by the introduction of the international certification ISO 14006.
- SBU:** Strategic Business Unit. One part of a business with its own plans for activities and use of resources to achieve growth, profits, etc. Each SBU is managed separately.
- SD:** System Dynamic. A computer modelling and simulation methodology.

APPENDIX 1. INTERVIEWS AMONG BASQUE COMPANIES

Appendix 1 shows the questions that were made to environmental managers of the 19 Basque companies. It was a first round of interviews to take information about how environmental management evolves among companies. They were open-ended questions taking more time in those questions that the company was more confident with because they had done more things in those areas and taking less time in those questions that they could not provide any information as they had not done anything in those issues.

Company's initial situation

- Certifications: ISO 14000, EMAS, Ekoscan:
 - Do you have any environmental certification?
 - What has been the reason of obtaining this certification?
 - Why do you obtain some certifications and not other ones?
 - Have these certifications been obtained due to external requirements or due to the own company's conviction to improve its environmental management?
 - With the certifications, has any aspect been improved within the company? Which one?

Reasons and motives why good environmental practices are implemented

- Clients and Market:
 - Do clients demand any environmental requirement? Do they choose any brand depending on product environmental characteristics?
 - Is there any competition in this area? Do enterprises in the sector acquire improvements in their environmental practices?
 - Can a better position in the market be obtained as a consequence of providing environmental management improvements?

- Environmental management capitalization:
 - What are the results obtained as a consequence of a good environmental management?
 - Does it imply a large cost taking environmental measures?
 - Do you make a profit out of environmental improvements?
 - Does it provide name recognition? Do the clients appreciate it?

How is the environmental management implemented and measured?

a) Social

- Environmental Management influence inside the company
 - Is environmental training provided in the company? What types of courses are taught? Who are these courses aimed for?
 - Is awareness attempted to increase among all the employees or only among those who work with environmental issues? Do awareness measures exist through posters, recycling points...?
 - Is environmental management focused on aspects directly related to the product?

b) Formal

- Indicators to measure company's environmental impact
 - What types of indicators are being used? CO₂ emissions, energy consumption, resources reduction...?
 - Who does the measurement?

- Are there external auditors who measure these aspects?
- Are these indicators being presented to all the employees? To the clients? To Society?

c) Technological

- Equipment or technology to reduce the environmental impact
 - Do you have any equipment that reduces environmental impact?
 - Do you have any equipment to recycle waste?
 - Do you buy equipment taking into account its environmental requirements?

Eco-Innovation Relation

- “Eco-innovation” inside the company
 - Do environmental innovations take place in products/services? What environmental improvements have been done in products or services?
 - Do environmental innovations take place in processes? Which ones?
 - Are the environmental improvements the main objective of the environmental innovations or they are derived from other objectives such as productivity or quality improvement...?
 - Who promotes these innovations?
 - Internal factors: employees, suppliers...
 - External factors: clients, society, legislation...

- When creating a new product or service or improve a process, are environmental aspects taken into account?
 - Energy consumption,
 - CO₂ footprint,
 - Life Cycle assessment (LCA) ...

APPENDIX 2. SPANISH AND ITALIAN SURVEY

Appendix 2 shows the structure of the survey that was made among Spanish and Italian companies. The objective of this survey was to validate the preliminary maturity model. To achieve this objective, the survey consisted of four different sections, as it has been mentioned before. The first part was focused on the order of the different maturity stages. The second part paid attention to the factors that take part in each of the different stages. This section did not provide direct input to the EMM Model, so the results of this part are presented in this Appendix. The third part was to know if they could position themselves in one of the aforementioned maturity stages. The last part consisted of general information about the companies.

A2.1 SURVEY STRUCTURE

[Leave survey](#)
[Continue later](#)

1.- Identifying the evolution's maturity stages

Our objective is to check how the environmental management really evolves within the firms. So, let's answer to the questions NOT thinking to how the evolution SHOULD BE in an ideal way, but to HOW IT IS.

In the evolution model we're designing we've identified some maturity stages which almost every firm gets across; here they're shown in ALPHABETICAL order:

ECO2: the firm tries to reduce its costs thanks to environmental management

ECO-INNOVATION: the firm develops and/or uses some environmental tools to design products, processes or services more "green"

LEADING GREEN COMPANY: the firm takes care to externally share and communicate its environmental practices and it is socially recognized as a reference in matter of environmental management.

LEGISLATION FULFILLMENT: the firm takes care to comply with minimum requirements giving by existing legislation

SYSTEMATIZATION: there is a formalization of the environmental management, and sometimes the company tries to reach an environmental certification

TRAINING: the firm tries to train its workers in using new equipments or new measures that are being implemented.

1. Do you think there are any maturity stages missing?

If yes, explain it

Added Stage 1:

Added Stage 2:

Added Stage 3:

***2. Put the different stages in the order in which they appear in the evolution of a firm's environmental management.**

"1" means that the maturity stage is the first to appear in chronological order; "9" means that is the last one (in case you think appear nine separate maturity stages).

You can use the same ranking for more stages meaning that they're parallel.

You can also add in the ranking the missing stages identified previously.

If you think the stage doesn't exist or couldn't be strictly considered as a "maturity stage", choose the option "no".

	no	1	2	3	4	5	6	7	8	9
ECO2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Eco-Innovation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Leading Green Company	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation Fulfillment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Systematization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Your added Stage 1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Your added Stage 2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Your added Stage 3	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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2.- Identifying the factors in each maturity stage

Here there is a brief description of the factors that you're going to evaluate:

ENVIRONMENTAL MEASURES AND ACTIONS: represents the intensity of the actions in matter of environment to lower the firm's environmental impact

EXTERNAL COMMUNICATION: represents the way in which the firm communicates externally its environmental commitment and its results about environmental issues

FORMALIZATION: measures the firm's grade of systematization in its environmental management (with the possibility of certifying it)

GREEN IMAGE: measures in what way the market perceives the company as committed to the environmental issues

GREEN PRODUCTS AND PROCESSES: measures how the firm is able to develop innovative processes and products with low environmental impact

LEGISLATION: measures the intensity in which the legislation affects the firm's strategies and commitment in matter of environment (with laws, penalties...)

MARKET REQUIREMENTS: measures the market's influence on the firm's environmental management strategies/commitment

PROCESS EFFICIENCY AND SAVINGS: indicates in which way the firm is able to achieve savings and efficiency in its processes thanks to the environmental management

TOP MANAGEMENT COMMITMENT: measures how the Top Management is committed to environmental issues

TRAINING: measures the intensity of training given to employees to use environmental friendly technologies and/or to increase their commitment about environmental issues)

3. Which factors take part in the "ECO2" stage? In what measure do they take part?

	1. No influence	2. Very low	3. Low	4. High	5. Very High
Environmental measures and actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
External communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formalization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green Image	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green product and processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Processes efficiency and savings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Top Management Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. Do you think there are any factors missing?

Rate in what measure they take part as done with the previous ones.

Factor 1:

Factor 2:

Factor 3:

5. Which factors take part in the "Eco-innovation" stage? In what measure do they take part?

	1. No influence	2. Very low	3. Low	4. High	5. Very High
Environmental measures and actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
External communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formalization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green Image	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green product and processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Processes efficiency and savings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Top Management Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**6. Do you think there are any factors missing?
Rate in what measure they take part as done with the previous ones.**

Factor 1:

Factor 2:

Factor 3:

7. Which factors take part in the "Leading Green-Company" stage? In what measure do they take part?

	1. No influence	2. Very low	3. Low	4. High	5. Very High
Environmental measures and actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
External communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formalization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green Image	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green product and processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Processes efficiency and savings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Top Management Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**8. Do you think there are any factors missing?
Rate in what measure they take part as done with the previous ones.**

Factor 1:

Factor 2:

Factor 3:

9. Which factors take part in the "Legislation fulfillment" stage? In what measure do they take part?

	1. No influence	2. Very low	3. Low	4. High	5. Very High
Environmental measures and actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
External communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formalization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green Image	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green product and processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Processes efficiency and savings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Top Management Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. Do you think there are any factors missing? Rate in what measure they take part as done with the previous ones.

Factor 1:

Factor 2:

Factor 3:

11. Which factors take part in the "Systematization" stage? In what measure do they take part?

	1. No influence	2. Very low	3. Low	4. High	5. Very High
Environmental measures and actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
External communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formalization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green Image	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green product and processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Processes efficiency and savings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Top Management Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

12. Do you think there are any factors missing? Rate in what measure they take part as done with the previous ones.

Factor 1:

Factor 2:

Factor 3:

13. Which factors take part in the "Training" stage? In what measure do they take part?

	1. No influence	2. Very low	3. Low	4. High	5. Very High
Environmental measures and actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
External communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formalization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green Image	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green product and processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Processes efficiency and savings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Top Management Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**14. Do you think there are any factors missing?
Rate in what measure they take part as done with the previous ones.**

Factor 1:

Factor 2:

Factor 3:

15. Which factors take part in "Your added stage 1"? In what measure do they take part?

	1. No influence	2. Very low	3. Low	4. High	5. Very High
Environmental measures and actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
External communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formalization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green Image	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green product and processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Processes efficiency and savings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Top Management Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**16. Do you think there are any factors missing?
Rate in what measure they take part as done with the previous ones.**

Factor 1:

Factor 2:

Factor 3:

17. Which factors take part in "Your added stage 2"? In what measure do they take part?

	1. No influence	2. Very low	3. Low	4. High	5. Very High
Environmental measures and actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
External communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formalization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green Image	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green product and processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Processes efficiency and savings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Top Management Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**18. Do you think there are any factors missing?
Rate in what measure they take part as done with the previous ones.**

Factor 1:

Factor 2:

Factor 3:

19. Which factors take part in "Your added stage 3"? In what measure do they take part?

	1. No influence	2. Very low	3. Low	4. High	5. Very High
Environmental measures and actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
External communication	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formalization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green Image	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Green product and processes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Processes efficiency and savings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Top Management Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Training	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**20. Do you think there are any factors missing?
Rate in what measure they take part as done with the previous ones.**

Factor 1:

Factor 2:

Factor 3:

[Leave survey](#)[Continue later](#)

3.- Feedback

21. Once you have read our questionnaire, understanding the maturity stages we've identified, does it help you to put your company in one of the maturity stage?

- NO
 YES: which of them? why?

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4.- Information about the firm

22. Name of the company:

***23. Number of workers:**

- 0-10 11-50 51-250 >250

***24. Organizational sector:**

- Manufacturing
 Other: please specify

***25. How could you define your market size?**

- Local Regional National International

***26. What is the task in the company of who have filled the questionnaire?**

- CEO
 Environmental Manager
 Other:

27. Do you want to receive a feedback about the results of this questionnaire?

- No
 Yes; this is the email where I want to receive it

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A2.2 OTHER SURVEY RESULTS

Participants were asked to identify the main factors in each of the maturity stages. The factors that were identified from the semi-structured interviews among Basque companies were analyzed:

- Legislation (Environmental regulation).
 - Top management commitment.
 - Environmental measures and actions (Environmental impact).
 - Formalization.
 - Training.
 - Process efficiency and savings (Savings).
 - Market requirements (Market demands).
 - Green products and processes
 - Green Image
 - External Communication.
- } (Company green image).

In the analysis of the answers, it was assigned a value 0 to 'No influence', 1 to 'Very Low' and so on until 4 to 'Very High'; as it was more coherent with the meaning of the judgments themselves. The following analysis was done according to the order of the different maturity stages, starting from Legislation Fulfillment and ending with Leading Green Company.

Legislation Fulfillment

Table 17 summarizes the average score and the variance for each of the proposed factors. They were ordered according to the obtained average score, from the factor that most affected the Legislation Fulfillment stage to the one that affected it less (Table 17). The Legislation factor was eliminated from this classification as it did not have sense to evaluate it in the Legislation Fulfillment stage. Top management commitment was considered very important with an average score of 2.85 out of 4.00. Environmental measures and actions had an average score of 2.58 with a very low variance. On the other hand, Green image, External communication, Green products and processes and Market requirements seemed unimportant during this maturity stage.

Table 17. Influence of the Legislation Fulfillment factors

Legislation Fulfillment factors	Average	Variance
Legislation	3.67	0.298
Top management commitment	2.85	1.015
Environmental measures and actions	2.58	0.803
Formalization	2.20	1.274
Training	2.11	1.173
Processes efficiency and savings	1.85	0.830
Market requirements	1.69	1.662
Green products and processes	1.62	1.166
External communication	1.22	1.470
Green Image	1.05	1.349

Training

Table 18 indicates the influence of all the factors (except Training) in the second maturity stage. Top management commitment gained more strength in this stage with an average value of 3.22, which was higher than the previous maturity stage value. Processes efficiency and savings began to increase. The less important factors were the same as the previous maturity stage ones, External communication, Green products and processes, Market requirements and Green Image, pointing out that these factors did not have much of an effect on the first steps of the environmental management evolution.

Table 18. Influence of the Training factors

Training factors	Average	Variance
Top management commitment	3.22	0.581
Formalization	2.38	1.092
Environmental measures and actions	2.24	0.851
Legislation	2.20	0.756
Processes efficiency and savings	2.04	1.221
Green Image	1.55	1.327
Market requirements	1.51	1.329
Green products and processes	1.45	1.215
External communication	1.36	0.976

Systematization

In the Systematization maturity stage the formalization factor was not analyzed. The answers were characterized by a minor global variance (Table 19) and the factor considered as the most important one was the Top management commitment (3.38). Training continued having a relevant importance while Processes efficiency and savings and Environmental measures and actions started having a more significant weight too. The last four positions of the ranking in terms of average score were still occupied by the same factors of the previous maturity stages.

Table 19. Influence of the Systematization factors

Systematization factors	Average	Variance
Top management commitment	3.38	0.463
Processes efficiency and savings	2.85	0.608
Training	2.85	0.867
Environmental measures and actions	2.84	0.547
Legislation	2.36	0.495
Green Image	2.29	0.877
Green products and processes	2.24	0.888
Market requirements	2.16	0.806
External communication	2.02	1.203

ECO²

In the ECO² maturity stage the respondents considered Processes efficiency and savings, Top management commitment and Environmental measures and actions as the most important factors with average scores of 3.35, 3.15 and 2.98 respectively (Table 20). The average score of Formalization notably decreased; which did not mean that the grade of formalization decreased, but that formalization's influence was minor in this stage. The factors judged as the less important were Market requirements, Green Image and External communication and this time also Legislation, whose importance remained somewhat constant through the evolution of the environmental management.

Table 20. Influence of the ECO² factors

ECO ² factors	Average	Variance
Processes efficiency and savings	3.35	0.564
Top management commitment	3.15	0.460
Environmental measures and actions	2.98	0.574
Training	2.71	0.618
Formalization	2.49	1.069
Green products and processes	2.20	0.867
Legislation	2.04	1.258
Market requirements	2.00	1.037
Green Image	1.75	0.971
External communication	1.24	0.999

Eco-Innovation

Analyzing the results of the Eco-Innovation maturity stage, it can be observed in Table 21 that the Top management commitment was considered the most important factor, with the highest average (3.15), and also with a low variance (0.708). There were other factors with high average scores as well: Green products and processes (3.13), Green Image (3.00), Environmental measures and actions (2.77) and Market requirements (2.75), which showed a very relevant growth compared with the previous stages. The last factors in terms of average score were External communication (2.38) and Legislation (1.92).

Table 21. Influence of the Eco-Innovation factors

Eco-Innovation factors	Average	Variance
Top management commitment	3.15	0.708
Green products and processes	3.13	1.155
Green Image	3.00	1.077
Environmental measures and actions	2.77	0.755
Market requirements	2.75	0.573
Processes efficiency and savings	2.68	0.914
Formalization	2.53	1.254
Training	2.43	1.097
External communication	2.38	1.239
Legislation	1.92	0.763

Leading Green Company

A sensible global growth in matter of importance of the factors was underlined in the last maturity stage (Table 22); with the only exception of Legislation, whose average score decreased further and occupied the last position of importance. The greatest growth was the average of External Communication that achieved a score of 3.48, placing it among the three most important factors. The first two were Top management commitment and Green Image, both with an average score of 3.52. The factors that did not influence much were Market requirements, Training and Legislation.

Table 22. Influence of the Leading Green Company factors

Leading Green Company factors	Average	Variance
Top management commitment	3.52	0.330
Green Image	3.52	0.594
External communication	3.48	0.519
Green products and processes	3.43	0.400
Environmental measures and actions	3.09	0.425
Processes efficiency and savings	2.96	0.640
Formalization	2.87	0.719
Market requirements	2.83	0.896
Training	2.69	0.899
Legislation	1.83	1.047

With all this information a graph was created to represent the importance of these factors over the six maturity stages (Figure 31).

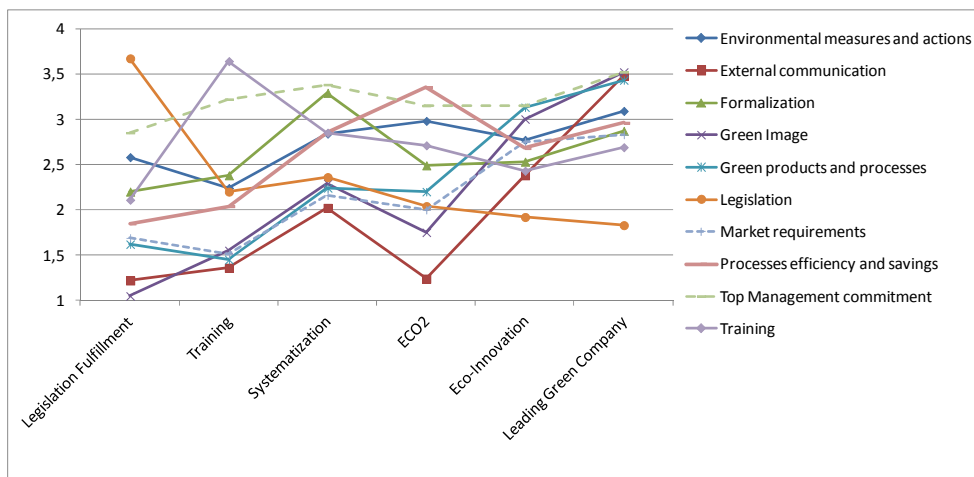


Figure 31. Factors' importance in the Spanish and Italian survey

Within these maturity stages, the importance of the environmental factors has been identified. It can be concluded that there are two factors that are highly important during all the stages: the top management commitment (particularly in the last stages) and the environmental measures and actions. Some other examples of this evolution are: legislation, external communication and formalization. Legislation is really important at the beginning but afterwards its importance decreases. A significant growth is observed regarding external communication. And formalization is quite important in the systematization stage.

APPENDIX 3. SURVEY AMONG UK COMPANIES

Appendix 3 shows the survey that was made among UK companies. The objective of this survey as it has been mentioned before was to validate the EMM Model with UK companies and to identify the proactive companies that were willing to communicate their experience in their followed path towards environmental excellence.

Environmental management evolution in your company

In this section we are looking at how corporate approaches to environmental management evolve over time.

In our previous research we have identified the following stages which firms tend to progress through towards environmental excellence:

1. LEGAL REQUIREMENTS: the firm identifies environmental regulations and introduces new equipment.
2. RESPONSIBILITY ASSIGNMENT AND TRAINING: the firm assigns an environmental management responsible and trains its workers in using new equipment, such as air quality monitors or new measures that are implemented.
3. SYSTEMATISATION: environmental management is formalised, and sometimes environmental certification is achieved.
4. ECO2: the firm reduces its costs due to environmental improvements in its processes.
5. ECO-INNOVATIVE PRODUCTS AND SERVICES: the firm develops and/or uses some environmental tools to design "greener" products or services.
6. LEADING GREEN COMPANY: the firm externally communicates its environmental performances and it is recognised as a leader in environmental management.

As not all companies are at the same level of environmental management, we are interested in finding out about your company's position.

*** 1. Do you agree with the order we have proposed above?**

- Yes
- No (please comment below)

Comment

*** 2. In which state is your company right now?**

- Legal Requirements
- Responsibility Assignment and Training
- Systematisation
- ECO2
- Eco-Innovative Products and Services
- Leading Green Company

*** 3. Has your company passed through all the previous states until reaching the present state?**

- Yes
- No (please, state below which states have been omitted)

Omitted states

*** 4. In your own experience, to what extent have the factors below acted as drivers to reach the present state of environmental management in your organisation?**

	1-Small influence	2	3	4- A great influence	N/A
Corporate image improvement	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Productivity increase	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Top Management Commitment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Process efficiency and savings	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Innovation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Society Requirements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
International trade barriers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market Requirements (customers, competitors, suppliers...)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Market position (market share) improvement	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Internal environmental awareness	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Legislation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Other/s (please specify)

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Company profile

All information provided in this survey will remain strictly confidential. However, as the respondent's position within/relation to the company might affect the survey outcome, we would like to kindly ask you to fill out the personal information below. Your email contact will not be used for any other purpose than this specific research project.

15. Company

Organisation name	<input type="text"/>
Country	<input type="text"/>
Sector	<input type="text"/>
Number of employees	<input type="text"/>
Your name	<input type="text"/>
Email address	<input type="text"/>

16. Who in the company decides which standards are used?

- Specialists in particular areas
- General managers
- CSR committee or similar
- Other (please specify)

17. Are you a member of any of the following?

- Company board
- CSR Committee
- Environmental management team
- Marketing/branding team
- Communications team
- None of the above

18. If you would like a copy of the results of the project please tick here:

- Yes

19. FUTURE RESEARCH

We would like to interview some of you so you can provide us with detailed information about your organisation with respect to the evolution of environmental management in your company and the use of standards. Participants will have the opportunity to receive feedback on the current state of environmental management within their company and ways to progress further.

Would you be interested in taking part in this further research?

- Yes
- No

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THANK YOU!!

Thank you for completing our survey - your time is much appreciated!

If you would like to contact us please email:

mormazabal@tecnun.es

Many thanks

Prev

Done

APPENDIX 4. INTERVIEWS AMONG UK COMPANIES

Appendix 4 shows the structure of the interviews that were carried out among UK companies. The idea of the structure was to have the same guide in all the interviews. However, respondents could emphasize what they thought it was more interesting in the evolution of environmental management in their companies.

Legal Requirements

- When/Why/How did environmental concern start in your company? Did environmental regulation influence in this initial concern?
 - When did your company actively start to manage environmental performance? (Year)
 - Which were the first milestones related to environmental management?
 - What were the main drivers for the introduction of environmental management in your company?
 - What tools have been used to reach this aspect? Each tool could be linked to the previously mentioned milestones.

Responsibility Assignment and Training

- Can you please describe any type of environmental management training measures your company has provided?
 - What has been the main reason to introduce environmental training in your company?
 - What tools have been used to reach this stage? (Training tools) What milestones (environmental courses or other activities) have been there? When: In which year?
 - Are there specific employee groups these training measures are focusing on?

Systematization

- What measures have you taken to manage environmental performance in a systematic way? When/How and Why?
 - What has been the main reason to systematize your environmental management?
 - What tools have been used to reach this stage?
 - In which year did you obtain an environmental management system?
 - Do you have any certification? Why? Year?

ECO²

- Have you had economical benefits due to environmental measures that have been taken?
 - What has made your company earn some money due to environmental management?
 - What tools have been used to reach this stage? Which type of measures do you take?
 - Do you systematically record and manage environmental expenditure as well as the benefits derived from environmental management?

Eco-Innovative Products and Services

- Have you introduced any innovation in your products/services that improve environmental impact?
 - What has been the main reason to introduce eco innovation in your company?
 - What tools have been used to reach this stage?
 - Which have been the new products/markets that improve the environmental impact? Year?

Leading Green Company

- Do you consider yourself to be in a leading position among your competitors in environmental aspects?
 - What has made your company to be a leading green company?
 - What tools have been used to reach this stage?
 - Have you won any prize in this field or have you got any other type of recognition due to environmental management? Which ones? Year?
 - Do you have any type of external communication? Which milestones have been there in this stage?

APPENDIX 5. MODEL REPRESENTATION

Appendix 5 presents the whole final EMM Model. It has been represented in different tables for each of the maturity stages: Legal Requirements, Responsibility Assignment and Training, Systematization, ECO², Eco-Innovative Products and Services, and Leading Green Company. In each of the tables the agents involved in the stage, the policies, indicators, tools, CLD and BOT graphs are presented to understand how each stage works and which should be the way to complete each of the stages.

Table 23. EMM Model (1). Legal Requirements

MATURITY STAGE	LEGAL REQUIREMENTS: Identify the environmental requirements that the company has to fulfill and fulfill major requirements (although this can be done without responsibility assignment).	
AGENTS	- Person in charge of legal aspects.	
POLICIES	<ul style="list-style-type: none"> - Identify and have access to the legal requirements: <ul style="list-style-type: none"> o International and national. o State, province, departmental. o Local. related to the following legal environmental aspects: <ul style="list-style-type: none"> o Waste: <ul style="list-style-type: none"> • Hazardous waste. • Used oils. • Inert industrial waste. • Waste similar to urban waste. 	<ul style="list-style-type: none"> • Packages. o Atmospheric emissions. o Discharge of waste water. o Chemical and fuel storage. <ul style="list-style-type: none"> - Estimate the different legal environmental aspects in the company. - Invest in necessary end-of-pipe technologies. - Document and identify the level of compliance. <ul style="list-style-type: none"> o - Revise the law continuously to see if some new legal requirements come up.
INDICATORS	<ul style="list-style-type: none"> - Investment in end-of-pipe equipment (€/turnover). - Environmental requirements (green house gasses emissions, waste generation, water drainage and emissions of other substances under regulation). 	<ul style="list-style-type: none"> - Environmental impact (measure in the company the environmental requirements). - Level of compliance (number of violations, amount of fines...).
TOOLS	<ul style="list-style-type: none"> - Legislative Self-Assessment. - Different laws. - Measurement systems. 	<ul style="list-style-type: none"> - Ihome tools. - Hire waste managers. - Technological equipment.

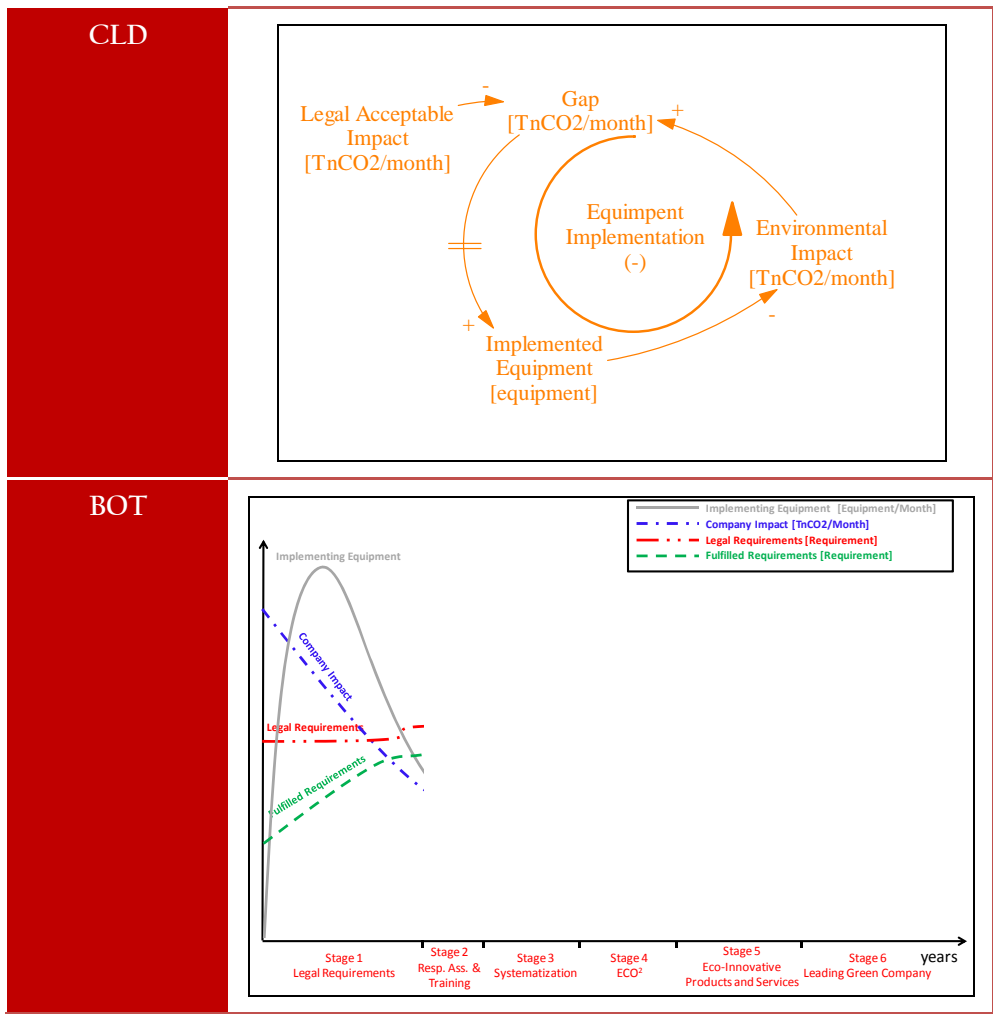


Table 24. EMM Model (2). Responsibility Assignment and Training

MATURITY STAGE	RESPONSIBILITY ASSIGNMENT AND TRAINING: Assign a person in charge of environmental management that consequently will assign responsibilities and will manage the necessary training, what will lead to the fulfillment of almost all legal requirements (this will depend on the sector).	
AGENTS	- Environmental Manager.	
POLICIES	<ul style="list-style-type: none"> - Name an environmental management responsible. - Define and document a legal adjustment plan: <ul style="list-style-type: none"> o Identify the causes of the different environmental impacts. o Identify the law fulfillment actions that should be taken and in which work places. 	<ul style="list-style-type: none"> - Assign responsibilities, duties and resources for each of the actions. - Train the necessary workers so they have the skills to carry out the environmental measures that are being planned. - Implement the environmental actions to fulfill the law. - Check the results and see if more law fulfillment actions are needed.
INDICATORS	<ul style="list-style-type: none"> - Training hours provided. - Number of people trained/total number of workers. 	<ul style="list-style-type: none"> - Environmental tasks explicitly assigned to job descriptions/total amount of tasks.
TOOLS	<ul style="list-style-type: none"> - Basic management tools: <ul style="list-style-type: none"> o Brainstorming. o Flow chart. o Fishbone chart. 	<ul style="list-style-type: none"> - Internal communication /Training tools: <ul style="list-style-type: none"> o Notice board. o Specific courses. o Panels for the work place.

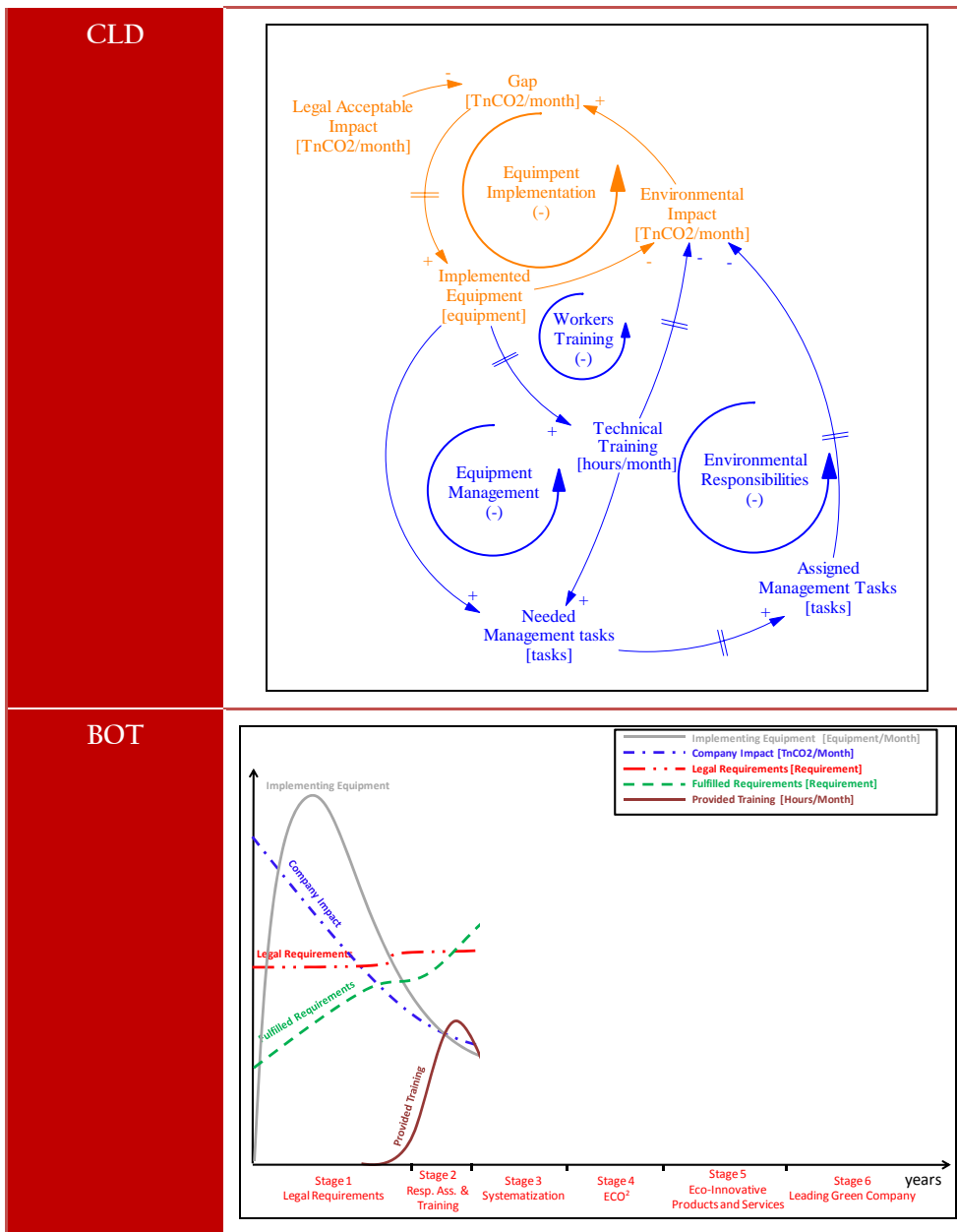


Table 25. EMM Model (3). Systematization

MATURITY STAGE	<u>SYSTEMATIZATION</u>: Formalization of the environmental management.	
AGENTS	- Top Management	
POLICIES	<p>- Document and systematize all the environmental steps that are being carried out in the company.</p> <p><u>Environmental Policy</u>:</p> <p>- The Top Management defines the environmental policy that includes:</p> <ul style="list-style-type: none"> o The commitment to improve the environmental performance within the company in a continuous improvement way. o The commitment to fulfill the different environmental requirements. o The objectives and environmental goals. <p>- The policy is documented, implemented and maintained.</p> <p>- It is communicated to all the workers and available to the public.</p> <p><u>Planning</u>:</p> <p>- Identify the environmental aspects of the company's activities, products and services:</p> <ul style="list-style-type: none"> o Use of raw materials and natural resources. o Use of energy. o Energy emitted, for example, heat, radiations, vibration. o By-products. o Physic properties, for example, size, shape, 	<p><u>Implementation and Operation</u></p> <p>- Procedure of internal communication.</p> <p>- Documents Control.</p> <p>- Operational Control. Identify and plan those operations related to the significant environmental impacts.</p> <p>- Have a preparation and response in case of emergency.</p> <p><u>Verification</u></p> <p>- Assign responsibilities, duties and resources.</p> <p>- Train the workers in new environmental aspects and keep records.</p> <p>- Track and measure the operations that could have significant environmental impacts.</p> <p>- Identify the non-compliances and take corrective actions and preventive actions.</p> <p>- Records control. Records need to be legible, identifiable and traceable.</p> <p>- Internal audit.</p> <p><u>Top Management revision</u></p> <p>- Revise periodically:</p> <ul style="list-style-type: none"> o Internal audits' results. o External communications (complaints). o Environmental performance. o Objectives and goals

	<p>color, appearance.</p> <ul style="list-style-type: none"> - Identify those that have or could have significant impacts over the environment. <ul style="list-style-type: none"> o Define the environmental objectives and goals coherent with the environmental policy. <p>compliance level.</p> <ul style="list-style-type: none"> o Corrective and preventive actions state. o Track the resulting actions from previous revisions. o Improvement recommendations. <p>- All the steps that are carried out from now onwards need to be formalized.</p>
<p>INDICATORS</p>	<ul style="list-style-type: none"> - Hours devoted to environmental management. - EMS certifications. - Documented and/or certified processes / total number of processes.
<p>TOOLS</p>	<ul style="list-style-type: none"> - Template to carry out the actions. - Process map. - Pareto chart - Control chart. - Report. <ul style="list-style-type: none"> - Procedure. - Record. - Systematization guides. - Basic indicators. - Environmental Impact Assessment. - Strategic Environmental Assessment.
<p>CLD</p>	<p>The CLD illustrates the following causal relationships:</p> <ul style="list-style-type: none"> Legal Acceptable Impact [TnCO2/month] (+) leads to Gap [TnCO2/month] (+). Gap [TnCO2/month] (+) leads to Equipment Implementation (-) (-). Equipment Implementation (-) (-) leads to Environmental Impact [TnCO2/month] (-). Environmental Impact [TnCO2/month] (-) leads to Implemented Equipment [equipment] (+). Implemented Equipment [equipment] (+) leads to Workers Training (-) (-). Workers Training (-) (-) leads to Technical Training [hours/month] (+). Technical Training [hours/month] (+) leads to Equipment Management (-) (-). Equipment Management (-) (-) leads to Needed Management tasks [tasks] (+). Needed Management tasks [tasks] (+) leads to Assigned Management Tasks [tasks] (+). Assigned Management Tasks [tasks] (+) leads to Environmental Responsibilities (-) (-). Environmental Responsibilities (-) (-) leads to Systematization (-) (-). Systematization (-) (-) leads to Desired Processes [process] (+). Desired Processes [process] (+) leads to Implemented Processes [process] (+). Implemented Processes [process] (+) leads to Environmental Impact [TnCO2/month] (-). Implemented Processes [process] (+) leads to Implemented Equipment [equipment] (+). Implemented Processes [process] (+) leads to Workers Training (-) (-). Implemented Processes [process] (+) leads to Technical Training [hours/month] (+). Implemented Processes [process] (+) leads to Assigned Management Tasks [tasks] (+). Implemented Processes [process] (+) leads to Environmental Responsibilities (-) (-). Implemented Processes [process] (+) leads to Systematization (-) (-). Implemented Processes [process] (+) leads to Desired Processes [process] (+).

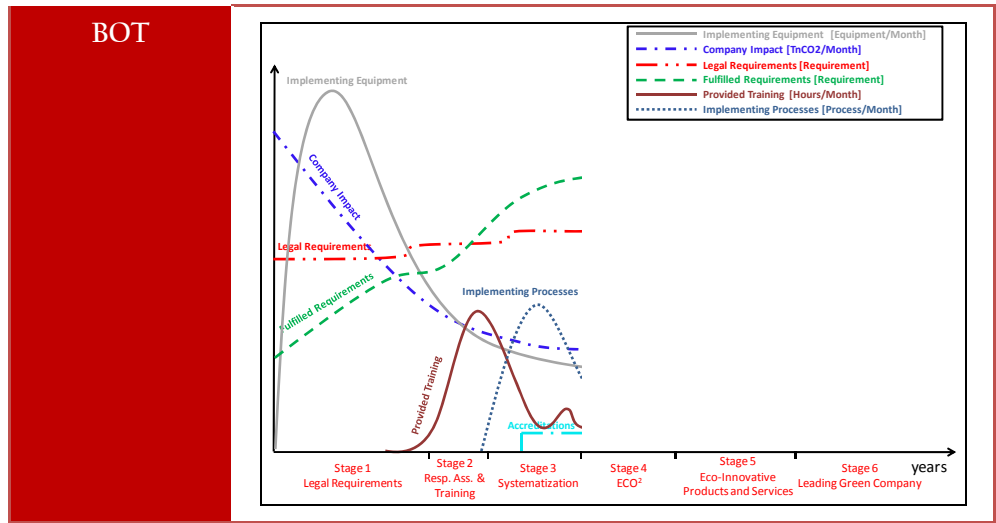


Table 26. EMM Model (4). ECO²

MATURITY STAGE	ECO²: Minimize environmental aspects through a proactive attitude. Obtaining as a consequence economic benefits.	
AGENTS	- Workers.	
POLICIES	<ul style="list-style-type: none"> - Top Management Commitment → Believe that all the previous states are important. - Implement the systematization state in a continuous improvement way. - Identify critical processes: <ul style="list-style-type: none"> o Generation of unnecessary waste. o Excessive consumption of raw materials, energy and water. o Inadequate use of containers and packages. o Inefficient transport. - Prioritize the environmental aspects according to: <ul style="list-style-type: none"> o Quantity. o Dangerous. 	<ul style="list-style-type: none"> o Economic costs. o Minimization and improvement results capacity. - Define objectives. - Define suitable indicators and measure. - Design possible actions/solutions. Economic-technical-environmental viability analysis. - Implement. Implement measures. - Control the results. Track the results and compare them periodically. - Encourage workers' participation in new ideas that may improve environmental aspects while reducing some costs.
INDICATORS	<ul style="list-style-type: none"> - BAT investment. - Consumptions (energy, water...). - Number of environmental audits (internal and external). 	<ul style="list-style-type: none"> - Estimated economic benefits. - Number of workers' suggestions. - Number of workers who send suggestions.
TOOLS	<ul style="list-style-type: none"> - Ideas competition. - Eco efficiency. - Recycling. - Reuse. 	<ul style="list-style-type: none"> - SWOT. - Other sophisticated tools for efficiency that may depend on the specific situation.

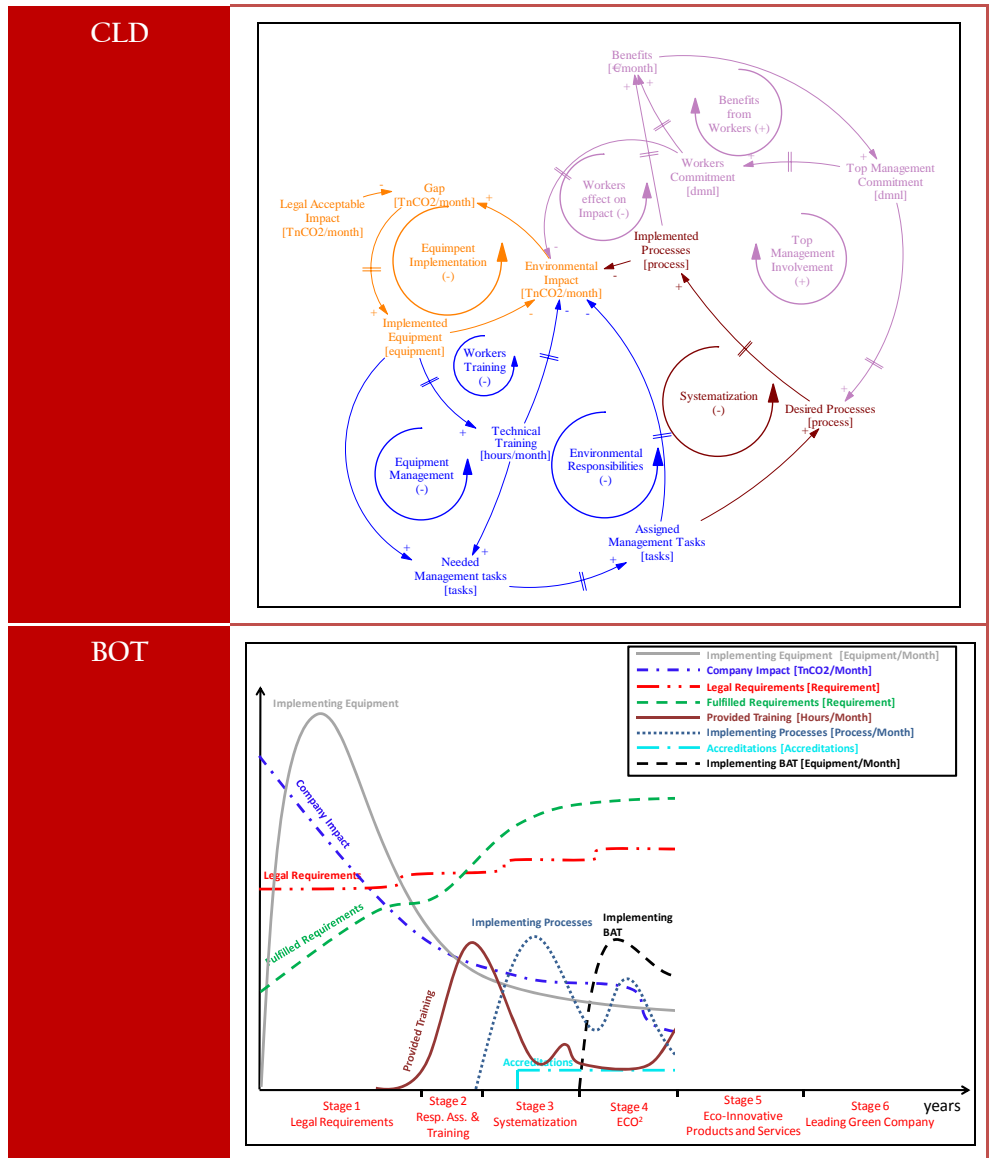


Table 27. EMM Model (5). Eco-Innovative Products and Services

<p>MATURITY STAGE</p>	<p><u>ECO-INNOVATIVE PRODUCTS AND SERVICES</u>: Create new products and services that take into account environmental aspects.</p>	
<p>AGENTS</p>	<ul style="list-style-type: none"> - Research and Development People and Designers. - Commercial people. 	
<p>POLICIES</p>	<ul style="list-style-type: none"> - Identify market demands. - Define some objectives to know where to focus on. - Identify the environmental aspects and impacts from the raw materials acquisition to the final disposal. 	<ul style="list-style-type: none"> - Cooperate with customers and suppliers. - Asses each of the environmental aspects and impacts to identify the most significant ones according to the objectives.
<p>INDICATORS</p>	<ul style="list-style-type: none"> - Number of products/services eco-designed /Total products and services. - Turnover of green products and services / Total turnover. 	<ul style="list-style-type: none"> - Number of new customers due to green products and services. - Amount of products with certified environmental labeling.
<p>TOOLS</p>	<ul style="list-style-type: none"> - Life cycle assessment. - Eco-design. - Eco- Indicator 99. - Recipe. - Benchmarking. 	
<p>CLD</p>		

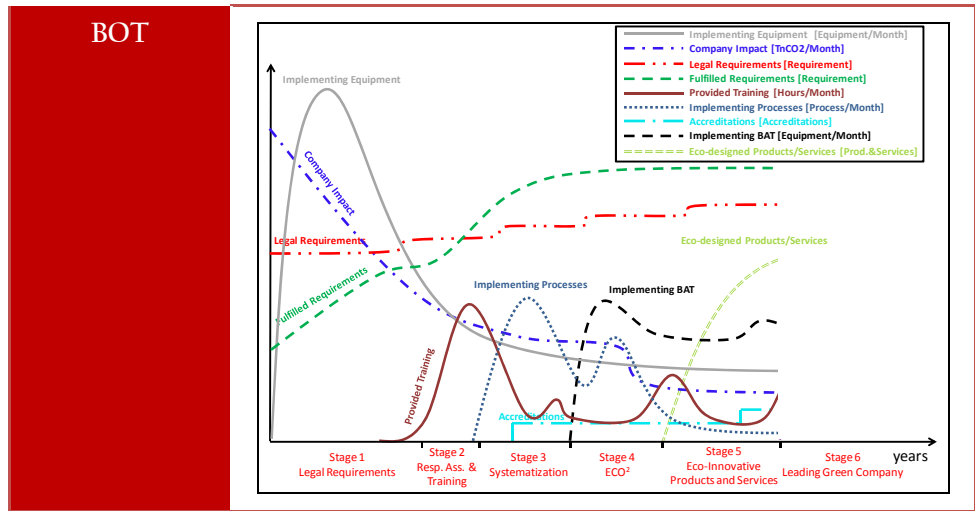
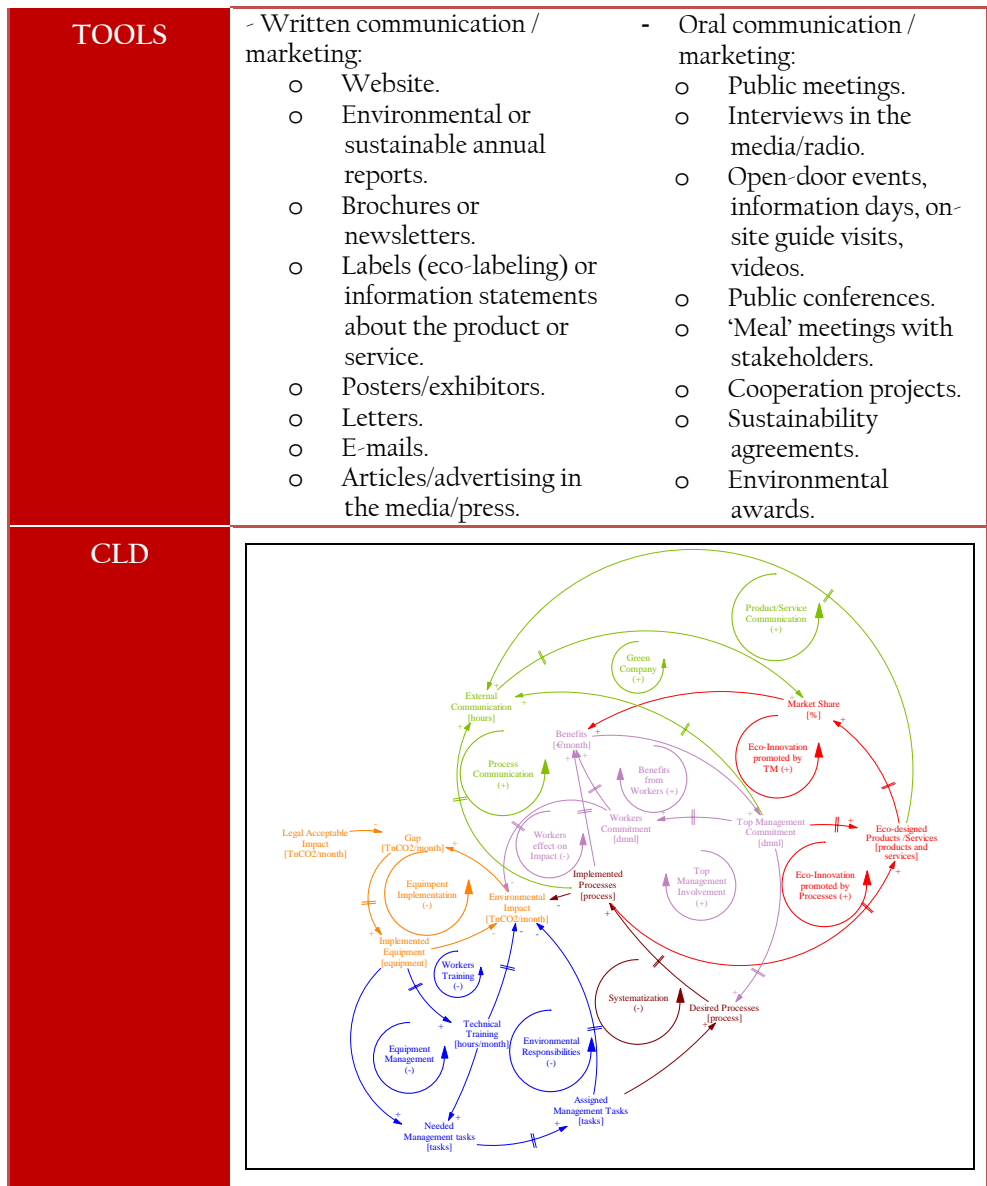
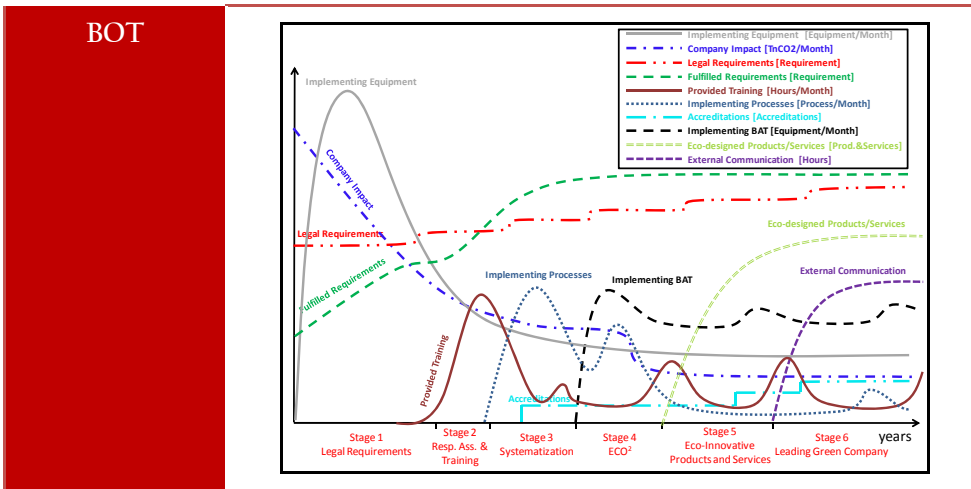


Table 28. EMM Model (6). Leading Green Company

MATURITY STAGE	LEADING GREEN COMPANY: Become a reference company in matter of environmental management through communication and marketing.	
AGENTS	- Communication responsible.	
POLICIES	<ul style="list-style-type: none"> - Collect and asses data. Analyze the situation: <ul style="list-style-type: none"> o Identify the issues that concern stakeholders. o Identify the media and activities that have been effective when communicating to stakeholders. o Identify the opinion leaders and their influence in environmental communication. - Define goals of external communication/marketing regarding: 	<ul style="list-style-type: none"> o The environmental aspects of the different activities, products and/or services. o The environmental actions that are being taken in the company. o The environmental improvements, o The environmental objectives and goals. - Define the geographic scope. - Make an Environmental Declaration regarding all the environmental aspects of the company.
INDICATORS	<ul style="list-style-type: none"> - Number of environmental reports. - Press impacts (number of news). - Number of environment related advertisements. 	<ul style="list-style-type: none"> - Participation in environment related conferences. - Number of awards. - Number of mentions by third parties.





APPENDIX 6. CASE STUDIES' GUIDE

This appendix shows the guide of the case studies that were carried out among three important companies. The idea of the structure was to have the same guide in all the interviews not to miss any important information.

Legal Requirements

- When did you start to identify legal requirements applicable to the firm?
- Which were the main areas in which the legal requirements identification took place? Which were the steps carried out? In which years?
- How often was the regulation revised to look for new applicable requirements? Where was attention paid: Europe, Spain, Basque Country? Was there any person specifically for that?
- Do you have any list of the requirements that have been appearing yearly and in which year they have been fulfilled?
- In which year was internally required a lower impact than the one that required the law?
- Which was the year when you shift from identifying legal requirements to trying to fulfill them?

Responsibility Assignment and Training

- What have been the actions carried out during the years to fulfill the law? When have these actions been taken?
- In which year has employee's training started to carried out the mentioned actions? Which type of training was needed? For how many people? For how long?
- In which year was the first environmental manager designated?
- Were responsibilities designated to carry out the necessary actions?

- How has the evolution been regarding the environmental management training hours?
- Specific training activities. Is it possible to provide any documentation? (procedures, objectives, necessary resources...).
- How the training was when it started and how is at the moment? What are the current environmental training activities? How is that related to the training of previous years? Training evolution.
- Who was in charge of providing training in the different decades? Who is the person in charge today?
- How has the percentage of the total budget dedicated to workers training in environmental issues evolved?
- What was the relation between the identification of legal requirements and the actions planning and training?
- Was legal fulfillment improvement observed due to training? Was/Is there any way to measure that?
- How much time was taken since they took notice of social and legal pressures until they did some specific training?

Systematization

- In which year have the environmental actions started to systematize? How? Did the company follow any recognized standard? How has been this systematization over the years? How is it now? Would you provide us with documentation of those measures and the corresponding years?
- Which were/are the followed steps to get this systematization?

- Did the market pressure the company to be greener and reflect that necessity with systemic plans, processes and/or activities focused on achieving a greener company?
- From which year has the top management been involved in Environmental management issues?
- Who proposed, provided and carried out systematic environmental measures?
- In reference to ISO 14001 Standard. Do you have it implemented? In which year? What was the main reason? What were some of the environmental measures that were carried out to get the certification? Have they led to process and/or product improvements?
- Is it possible to get some documentation of this systematization stage?
- What other accreditations have you achieved over the years? Provide information and documentation.
- Once the systematization is carried out, how is the identification of new legal requirements changed? And the actions implementation? How has the training changed?
- How is the assessment and control of measures and processes carried out with the systematization? Has it changed a lot? How is the tracking of these environmental measures or solutions?
- What were/are the external actions that affect formalization of any environmental measure?
- Is the current system audited from time to time? Is the workers' behavior changed when approaching the audit or alternately, is there a more integrated culture in the organization, being the audit a mere formality?

- How has the evolution of workers' commitment been in these systematization years?

ECO²

- In which year was the systematization implemented in a continuous improvement way?
- How were the environmental aspects and measures prioritized to achieve a greener company? Which have been the efficient measures that have been taken over the years to address these aspects?
- How has the process been to look for improvements? Was it done based on opportunities, necessities or threats?
- In which year were the first economic benefits seen due to environmental measures and actions?
- Which was the payback or the savings of some of the measures? (%)
- In all those environmental measures was payback expected? Or only for the most important ones?
- Have you had any grants to carry out environmental measures?
- Which have been the implemented measures that resulted in any type of economic benefit? What is the percentage of the measures that have any type of economic benefit?
- How was the top management commitment in this stage? What has been the evolution of this commitment?
- How was the workers' commitment? Was their participation active or passive? How are they encouraged to participate in the environmental improvements that could be carried out in the company?

Eco-Innovative Products and Services

- In which year was the first product/service with an environmental perspective created? Why was it created? What was the green innovation about?
- What was the impact of this product/service regarding the economic and social aspects?
- How has the evolution of the percentage of green products been?
- Do customers care about eco-innovative products or services? In which year did the market pressure begin to be felt, in particular customer pressure to have eco-innovative green products or services?
- Nowadays, does the company focus more on green products or services? Which are the main aspects for the company? Why?
- In which year was the environmental factor raised not only as important but as a pillar?
- Which percentage of the budget was/is allocated to research and development of eco-innovative products and services?
- Which have the main factors been when designing and producing eco-innovative products? Which have the followed procedures been? Which tools have been used?
- Was/is the top management committed to eco-innovative projects? In which way?
- Has it been difficult to implement eco-innovative actions?
- How were/are the design and development responsibilities distributed?

- How is the profitability and viability analysis of the eco-innovative products or services done? What are the parameters that need to be taken into consideration?

Leading Green Company

- From which year it could be said that this company is a leader in environmental management? Why?
- How is the green image promoted? From which year is the company's green image managed?
- Do you sell more due to the fact that a product or a service is eco-innovative? From which year it is used as a sell tool? Could you quantify and/or specify actions regarding this point?
- How is the person in charge of the green image?
- How is the information related to the green image leadership managed?
- Have you won any prize due to Environmental management excellence? Which ones and when?
- Have you appeared in press due to environmental issues? How many times? When? Does it have any added value? Why?

APPENDIX 7. MILESTONES IN EACH CASE STUDY

Appendix 7 presents the milestones identified in each of the case studies. These milestones are divided into six groups, which correspond to the six maturity stages of the model.

Table 29. Environmental management evolution in the railway company

Stage	Year	Milestones
1. Legal Requirements	1975	<ul style="list-style-type: none"> - With the RD 833/1975 the control of the atmospheric emissions in the stillworks starts. - The look at the legal limits that appear in the "BOE". - The plant levels are measured and the emissions are diminished in quantity and improved in quality optimizing the equipments and the raw materials. - With the RD 833/1988 the production activities and the hazardous waste management are regulated. - The Basque Government starts to require a License for Hazardous Waste Management with the objective of identifying, declaring and managing hazardous waste. - Important investments to reduce the environmental impact: <ul style="list-style-type: none"> - 3,000 filters in the oven doors to purificate the diffuse emissions. - Canopy in the oven to control the emissions in the steelworks. - Water collector to separate fecal waters and industrial waters.
2. Responsibility Assignment and Training	1998	<ul style="list-style-type: none"> - A legal environmental action is established to deeply assess the environmental emission points and at the same time identify and implement the specific actions to fulfill the legal environmental requirements. - Assign environmental responsibilities to the Maintenance Department in order to measure, control the limits and actions related to the fulfillment of the environmental legal requirements in the different emission points. - The Maintenance Department is also responsible of the hazardous and non-hazardous waste management. - Creation of the ecological committee with wich training sessions are established to group of workers of different departments and areas.
3. Systematization	2000	<ul style="list-style-type: none"> - Creation of the environmental management section to centralize the environmental knowledge, risks and in general the management of the ecological aspects. - The environmental management section is in charge of the ecological responsibilities and works together with the maintenance department that is in charge of the technical environmental aspects. - The identification of legal requirements is outsourced to have all the legal requirements continuously updated. - In 2001 the ISO certification is obtained.
4. ECO ²	2001	<ul style="list-style-type: none"> - Important investments: <ul style="list-style-type: none"> - Heat gasification. - Lighting automation. - Move from halide lamps to LED. - In 2003 energetic studies are carried out to look for savings and improvements in the environmental impact. Some investments are done as a consequence of these studies. - In 2005 an important campaign is launched to commit workers in being more efficient with their places' energy and with the whole plant not to only have economic benefits but also ecological benefits.
5. Eco-Innovative Products and Services	2008	<ul style="list-style-type: none"> - Since the 90's ecological aspects have been taken into account when designing. However is in 2008 when the eco-design has a great importance. - In 2008 a project is carried out to analyze the recyclability of the products, the materials and the components used. A methodology is introduced to control the recyclability in the design phase. - In 2010 another project is carried out to study the environmental aspects during the whole life cycle. - In 2008 the first order with environmental requirements is received and the studied environmental aspects are introduced.
6. Leading Green Company	2010	<ul style="list-style-type: none"> - In 2010 the company makes an environmental management statement in which the environmental aspects that the company has been working to be greener, more energy efficient and committed to society, are presented. - It appears in press due to the achievement of important contracts in different parts of the world showing its internationalization and bringing to light the green factors that help them to achieve these contracts. - Ongoing renewal of their web page to make it even more focused on the environmental aspects.

Table 30. Environmental management evolution in the elevation company

Stage	Year	Milestones
1. Legal Requirements	1980	<ul style="list-style-type: none"> - Acquire the activity licence and consequently meet the 4 or 5 things that the law requires. - RD 2291/1985. Regulation of elevation appliances and their maintenance. It defines the technical conditions that need to meet the elevation appliances installed in Spain and the corresponding maintenance. - RD 849/86. Hydraulic Public Domain Regulation, that is reinforced in EM by the RD 11/95 where the applicable requirements to urban waste water treatment and corresponding discharges are established, limiting the polluting effects.
2. Responsibility Assignment and Training	1996	<ul style="list-style-type: none"> - The necessary training was given, especially to the maintenance people and afterwards the maintenance people were the responsible of spreading their knowledge among the rest of the workers that needed that training.
3. Systematization	1999	<ul style="list-style-type: none"> - Creation of the environmental management department. - In 2001 the ISO 14001 certification is obtained. - The identification of legal requirements is outsourced to have all the legal requirements continuously updated. - Join the Global Compact.
5. Eco-Innovative Products and Services	2006	<ul style="list-style-type: none"> - Top Management Commitment. - In 2006, the company relies on Ihobe to analyze and apply in a simple and preliminary way the eco-design in one of their products. - UNE 150301 (2008) that becomes ISO 14006 in 2011. - Development of their own LCA software that uses the eco-indicator 99. - Some eco-innovations: <ul style="list-style-type: none"> - Elevators' energy standby. - Recovery of braking energy. - Electric cars and efficient driving courses. <p>In 2012 the 58% of the sold products are eco-designed.</p>
4. ECO ²	2010	<ul style="list-style-type: none"> - Due to several leaks, several investments are done and great savings are achieved. - In 2011 a project is carried out to analyze the performance and energetic efficiency: <ul style="list-style-type: none"> - Lighting. - Heating. - Compressed air. - In 2012: optimization of the lighting with an investment of 130,000 €, obtaining savings of nearly 40% of the consumption. - Commitment from workers to save and reduce the environmental impact with measures such as switching off the lights and the compressed air outside working hours.
6. Leading Green Company	2011	<ul style="list-style-type: none"> - Communication has been done since 30 years ago, but environmental communication has started in the last few years. - Entry in the Good Environmental Practices Book of Endesa. - Acknowledgement and prizes in the Basque Country.

* Stage 5 has been carried out before level 4, but this company has realized that level 4 should have been taken before.

Table 31. Environmental management evolution in the chemical company

Stage	Year	Milestones
I. Legal Requirements	1980	<ul style="list-style-type: none"> - 82/232/CEE Guideline that is adjusted to the 67/548/CEE Guideline relative to the classification, packaging and labeling of dangerous substances. - RD 3349/1983, technical health regulation regarding the preparation and distribution of pesticides. - RD 3360/1983 technical health regulation regarding the preparation and distribution of bleach. - Big investment. Transfer to a different headquarter in 1996.
2. Responsibility Assignment and Training	1996	<ul style="list-style-type: none"> - Technical training to workers: <ul style="list-style-type: none"> - Training to the responsible of the technical areas. - Specific training for the workers in the factory depending on their work. - Assignment of the environmental aspects responsible, so the decisions, knowledge and projects could be centralized.
3. Systematization	1998	<ul style="list-style-type: none"> - The identification of legal requirements is outsourced in 1998, so legal requirements are fulfilled in a more systematized way. - ISO 14001 certification in 1999.
4. ECO ²	2003	<ul style="list-style-type: none"> - Top Management Commitment. - EMAS certification in 2003. - Awareness transmitted to all the workers. The environmental issues become part of the jargon of the company. - Measures to improve the ecological impact of the facilities and processes. - There are not too many changes due to the transfer to a new building that is environmentally friendly. - The environmental plans are established (2005) to prioritize, analyze, control and improve the environmental aspects in a continuous improvement way.
5. Eco-Innovative Products and Services	2008	<ul style="list-style-type: none"> - The top management requires green products. - In 2009 the first green products are launched. In 2012 the green product family is a 20% of the company turnover. - Eco design and eco-innovation tools development: LCA, recyclability, environmental impacts... - Own software development for the life cycle analysis. - The package is improved.
6. Leading Green Company	2010	<ul style="list-style-type: none"> - External communication through the web page, press... - Recognition: <ul style="list-style-type: none"> - "Fundación Laboral San Prudencio" award due to good environmental practices. - Participation in the "Bilbao Ecodesign Meeting". - OCDE recognition at European level and the company's eco-design case is published.

APPENDIX 8. SIMULATION MODEL EQUATIONS

Appendix 8 presents the equations that were used in the simulation model. They have been grouped in the different maturity stages and they have been colored according to the representation of the different maturity stages in the Causal Loop Diagram (CLD) and in the simulation model.

Fulfilled Requirements=Legal Requirements-Requirements Gap

~ Requirement

Time implementing equipment=3

~ Month

Requirements Gap=Impact Gap/Impact per requirement

~ Requirement

Equipment Useful Life=96

~ Month

Implementing Equipment=Perceived Equipment Needed/Time implementing equipment+Obsolescence

~ equipment/Month

Obsolescence=Implemented Equipment/Equipment Useful Life

~ equipment/Month

Perceived Equipment Needed=DELAY3(Equipment Needed, 6)

~ equipment

Company Impact=Initial Impact*(Equipment Effect on Impact*DELAY3(Training Effect on Impact*Responsibility Effect on Impact,6)*DELAY3(Process Effect on Impact,3)*BAT Effect on Impact*DELAY3(Workers Effect on Impact,6))^(1/6)

~ Tn CO₂/Month

Impact Gap=Company Impact-Acceptable Impact

~ Tn CO₂/Month

Initial Impact=1500

~ Tn CO₂/Month

Equipment Effect on Impact=Table Equipment Effect(Implemented Equipment)

Table Equipment Effect $(((0,0)-(10,1)],(0,1),(0.391437,0.842105), (0.807339,0.679825),(1.37615,0.561404),(1.92661,0.491228),(3.36391,0.451754),(4.70948,0.447368),(6.48318,0.442982),(7.97554,0.442982),(10,0.443))$

Equipment Needed=Table Equipment per Impact(Impact Gap)

- equipment

Table Equipment per Impact([(-1000,0)-(1000,60)],(-1000,0),(-800,0),(-100,0),(0,0),(272.171,5.2),(455.658,12.6),(626.911,22.4),(730.887,32.6),(800,48))

Acceptable Impact=Initial Acceptable Impact-Impact per requirement*Legal Requirements

- Tn CO₂/Month

Initial Acceptable Impact=1500

- Tn CO₂/Month

Impact per requirement=25

- Tn CO₂/Month/Requirement

Implemented Equipment= INTEG (Implementing Equipment-Obsolescence,0)

- equipment

New applicable legal requirements=10*PULSE(0,1)+2*PULSE TRAIN(15,1,15,80)

- Requirement/Month

Legal Requirements= INTEG (New applicable legal requirements,0)

- Requirement

Necessary Training=(Implementing Equipment+Implementing BAT)*Training per new Equipment+(Implemented Equipment+ Implemented BAT)*Maintenance Training for Equipment

- Hours/Month

Provided Training=DELAY3(Table Necessary Equipment(Implemented Equipment)*Necessary Training,3)

- Hours/Month

Adjusting Average Training= (Provided Training-Average Training)/Time Changing Average

- Hours/Month

New Assignment Management Tasks=(Needed Management Tasks-Assigned Management Tasks)/Time Assigning Tasks

~ Tasks/Month

Time Changing Average=2

~ Month

Training Effect on Impact=Table Training Effect(Average Training)

Time Assigning Tasks=3

~ Month

Maintenance Training for Equipment=1

~ Hours/Month/equipment

Needed Management Tasks=Table Necessary Equipment(Implemented Equipment)*(Implemented Equipment*Tasks per Equipment+Average Training*Tasks per Training)

~ Tasks

Responsibility Effect on Impact=Table Task Effect(Assigned Management Tasks)

Table Training Effect([(0,0.3)-(50,1)],(0,1),(1.22324,0.894737),
(2.29358,0.797368),(3.66972,0.696053),(6.72783,0.594737),(12.5382,0.560965),
(20.3364,0.554825),(31.0398,0.542544),(49.5413,0.542544))

Table Task Effect([(0,0.3)-(100,1)],(0,1),(1.83486,0.858772),(3.36391,0.708333),
(6.11621,0.628509),(8.25688,0.594737),(9.78593,0.570175),(18.3486,0.539474),(
26.9113,0.517982),(45.5658,0.517982),(80.4281,0.508772),(99.6942,0.508772))

Average Training= INTEG (Adjusting Average Training,0)

- Hours/Month

Assigned Management Tasks= INTEG (New Assignment Management Tasks,0)

- Tasks

Table Necessary Equipment([(0,0)-(11,1)],(0,0),(2.59021,0),(2.75841,0.171053),
(2.85933,0.337719),(3.02752,0.653509),(3.36391,0.877193),(3.80122,0.964912),(
5.14679,0.986842),(7.16514,0.991228),(10.0306,0.991228))

Tasks per Equipment= 10

~ Tasks/equipment

Tasks per Training=1/5

~ Tasks/Hours

Training per new Equipment= 20

~ Hours/(Month*equipment)

Process Obsolescence= Implemented Processes/Process Useful Life

~ Process/Month

Implementing Processes=(Desired Processes-Implemented Processes)/Time
Implementing +Process Obsolescence

~ Process/Month

Process Useful Life=48

~ Month

Implemented Processes= INTEG (Implementing Processes-Process
Obsolence, 0)

- Process

Table Needed Tasks([(0,0)-(100,1)],(0,0),(14.6789,0),(23.2416,0),
(26.9113,0.171053),(31.8043,0.385965),(36.0856,0.631579),(39.7554,0.789474),(
43.7309,0.921053),(51.0703,0.960526),(58.7156,0.982456),(80,1),(100,1))

Desired Processes=Table Needed Tasks(Assigned Management
Tasks)*Assigned Management Tasks*Process per Task*(1+Top Management
Commitment)

- Process

Accreditations=Table EMS certification(Implemented Processes)+Table Eco-
design certification("Eco-designed Products/Services") +Table
Communication certifications(External Communication)

- accreditations

Process Effect on Impact=Table Process Effect(Implemented Processes)

Table Process Effect([(0,0.3)-(50,1)],(0,1),(3.0581,0.745614),(5.35168,0.618421),
(8.10398,0.514912),(14.6789,0.456579),(24.9235,0.450439),(41.4373,0.450439))

Table EMS certification([(0,0)-(2000,10)],(0,0),(5,0),(5,1),(2000,1))

Time Implementing=3

~ Month

Process per Task=1/10

~ Process/Tasks

Implementing BAT=Needed Top Management(Top Management
Commitment)*(Needed BAT-Implemented BAT)/Time Implementing
BAT+BAT Obsolescence

~ equipment/Month

Needed BAT=Implemented Processes*BAT per process

~ equipment

BAT Obsolescence=Implemented BAT/BAT Useful Life

~ equipment

Time Implementing BAT=3

- Month

BAT Useful Life=96

- Month

Benefits from Workers Commitment= 200*Workers Commitment

- Euros/Month

Time to commit=3

- Month

Benefits from BAT=Implemented BAT*1500

- Euros/Month

Top Management Modification=(Table Economic-TM*(Perceived Economic Benefits)-Top Management Commitment)/Time to commit

- Dmnl

Total Economic Benefits=DELAY3(Benefits from Processes+Benefits from BAT+Benefits from Workers Commitment+Benefits from Market,3)

- Euros/Month

Benefits from Processes=Implemented Processes*1000

- Euros/Month

Perceived Economic Benefits= DELAY3(Total Economic Benefits,3)

- Euros/Month

Needed Top Management([(0,0)-(1,1)],(0,0),(0.107034,0.429825),
(0.168196,0.649123),(0.24159,0.79386),(0.357798,0.916667),(0.550459,0.97807),
(1,1))

Workers Effect on Impact= Table Workers Effect(Workers Commitment)

Table Workers Effect([(0,0)-(1,1)],(0,1),(0.0214067,0.843421),
(0.0428135,0.723684),(0.0825688,0.600877),(0.159021,0.527193),(0.247706,0.5
21053),(0.437309,0.521053),(0.996942,0.521053),(1,0.5211))

Table BAT Effect([(0,0.3)-(25,1)],(0,1),(1.52905,0.754386),(2.59939,0.627193),
(4.89297,0.521053),(6.49847,0.475),(7.95107,0.459649),(11.0092,0.450439),(16.
208,0.447368),(22.1713,0.447368))

BAT Effect on Impact= Table BAT Effect(Implemented BAT)

BAT per process=1/5

- equipment/Process

Implemented BAT= INTEG (Implementing BAT-BAT Obsolescence,0)

- equipment

Workers Commitment=SMOOTH(Top Management Commitment,3)

- Dmnl

Top Management Commitment= INTEG (Top Management Modification,0)

- Dmnl

"Table Economic-TM"([(0,0)-(60000,1)],(0,0),(2018.35,0.0175439),
(3486.24,0.105263),(4770.64,0.29386),(6055.05,0.434211),(7522.94,0.592105),
(8440.37,0.679825),(10458.7,0.754386),(13578,0.837719),(16513.8,0.921053),(207

33.9,0.947368),(26422,0.97807),(31559.6,1),(36697.2,1),(45871.6,1),(54495.4,1),
(60000,1))

Benefits from Market= Table Market(Market Share)

~ Euros/Month

"Requested Products/Services"=Table Needed Top Management
Commitment(Top Management Commitment)*"Total Number of
Products/Services"*(Implemented Processes*0.5/40+Top Management
Commitment*0.5)

~ prodserv

"Time eco-designing"= 3

~ Month

"Eco-designing"=("Perceived Requested Products/Services"-Eco-designed
Products/Services)/"Time eco-designing"

~ prodserv/Month

"Perceived Requested Products/Services"=DELAY3("Requested
Products/Services", 3)

~ prodserv

"Total Number of Products/Services" = 50

~ prodserv

"Table Eco-design certification"([(0,0)-(80,10)],(0,0),(2.5,0),(2.5,1),
(30,1),(60,1))

Table Market([(0,0)-(80,200000)],(10,0),(17.1254,3508.77),(22.0183,6140.35),
(32.2936,8771.93),(44.526,14035.1),(54.8012,18421.1),(67.0336,28947.4),(74.862
4,44736.8),(80.7339,67543.9))

Table Needed Top Management Commitment([(0,0)-(1,1)],(0,0),
(0.0825688,0.00877193),(0.100917,0.0657895),(0.137615,0.267544),(0.189602,0.
596491),(0.235474,0.811404),(0.330275,0.942982),(0.59633,0.97807),(0.83486
2,0.991228),(1,1))

"Eco-designed Products/Services" = INTEG ("Eco-designing",0)

~ prodserv

Market Share = Table Market Product or Service("Eco-designed
Products/Services") + Table Market Communication(External Communication)

~ Percent

Table Market Product or Service([(0,0)-(80,80)],(0,10),(8.80734,11.5789),
(12.9664,17.193),(17.1254,24.9123),(19.0826,31.9298),(22.0183,39.2982),(24.9541
,43.5088),(28.9908,45),(40.5505,45),(50,45),(60,45))

Table Communication certifications([(0,0)-(1000,10)],(0,0),(100,0),
(100,1),(1000,1))

External Communication=DELAY3((((Table Process Communication
(Implemented Processes)*"Table Needed Eco-design"("Eco-designed
Products/Services"))^(1/2))*Table Needed Top Management(Top
Management Commitment), 6)

~ Hours

Table Needed Top Management([(0,0)-(1,10)],(0,0),(0.4,0),
(0.507645,0.482456),(0.584098,1.22807),(0.64526,1.57895),(0.730887,1.79825),
(0.798165,1.88596),(0.9,1.9),(1,2))

~ Dmnl

Table Process Communication([(0,0)-(200,800)],(0,0),(15.2905,30.7018),
(31.8043,83.3333),(50.1529,157.895),(91.1315,333.333),(117.431,460.526),(155.963
,701.754))

~ Hours

"Table Needed Eco-design"([(0,0)-(1000,10000)],(0,0),(20,0),
(45.8716,131.579),(262.997,1885.96),(379.205,3201.75),(513.761,5175.44),(642.20
2,7894.74),(801.223,9692.98),(1000,10000))

- Hours

Table Market Communication([(0,0)-(2000,20)],(0,0),(375,10),(530,13),
(750,16),(1000,18),(1500,19))