Rapport sur les critères de sensibilité de demande par rapport à la performance environnementale

CONception des **C**haînes **L**ogistiques avec **u**ne **D**emande sensible à la performance **E**nvironnementale

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Synthèse du rapport

Ce rapport constitue le premier livrable du rapport CONCLUDE (CONception des Chaînes Logistiques avec Une Demande sensible à la performance Environnementale). Son objectif est d'identifier des critères de sensibilité de la demande par rapport à la performance environnementale à partir d'une revue de littérature. Nous avons dans un premier temps défini les notions de qualité environnementale, performance environnementale et préciser les attributs relatifs aux produits susceptibles d'influencer la demande. Un état de l'art de la littérature sur le « marketing vert » a ensuite été effectué. Ont ensuite été identifié dans la littérature les critères environnementaux susceptibles d'être mobilisés pour la sélection de fournisseurs. Ces critères étant très nombreux dans la littérature (plusieurs centaines), une typologie, validée par double-codage, de ces critères environnementaux a été proposée.

Abstract

This report is the first deliverable of the CONCLUDE report (Logistics Chain Design with Environmental Performance Sensitive Demand). The aim of this report is to identify demand sensitivity criteria in relation to environmental performance based on a literature review. In the first part, we defined the concepts of environmental quality; environmental performance and we specified the attributes related to the products that likely influence the product's demand. Then, it is presented the literature review of "green marketing". Finally, environmental criteria that can be used to select suppliers have been identified in the literature. Since these criteria are very numerous in the literature (several hundred), a typology, validated by double-coding method of these environmental criteria is proposed.

Introduction

This work contributes to the fields of eco-responsible product demand, green supply chain and life cycle analysis by explaining how to define the influence of environmental criteria on a products' demand. The contributions of this research project to the society will include the main statements and frameworks that may help the industry and in general the decision makers (private and public sectors) to identify, analyze and evaluate sustainable solutions on their life cycle of the green supply chain to improve the eco-responsible product demand forecasting. This report first presents the methodological approach that was conducted for the CONCLUDE (CONception des Chaînes Logistiques avec une Demande sensible à la performance Environnementale) project. Then, our literature review allowed defining more precisely, which are the environmental criteria that may influence the demand of a product. Finally, a typology, validated by double coding method is proposed to classify the 300 criteria that were identified and then synthesized in 29 final criteria.

Section A: Methodological approach

The methodology proposed for the CONCLUDE project has three main parts. The first phase is the literature review; the aim is to define the product's environmental quality to extract the potential criteria that could affect the product demand. In parallel, the second phase is to develop a set of semi-structured interviews to define the product's environmental quality perceived by the stakeholders to extract the perceived criteria that could impact the product demand. Once the potential and perceived criteria are defined, a quantitative survey will be developed to contrast those criteria with the actual perception of the product's environmental quality and environmental practices that impact the product demand. Nevertheless, this report presents only the first phase results : the literature review.

1. Literature review methodological approach

It is important to conduct a rigorous, systematic and reproducible literature review to consolidate the existing literature, and to identify the gaps and barriers.

1.1 Material collection

Material collection was mainly based on a documentary gathering. We used Scopus database in order to quantify the articles published, taking into account that Scopus shows a broad overview of global, interdisciplinary scientific work about a specific topic research. Then we selected the major publisher's databases and library services such as Science direct, Emerald and Springer to compare and complete the list of papers.

1.1.1 Inclusion criteria

First, the main keywords of the problematic of the research were defined to make the search as focused as possible. To select the search terms, it was necessary to choose those that are closely related to our research topic (including alternative words and abbreviations). Then, we took into account the keywords equation to define the use of Boolean operators to get the right information. After that, we defined the time period. Finally, we chose the field codes; the research was based on the abstracts, titles and keywords of papers published.

We included in the first selection the conference proceedings and grey literature (i.e. technical reports and work in progress). Then we performed a second round of keywords inclusion to answer more precisely to the first research questions. We made a third round to select only the papers that offer a detail list or mention environmental characteristics and attributes of products and that explain green practices and green strategies to improve the product's environmental quality. Table 1 shows the main inclusion criteria that we took into account.

Table 1 Inclusion criteria

	First round	Second round	Third round
Keywords	Green Supply Chain, Environment, Eco-product, Supply Chain, Purchase decisions	Green product, eco-responsible product, sustainable product, eco-efficiency product.	Product's environmental quality, product's environmental attributes
Document type	Paper, book chapter, conference paper, article in press	Paper, book chapter, conference paper, article in press	Paper, book chapter, conference paper, article in press, technical reports
Time interval	2007 - 2017	2007 - 2017	1987-2017
Language	English	English	English

For the first round of inclusion criteria, to address the main research question of this first phase of the study, it was necessary to select the main combination of keywords that are the most significant for the literature review. Table 2 shows the main typology and the keyword equation used.

Table 2 Typology and the keyword equation used

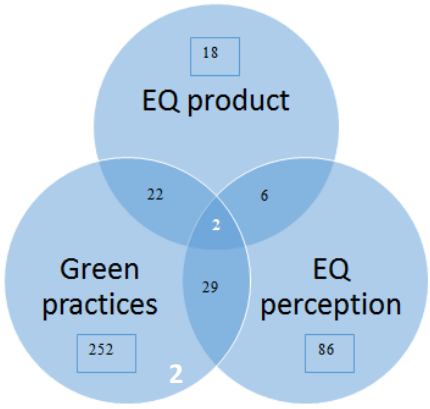
Typology	**keyword equation**
SUPPLY CHAIN	Business strategy + Sustainable Supply Chain Management
	Life Cycle Analysis + Sustainable Supply Chain Management
	Competitive advantage + Sustainable Supply Chain Management
	Value creation + Sustainable Supply Chain Management
	Green product + Sustainable Supply Chain Management
ENVIRONMENT	Environment policy + Green Product
	Environment awareness + Green Product

	Environment consciousness + Green Product
	Environment criteria + Green Product
	Environment friendliness + Green Product
	Environment knowledge + Green Product
	Environment performance + Green Product
	Environment values + Green Product
	Environment variables + Green Product
ECO-PRODUCT	Eco-friendly product + Green Supply Chain
	Eco-responsible product + Green Supply Chain
	Eco-efficiency product + Green Supply Chain
PURCHASE DECISIONS	Consumer perceptions + Green Product
	Post-purchase behaviour + Green Product
	Purchase decision-making + Green Product
	Purchase intention + Green Product

The total number of documents found is 3037. Then, only those with DOI have been selected to ensure the paper publication and its electronic availability, 2333 papers have been found. After selected only the last ten years' publications, 2154 papers have been found.

1.1.2 Selection based on title and abstract

Researches on titles and abstracts have highlighted 415 papers that explain the product environmental quality. From that list, 252 study green practices and green strategies to obtain a product environmental quality, 18 explain the characteristics of environmental quality that a product must have; 86 explain the perception that the consumers have of a product environmental quality. Only 2 papers link the three concepts. Figure 1 shows the quantity of papers found per topic and covering several topics.



EQ product: Product's environmental quality characteristics

Figure 1 Number of papers related to environmental quality (EQ)'s product, perception and green practices.

In this report, we did not take into account the papers that deal with the product environmental perception exclusively. Thus, for the second step, the total papers' number is 329 papers.

1.1.3 Selection based on full text and snowballing

In this last step, we refined the list of selected papers by reading the full text and searching references of references and using citation-tracking databases. Following a discussion among the researchers, we selected 75 papers according to the content of the paper.

1.2 Material analysis

Considering this corpus, a set of descriptive analyses was first performed. Figure 2 presents the papers' distribution by year of publication and Figure 3 presents the description of the main identified papers per source.

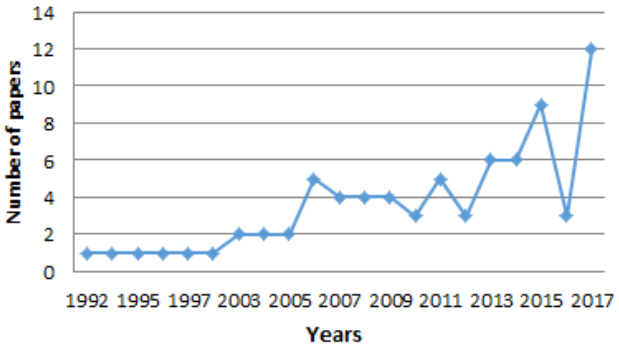


Figure 2 Papers' distribution by year of publication

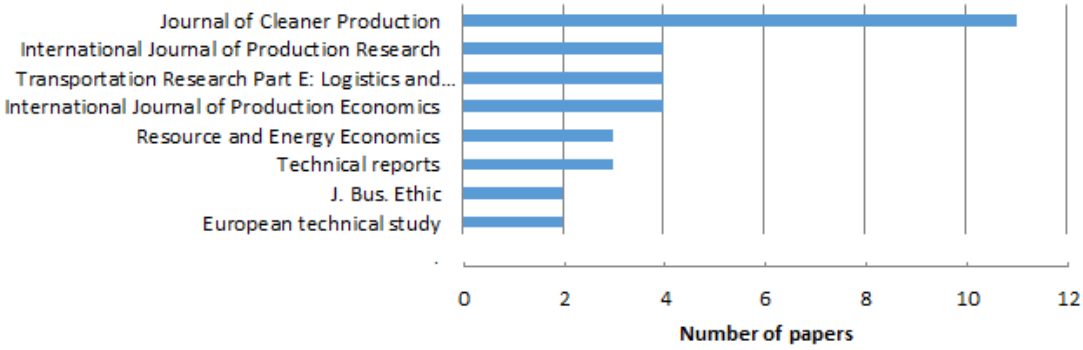


Figure 3 Identified papers per source

Section B: Literature Review: definition of environmental criteria that may impact the demand of a product

To describe the main concepts related to environmental criteria that may influence on the product demand, the objective is to integrate several definitions that have been found in the literature review in relation to the product's environmental quality. For this part, we propose different research questions:

Q1: Which are the main concepts defined in the literature related to a product's environmental quality?

Q2: Which are the environmental criteria to define the product's environmental quality?

To analyse the environmental criteria which influence the product demand in a Business to Business context, the objective is to integrate the green marketing definition that has been found in the literature review as a competitive strategy in relation to the perceived vs the actual product's environmental quality (or greenness of the product). We propose the following research question:

Q3: How the green marketing influence the B to B perception of the product's environmental quality?

To understand the context of product demand when the customer takes the decision to buy eco-responsible products, a review of the definition of green procurement, green purchasing and green supplier selection is performed to evince the environmental criteria took into account to prefer a supplier over other. Regarding the environmental criteria perceived as important by the business customer in a B to B context, the following research questions are proposed:

Q4: What are the most cited environmental criteria used to supplier selection?

Q5: How green supplier selection criteria can reflect the B to B greenness perception?

Q6: What are the outcomes that can be realized from the adoption of those green supplier selection criteria?

1. Eco-responsible demand and green supply chain

Nowadays, the firms offer more products with a high environmental quality by improving the environmental performance of their products (Mantovani, Tarola, & Vergari, 2016). However, product's environmental quality concept is very broad and embraces very different aspects, which generates confusion on the concept and it does not give clear directions to companies willing to offer more products with a high environmental quality. This is why it is necessary to clarify the product's environmental quality notion to avoid misunderstanding for the firm but also for the consumer perception between the pure environmental performance of a product and the green image that can be associated with its consumption. The next section explains the main definitions related to environmental quality.

1.1 Environmental Quality definition

(Johnson et al., 1997) define environmental quality as "*a measure of the condition of an environment relative to the requirements of one or more species and/or to any human need or purpose".* According to (Directorate, 2017), environmental quality is "*a state of environmental conditions in environmental media, expressed in terms of indicators or indices related to environmental quality standards".* In the same way, the (European Environment Agency, 2017) affirm that environmental quality is a general term which can refer to *"varied characteristics such as air and water purity or pollution, noise, access to open space, and the visual effects of buildings, and the potential effects which those characteristics may have on physical and mental health".* In this way, (Economics Discussion, 2017) established that the environmental quality "*can be measured in terms of the value the people place on these non-waste receptor services or the willingness to pay".* They propose four major forms of the environmental quality explained in Figure 4.

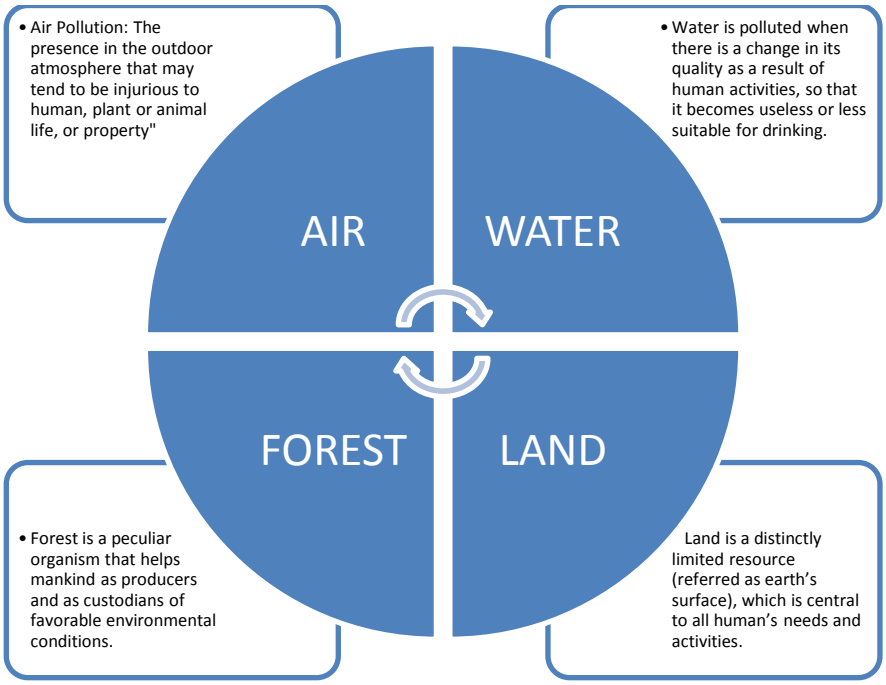


Figure 4 Environmental quality forms. Adapted from (Economics Discussion, 2017).

Finally, (Ding, Liu, & Zheng, 2016) establish that to the government, environmental quality is a public good that must be protected from damage created by any private agents. Thus, the term "environmental quality" concerns more the quality of the state of the environment that the ability of an anthropic system to reduce the environmental pressures that it generates.

1.2 Product's environmental quality definition

Although the term "environmental quality" is not the most appropriate to define the environmental attributes of a product, it can sometimes be used in this meaning. Here are some. Table 3 summarizes the main definitions that can be found in the literature:

Table 3 Product's environmental quality definition

Author	Definition
(Gupta & Palsule-Desai, 2011) (Mantovani & Vergari, 2017)	Product's environmental quality refer to those products with specific environmental attributes such as lowering emissions, reducing amount of waste generated/ disposed, and increasing energy efficiency.
(Nouira, 2013)	The attributes of the product's environmental quality are: (1) linked to carbon emissions from transport activities; (2) linked to the emission rates generated by the selected production process and the rate of green components used.
(Brécard, 2014)	Environmental quality measures the environmental consequences of a product from cradle to grave. It may differ according to the stringency of eco-labelling standards.

1.3 Product environmental attributes

(Deltas & Ramirez, 2005) define environmental attribute as the cleanliness or high product's environmental quality. It could represent energy efficiency, the degree to which the product can be recycled, the reduction in pollutants generated by production and/or use of the product, and possibly others. The environmental attribute creates both social and private benefits. They explain that all consumers attach the same value to the environmental characteristic but they divide the environmental attributes into:

- Vertical attributes such as "greenness" and intrinsic quality (e.g., safety and reliability).
- Horizontal attributes such as design, style and convenience.

According to (Alwitt & Pitts, 1996), environmentally related product attributes (EATIMP) measure consumer perceptions of product characteristics that may increase or mitigate the product's environmental impact. These attributes include beliefs regarding recyclability or the perception that the manufacturer is environmentally conscious and differentiate green product consumption with positive environmental consequences from environmentally harmful consumption.

(Schuhwerk & Lefkoff-Hagius, 1995) consider "green" to address the environmental attributes or ecological implications of the product. (Dunk, 2004) support the fact that the product environmental attributes are largely fixed at the design stage. According to (Yenipazarli & Vakharia, 2017), Chen (2001) affirm that an environmental attribute represents a set of product characteristics that are more environmentally sustainable such as recycled content, energy- and fuel-efficiency, and non-toxicity.

(Soylu & Dumville, 2011) define environmental attributes as the products that include attributes such as: (1) to be free from toxic substances, (2) to be biodegradable, (3) to be recyclable, (4) to be upgradeable, (5) to have low energy conversation. (Feng et al., 2016) consider as environmental attribute the product carbon emissions and product energy efficiency as well as (Giancarlo, 2006) propose product recyclability.

(Villanueva-Ponce et al., 2015) refer to green attributes as synonym of environmental attributes. They propose some environmental attributes regarding the product and the supplier as shown in Table 4.

Table 4 Environmental attributes according to (Villanueva-Ponce et al., 2015)

Focus on	**Environmental attributes**
Product	Product design • Recycling • Reduce controlled substances • Hazardous substances • Green product design • Green materials • Disassembly product
Supplier	Supplier selection: • Green product design • Green SCM, environmental management • Environmental regulations certification • Environmental competencies • Pollution control and production • Recycling rate • Impact to environment • Carbon emissions Waste management • Inventory of hazardous substances • Energy consumption • Environmental efficiency • Green research and development • Environmental costs • Effectiveness of clean technology • Green image • Green material coding • Green purchasing • Ozone depleting chemical • Material substitution for green materials • Validity of clean technique • Environmental audit • Pollution cost, control, production • Shipment inspection

(D'Souza, Taghian, & Lamb, 2006) affirm that the environmental attributes of a product is perceived by the customer through environmental labels with message such as, environment-friendly, ozone-friendly, earth-friendly, degradable, recycled, recyclable, renewable, reusable or for that matter biodegradable. Nevertheless, unlike other physical attributes of a product, environmental attributes are difficult to detect unless there is sufficient information about them.

To quantify the product environmental attributes, (Ingwersen & Stevenson, 2012) consider methodologies such as lifecycle assessment (LCA) and carbon footprinting. They propose the use of Product Category Rules (PCRs) to:

- Allow the producers to publish results of quantitative environmental attributes for products.
- Enable buyers or consumers to compare the results to those for similar products.

(Peano, Baudino, Tecco, & Girgenti, 2015) propose the use of "Eco profile" of a product to investigate the potential for the improvement of the product's environmental attributes and to propose the

implementation of corrective or offsetting measures. (Weeren & Wendschlag, 2007) explain that Product eco-declaration (PED) is a useful tool for communicating environmental attributes of ICT and consumer electronic products to professional buyers. It contains legal and market requirements that cover the whole range of the product eco-design. In the Annex 1 appears an example of PED performed by Lenovo.

However, in the literature review, other terms are more commonly used to define the environmental attributes that characterize a product.

Figure 5 shows some of them:

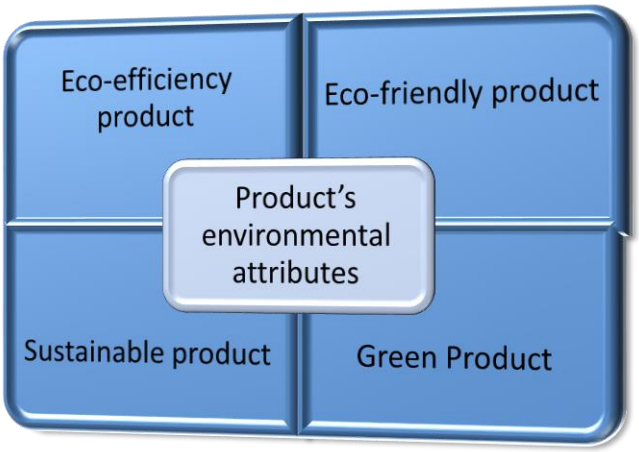


Figure 5 Definitions related to product environmental quality

1.3.1 Eco-efficiency product

According to (Huppes & Ishikawa, 2005), eco-efficiency has been defined as a general goal of creating value while decreasing environmental impact. They describe eco-efficiency as a ratio between two elements: environmental impact to be reduced, and value of production to be increased.

This joint consideration of ecological and economic issues underlies the concept of eco-efficiency, described by (Schvaneveldt, 2003) as *"the delivery of competitively-priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity".*

(Michelsen, Fet, & Dahlsrud, 2006) affirm that the eco-efficiency provides information about the relative performance of the products, which is valuable in green procurement processes. The World Business Council for Sustainable Development (WBCSD) has been credited for inventing the term eco-efficiency in the book Changing Course (Schmidheiny, 1992). The purpose of eco-efficiency is to maximise value creation while having minimised the use of resources and emissions of pollutants (Verfaillie & Bidwell, 2000). Measuring eco-efficiency is important in order to measure the potential decoupling of economic growth and environmental pressure. Eco-efficiency is in most cases expressed by the ratio in the equation 1:

$$Eco - efficiency = \frac{Product\ value}{Environmental\ influence}$$

Equation 1. Eco-efficiency. Source: (Verfaillie & Bidwell, 2000).

(Verfaillie & Bidwell, 2000) explain that the two most important applications for eco-efficiency are as an internal tool for measuring progress, and for internal and external communication of economic and environmental performance. Figure 6 shows the analysis to perform to know environmental and value performance for a product in the supply chain by identifying the different materials and components.

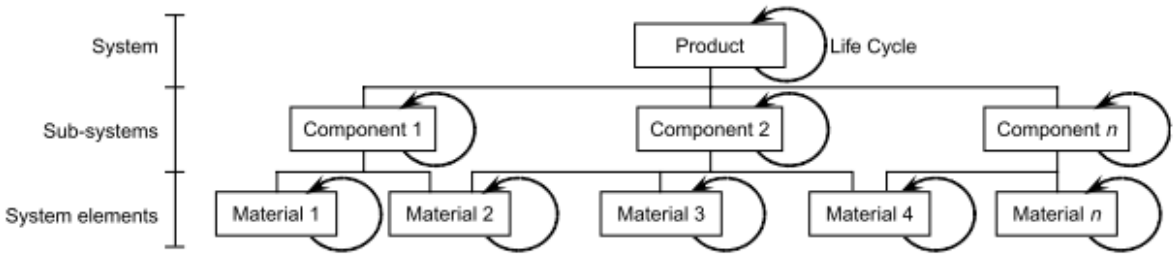


Figure 6. Product Eco-efficiency analysis. Source: (Verfaillie & Bidwell, 2000)

1.3.2 Eco-friendly product

According to (Cherian & Jacob, 2012), over the last decade, pressing environmental issues has emerged. This resulted in increase in consumer concern with regards to preservation and restoration of ecological balance by presenting demands for eco-friendly products in countries around the world. (Han, Hsu, & Lee, 2009) affirm that the term, ‘‘green’’ is alternatively called ‘‘eco-friendly’’, ‘‘environmentally responsible’’, or ‘‘environmentally friendly’’. (Frank-Martin & Peattie, 2009) defines ‘‘environmentally friendly’’ as those products that do not generate permanent damage to the environment during its entire life.

1.3.3 Sustainable Product

(Lindgreen, Antioco, Harness, & Van Der Sloot, 2009) affirm that environmental sustainability refers to a company’s use of natural resources and its consequent ecological impacts, taking into account a product’s resource consumption and value creation throughout its entire lifecycle (from extraction of raw materials for and manufacture, packaging, storage, distribution, recycle, until the destruction of the product). A firm can define its vision about environmental sustainability according to five aspects: reducing products’ energy consumption, packaging materials, hazardous substances, and weight, and increasing levels of recycling and safeguards during disposal of products.

According to (Frank-Martin & Peattie, 2009), “*sustainable products*” are those products that provide environmental, social and economic benefits while protecting public health and environment over their whole lifecycle, from the extraction of raw materials until the final disposal. It should be constantly environmental-friendly during its entire life. (Kumar, Manrai, & Manrai, 2017) established that environmentally sustainable products are supposed to be environment-friendly, environmentally superior and ecologically safe. (de Medeiros & Ribeiro, 2017) affirm that these

"*environmentally-correct products"* or *"environmentally-sustainable products*" are those capable of adding long-term benefits, reduce client stress and relieve them from their environmental responsibility, without, however, diminishing products' satisfying qualities.

1.3.4 Green Product

According to (Dangelico & Pontrandolfo, 2010), there are many meanings of the word 'green' in the literature and several dimensions of green (such as ecological, political, corporate social responsiveness, fair trade, conservation, non-profit, new-consumerism, sustainability, and equality) can be identified. (Dangelico & Pontrandolfo, 2010) enlists the main contribution to define green product concept detailed in Table 5.

Table 5 Green product literature review. Adapted from (Dangelico & Pontrandolfo, 2010)

Author	**Definition**
Pattie (1995, p. 181),	Defines a product as 'green' "when its environmental and societal performance, in production, use and disposal, is significantly improved and improving in comparison to conventional or competitive products offerings. This definition highlights the different lifecycle phases during which a product can show its environmentally friendly features.
Reinhardt (1998, p. 46)	He states that environmental product differentiation takes place when: "a business creates products that provide greater environmental benefits, or that impose smaller environmental costs, than similar products". This definition points out that green products are not only those products with a lower environmental impact, but also those providing higher environmental benefits compared to conventional products.
Commission of the European Communities (2001)	It defines green products as products that "use fewer resources, have lower impacts and risks to the environment and prevent waste generation already at the conception stage". This definition emphasizes the importance of designing products as 'green' since the conceptualization phase.
Ottman et al. (2006, p. 24)	They state that "although no consumer product has a zero impact on the environment, in business, the terms 'green products' or 'environmental product' are used commonly to describe those that strive to protect or enhance the natural environment by conserving energy and/or resources and reducing or eliminating use of toxic agents, pollution, and waste". This definition stresses the main types of environmental focus of green product development, namely energy, resources, pollution and waste.
(Yang, Lu, Guo, & Yamamoto, 2003)	They define green product as the final embodiment of green design and eco-design, and the carrier of the product greenness. Green product is a kind of products that meet the need of the given requirements for the environmental protection, and do no harm to or minimize the impact on the environment, maximize the utilization ratio of resources and reduce the consumption of the energy resources in its lifecycle.

(Yang et al., 2003) defines green product and its connotation mainly contains the following points:

1. Excellent environmental performance: The product can minimize the impact on the environment.
2. Fully utilizing the material resources: It reduces the sort and quantity of the material, especially rarity or costly material and poisonous or harmful material
3. Efficiently utilizing the energy resources: It makes full use of the resources and reduces the consumption of the energy resources in its life cycle.

According to (Chen, 1994), businesses and environmentalists often have different definitions of "greenness." Most companies think that "greenness" refers to minimization of waste level within a company. Environmentalists, on the other hand, believe "greenness" is sustainability, which is defined by the WCED (1987) as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Besides for minimization of waste, sustainability also includes maintaining biodiversity, minimizing use of non-renewable resource, and preservation of natural resources. A common goal must be realized by both the industries and the environmentalists. Industries must realize that minimization of wastes does not necessarily make a company green. "Greenness" relates to all the processes of a product from manufacturing to disposal. On the other hand, environmentalists must understand that there are trade-offs between economic growth and the environment. Certainly, stopping all business activities will minimize all kinds of pollution. They propose the following product strategies (Table 6).

Table 6 Product strategies to be green product. Adapted from (Chen, 1994).

Product strategies	**Description**
Environmental policies during product development	This involves developing products that results in the best combination of material usage, choice of material, waste emission, and cost-effectiveness without compromising the quality of the product
Product durability	It has major impacts on the environment. When a product is built to last longer, there is less need for replacement; hence, less emission is produced and fewer waste results. Furthermore, the cost of disposal is delayed until later.
Reparability	It is an important factor in the durability of a product, and hence the product's environmental soundness. Because of high labour cost, many of our consumer products are made to be replaced rather than repaired. With increasing environmental concerns, focus should shift back to making products that are easy and inexpensive to be repaired.
Material Usage	Materials that are environmental friendly should emit little pollutants during extraction and production. Recyclability is another important aspect of a material. When a material can be easily recycled, the solid wastes it generates will be significantly less. In addition, extraction of virgin material, which generates more pollution, will be unnecessary.

1.4 Performance of product's environmental quality

1.4.1 Product's greenness assessment

According to (European Commission, 2010), what is actually meant by 'green' is still debated. (Dangelico & Pontrandolfo, 2010) indicated that to refer to a product as 'green', it must be only on the basis of its environmental performance. Several green product classifications have been developed driven by distinct classification purposes (detailed in Figure 7).

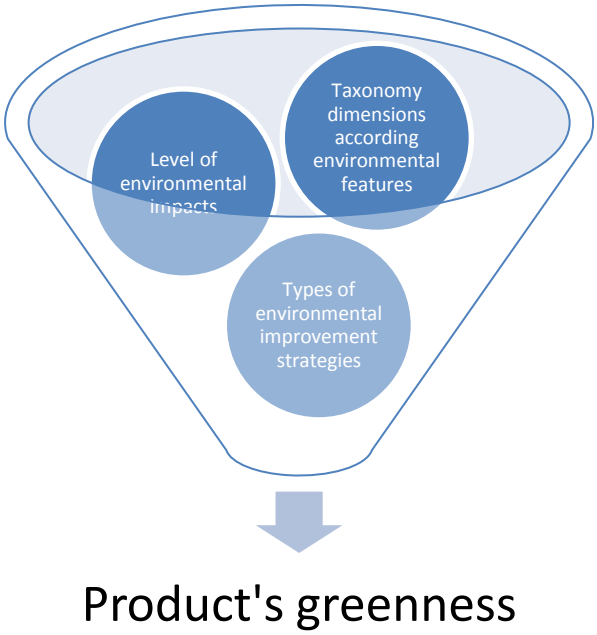


Figure 7. Product greenness classification

According to Chen (2001), the greenness is closely related to the design decisions since they affect the product recyclability, the energy and resource consumption during the use of the product, etc. In the same way, Sarkis (2003) established that a green product depends on its supplier's components and a supplier may be considered as a green supplier if he offers green components and/or has environmental certifications such as ISO14000 certification. This is confronted by Ottman et al. (2006) who affirmed that the greenness of a product highly depends on the characteristics of its manufacturing process.

(Nouira, Frein, & Hadj-Alouane, 2014) concluded that the greenness level of a product depends on two categories of decisions:

- *First category:* It regroups decisions that directly impact the characteristics of the product. (e.g. product design decisions).
- *Second category:* It includes decisions that do not change the product characteristics, but rather the environmental impacts that are generated by its fabrication and transportation, thus potentially impacting its environmental image:
    - Production decisions: The selection of manufacturing processes (clean or dirty technologies) impacts on the level of carbon emission and energy consumption during production which affects the environmental image of products.

- Supply chain decisions: The selection of components used to manufacture a product has a direct impact on the product greenness. For instance, for a given component, the company may have the choice between ordinary suppliers and green suppliers.

(Yang et al., 2003) stated that assessing the greenness of products needs to be performed according to LCA (Life Cycle Assessment) viewpoint, which is one of the important issues in PLCA (Products Life Cycle Analysis). PLCA is a process: (1) to evaluate the environment burdens associated with a product by identifying and quantifying energy and materials used, and the wastes released to the environment; (2) to assess the impact of those energy and materials used and released to the environment; and (3) to identify and evaluate opportunities to affect environment improvements. The assessment includes the entire lifecycle of the product, encompassing extracting and processing raw materials, manufacturing, use, re-use, maintenance, recycling, and final disposal.

(Dangelico & Pontrandolfo, 2010) named some of the main contributions to assess the product's greenness. This is explained in Table 7.

Table 7. Product's greenness assessment. Adapted from (Dangelico & Pontrandolfo, 2010)

Author	**Product's greenness assessment**
Peattie (1995)	He classifies products on the basis of their eco-performance, distinguishing different shades of 'green' (from deep green to black) and types of products (absolute green[1] or relative green).
Dewberry and Goggin (1996)	They develop an Eco-design Matrix, subsequently used by Roy et al. (1996), to classify the environmental impact of products on the basis of two dimensions: main lifecycle stage (production, use, and disposal) and environmental focus (energy, materials/resources, pollution/toxic waste).
Kaebernick and Soriano (2000)	They consider four product lifecycle phases (materials, process, usage, and disposal) and divide products into two groups, distinguishing two kinds of impact drivers, namely energy based and material based.
Sousa and Wallace (2006)	They develop an automated classification system guiding the identification of product groups based upon environmental categories.

The assessment index system

(Yang et al., 2003) propose the standards of the green assessment. It can be analysed by its index system, which usually contains four main attributes such as environment, energy, resource and economic phases. For each attribute, there are environmental standards and index that must be quantifiable or comparably describable. Among the environment attributes, there are: air pollution, water pollution and noise pollution. The indexes can be divided into two kinds (positive and negative index). This is illustrated in Figure 8 as the greenness assessment system.

[1] The concept of absolute green product is quite close to those of 'ameliorative product', defined as a product necessary to survive environmental deterioration (Ryan et al., 1992, p. 13), and of 'sustainable-function product', defined as "a product (or service) that reduces a negative impact in its surroundings to such as an extent that the reduction exceeds the impact caused by the product's lifecycle itself" (Wever and Boks, 2007, p. 201).

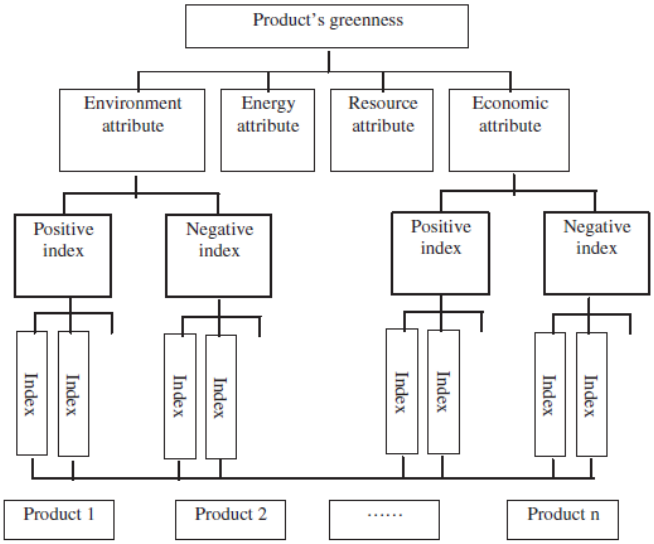


Figure 8. Product greenness assessment system. Source: (Yang et al., 2003)

Green Option Matrix

(European Commission, 2010) developed the Green Option Matrix to clarify the meaning of 'green' when used to describe the products and processes of companies. The matrix uses three dimensions to describe the environmental contributions of a green product:

1. It considers the environmental focus of the green product in terms of whether the focus is on materials, energy or pollution.
2. It considers the stage in the product's lifecycle in which the environmental benefit occurs: before usage, during usage or after usage.
3. It considers whether the environmental impact is less negative than conventional products, whether it is neither negative nor positive, or whether it positively contributes to the environment.

1.4.2 Standards for the environmental performance of products

According to (Schvaneveldt, 2003), environmental sustainability is reducing the environmental impact of the product over its life-cycle to a sufficiently benign level that the ecosystem's viability can be preserved for the present and future generations. Then, the environmental performance of a product can be analysed as shown in Figure 9. Those standards are available from a number of sources, including government legislation, industry guidelines and eco-labels. Corporate goals are the internal goals for environmental performance. These goals can be for near-term, incremental improvement, or mid-term stretch goals.

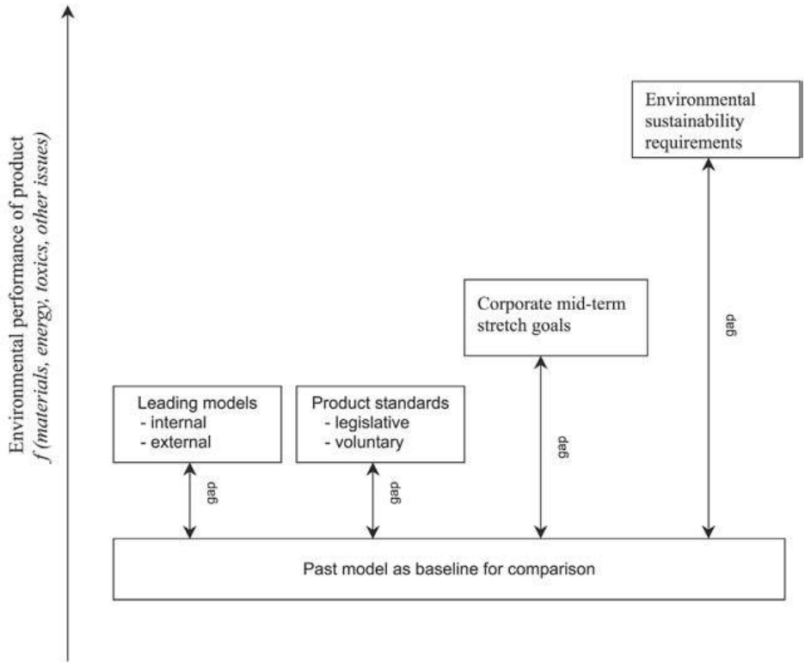


Figure 9. Standards for the environmental performance of products. Source (Schvaneveldt, 2003)

According to (Hainmueller & Hiscox, 2012), nowadays, many firms are using environmental certifications and product labelling to make their goods more appealing to consumers. This offers a mechanism for firms and consumers to formalize some standards for the environmental performance of products.

1.4.3 Implementation of Product environmental footprint (PEF)

Product environmental footprint (PEF) was proposed by European Commission in 2012 (European Commission, 2013). The PEF is one of multi-criteria measure methods for the environmental performance of a product throughout its lifecycle. The European Commission recommendation of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations promotes *"the use of the environmental footprint methods in relevant policies and schemes related to the measurement or communication of the life cycle environmental performance of products or organisations. I*t establishes two methods to measure environmental performance throughout the lifecycle, the Product Environmental Footprint (PEF) and the Organisation Environmental Footprint (OEF). It recommends, to Member States, companies, private organisations and the financial community, two methods to measure environmental performance throughout the lifecycle: the Product Environmental Footprint (PEF) and the Organisation Environmental Footprint (OEF). This recommendation proposes Default EF impact categories (with respective EF impact category indicators) and EF impact assessment models for PEF studies.

Table 8. Default EF impact categories (with respective EF impact category indicators) and EF impact assessment models for PEF studies (European Commission, 2013)

EF Impact Category	EF Impact Assessment Model	EF Impact Category indicators	Source
Climate Change	Bern model - Global Warming Potentials (GWP) over a 100 year time horizon.	kg CO2 equivalent	Intergovernmental Panel on Climate Change, 2007
Ozone Depletion	EDIP model based on the ODPs of the World Meteorological Organization (WMO) over an infinite time horizon.	kg CFC-11 (56) equivalent	WMO, 1999
Ecotoxicity for aquatic fresh water	USEtox model	CTUe (Comparative Toxic Unit for ecosystems)	Rosenbaum et al., 2008
Human Toxicity - cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Human Toxicity – non-cancer effects	USEtox model	CTUh (Comparative Toxic Unit for humans)	Rosenbaum et al., 2008
Particulate Matter/Respiratory Inorganics	RiskPoll model	kg PM2,5 (57) equivalent	Humbert, 2009
Ionising Radiation – human health effects	Human Health effect model	kg U235 equivalent (to air)	Dreicer et al., 1995
Photochemical Ozone Formation	LOTOS-EUROS model	kg NMVOC (58) equivalent	Van Zelm et al., 2008 as applied in ReCiPe
Acidification	Accumulated Exceedance model	mol H+ eq	Seppälä et al.,2006; Posch et al., 2008
Eutrophication – terrestrial	Accumulated Exceedance model	mol N eq	Seppälä et al.,2006; Posch et al., 2008
Eutrophication – aquatic	EUTREND model	fresh water: kg P equivalent marine: kg N equivalent	Struijs et al., 2009 as implemented in ReCiPe
Resource Depletion – water	Swiss Ecoscarcity model	m3 water use related to local scarcity of water	Frischknecht et al., 2008
Resource Depletion – mineral, fossil	CML2002 model	kg antimony (Sb) equivalent	van Oers et al., 2002
Land	Soil Organic Matter	Kg (deficit)	Milà i Canals et al.,

Transformation	(SOM) model		2007

This recommendation provides *"principles for communicating environmental performance, such as transparency, reliability, completeness, comparability and clarity"* (European Commission, 2013). In some sectors like the construction sector, this recommendation was followed by European standards, such as the CSN EN 15804+A1 - Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products. This standard defines the parameters to be declared and the way in which they are collated and reported. It also describes the stages of a product's life cycle that must be considered in the Environmental Product Declaration and which processes are to be included in the life cycle stages. In France, for this construction sector, a national database (http://www.base-inies.fr/iniesV4/dist/consultation.html) collects all the Environmental Product Declaration of the providers of products that publish such declaration. In other sectors, such as the Food industry sector, there is no such database.

Sustainable design is a design process for a product with the consideration of environmental sustainability during its entire lifecycle in consequence there is the creation of products with reduced product environmental footprints (He & Gu, 2016).

(He & Gu, 2016) establish two basic research issues that have been studied for sustainable design synthesis for product environmental footprints: 1) How a sustainable design for product environmental footprints allow the reduction of product environmental footprints? 2) How to generate feasible solutions through design synthesis? The current sustainable design methods could be generally classified into three categories:

- Checklist-based sustainable design method: It is a set of items used to assess a product of its entire lifecycle from the environmental perspective, which are developed particularly for the early stages of product development.
- Life cycle assessment (LCA)-based sustainable design method: As products are involved in the product environmental footprints at each stage of the lifecycle, the product lifecycle assessment (ISO 14040, 2006) is available to evaluate the environmental footprints of a product. LCA is essentially not a design-oriented process, but it is mainly used to evaluate the resource consumption and waste emissions associated with products across all stages of their life cycle.
- Quality function deployment (QFD)-based sustainable design method: QFD is originally defined as a method to transform qualitative user demands into quantitative parameters, to deploy the functions forming quality, and to deploy methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process. By introducing one or more indicators of product environmental footprints into QFD as new user demands and developing correlations between user demands and quality characteristics, a set of QFD-based approaches have been proposed.

1.5 Synthesis

This report aimed to establish the characteristics and environmental attributes that define the "environmental quality" of a product. To obtain this, it was necessary first, to search definitions

related to a product environmental quality. The first notion defined above was "environmental quality". It was found that the terms "environmental quality", in the scientific literature, refers rather to the "*state of environmental conditions in environmental media, expressed in terms of indicators or indices related to environmental quality standards*" (OECD, 1997). Definitions related to those media are explained in Figure 1.

However, several terms may refer to what is named by what is named "environmental quality of a product" by (Nouira, 2013): "environmental attributes of a product", "eco-efficiency of a product", "Eco friendliness of a product", "sustainability of a product", "product environmental footprint". These terms refer more generally to the environmental attributes of the product. On the one hand, those attributes are divided by (Deltas & Ramirez, 2005) in vertical and horizontal as perceived by the consumer. The first one is related to an intrinsic quality of the product, that may be called "*greenness*" and, the second one is related to design, style and convenience. On the other hand, (Gupta & Palsule-Desai, 2011) , (Nouira, 2013),(Brécard, 2014) and (Mantovani & Vergari, 2017) associate those environmental attributes to environmental consequences of a product from cradle to grave, especially to emissions at the production and distribution process.

Nonetheless, in the literature review there are different definitions of these environmental attributes for a product. They can be found in the literature addressing eco-efficiency product, eco-friendly product, sustainable product and green product's issues. The first two notions are related more to the results of the assessment process rather than the product itself. They refer to the environmental impact reduced through the product lifecycle regarding the value of production to be increased. These notions are defined by addressing ecological and economic issues.

Then, sustainable products are defined by different authors . At this point, there is a clear difference with the first two notions defined above. Sustainable products are those products that provide environmental, social and economic benefits. This notion does not address exclusively to the environmental impacts. Finally, the green product is defined. The literature review points out that the green products are not only those products with a lower environmental impact, but also those providing higher environmental benefits compared to conventional products. This definition emphasizes the importance of the green assessment on the entire product lifecycle and stresses a real environmental focus. Figure 10 explains the concepts related to product's environmental quality definition.

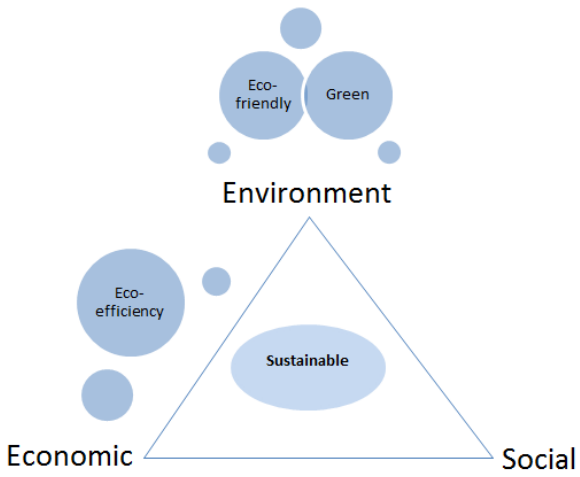


Figure 10. Concepts related to product's environmental quality definition.

Likewise, another concept is defined when talking about green product. This is the "product's greenness", that was proposed by (Nouira et al., 2014) into two categories. The first one is related to those decisions that influence the characteristics of the product (such as design decisions that influence the environmental impact on the entire product lifecycle) and the second one is related to those decisions that influence the environmental image of the product.

Similarly, in the literature review, different tools to assess the product's greenness were found, but the most common is the process of Products Life Cycle Analysis (PLCA). There is another tool used to assess the 'green' when used to describe the products and processes of companies, Green Option Matrix developed by (European Commission, 2010). The same entity in 2012 proposed the Product environmental footprint (PEF), multi-criteria measure method for the environmental performance of a product throughout its lifecycle. This standard is based on the Life-cycle analysis approach. Nevertheless, there are other types of tool assessment that take into account not only the environmental attribute of the product but also energy, resource and economic attribute of the product (the assessment index system proposed by (Yang et al., 2003)).

Finally, some standards have been proposed in the literature review for assessing the environmental performance of products. Those standards are available from a number of sources, leading models (such as internal and external models), product standards (including government legislation and voluntary practices such as green strategies and green practices), industry guidelines (corporate goals) and environmental sustainability requirements (such as eco-labels).

2. Green marketing definition on a BtoB greenness product demand

Nowadays, the firms offer more products with a high environmental quality by improving the environmental performance of their products (Mantovani et al., 2016). However, if the business customer is not conscious of the product's environmental quality (greenness of the product) because suppliers did not communicate their strategies and green practices, there is as (Lacoste, 2012) called "missed opportunity" to gain a competitive advantage and in consequence to increase the product demand. This is why it is necessary to clarify the role of green marketing in the product's environmental quality perception in a B to B context that influences the supplier selection criteria.

2.1 Green marketing definition

In the late 1980s and early 1990s, green marketing started to be distinguished as a management strategy that business firms started to take advantage from the boom of consumers with increased sensitivity facing environmental issues(Garg, 2015)

(Saxena & Khandelwal, 2010) define green marketing as the marketing tools application to simplify exchanges allowing the organizational and individual goals satisfaction but also by preserving, protecting and conserving the environment. Furthermore, (Garg, 2015) enlists several activities of green marketing that contribute to the environment protection such as: *"the production of ecologically safe products, recyclable and biodegradable packaging, pollution-free and energy efficient operations, efficient waste management, harmless product disposal and recycling, among other".*

2.2 Green marketing in a B to B context

The term "green marketing" has been widely studied in a business to customers (BtoC) context. However, the integration of environmental practices and green marketing strategies in the B2B context remains under-explored (Sharma, Iyer, Mehrotra, & Krishnan, 2010)**,**(Fraj, Martínez, & Matute, 2013)**,** (Garg, 2015)

Green marketing strategy (GMS) is defined by (Fraj et al., 2013) as an approach that incorporates: (1) practices that B2B customers perform on the products and process to satisfy their customers' environmental demands; (2) B2B customers decisions that allow to communicate towards stakeholders *"an environmentally responsible behaviour".* According to (Vaccaro, 2009), Business-to-business (B2B) green marketing is a vast subject and includes information about a wide range of activities such as product design, manufacturing process, service delivery processes, packaging, recycling, among others. In the literature review, we can find other similar terms used to refer to green marketing such as "*environmental marketing, ecological marketing, and sustainable marketing".* (Garg, 2015)

According to (Sharma et al., 2010), there is four main functions of the green marketing: (1) Demand management, which focuses on identifying green business customers concerned with the products environmental quality in response to customer demand and change in the market. (2) Predicting demand for environmentally-friendly products, which focus on the demand estimation and market forecasting through multivariate models used to analyse preferences criteria. (3) Promoting environmentally-friendly products, which focus on the product positioning and promotions that reveals the environmental qualities of the product as value-added benefits. (4) Building competitive advantages from a focus on environmental priorities, which focus on build image reputation and positioning the firm as an environmentally conscious business as a driver to strength the firms' market position.

Face-off the remaining question that has been postulated by academics and practitioners about the interest and benefits to be green, and if it really pays to be green?, (Sharma et al., 2010), (Vaccaro, 2009), (Saxena & Khandelwal, 2010), (Fraj et al., 2013), explain following benefits related B2B green marketing strategies :

- It can contribute to competitive advantage over their competitors, increased visibility of an organization's, enhanced corporate reputation, satisfied stakeholders (B2B suppliers, customers, employees), greater brand differentiation and business consumer brand loyalty.
- It can generate economic profitability and superior financial performance by bringing opportunities to cost savings, to increase sales and revenues, higher market shares and ROI.

(Sharma et al., 2010), contributed to the debate by suggesting, *"firms will be at a competitive disadvantage if they do not pay attention to sustainability issues".*

2.3 Strategies for green marketing

There are two strategies in green marketing that have been found in the literature review: (1) reactive and (2) proactive. (Vaccaro, 2009) and (Fraj et al., 2013) describe the two strategies and Table 8 summarize the findings.

2.3.1 Reactive vs proactive strategy

Table 9 Reactive and proactive strategy comparison

	Reactive strategy	**Proactive Strategy**
Definition	Strategy that reacts to changes. It focuses on repairing the damage that has already been done.	Strategy that focuses on the needs of customers, company stakeholders, with the objective to fulfil those needs with innovative solutions. It seeks to improve environmental performance indicators. It aims to redesign or to develop new processes, products, and technologies that allow organizations to eliminate environmental inefficiencies before they are

		generated.
Characteristics	• defensive or reactionary approach • related to end-of-process solutions • follows regulations of environmental management • requires limited resources (not very expensive and low in risk) • has a low level of organizational commitment, low involvement of top management • Short-term orientation	• assertive, aggressive strategy • creates new opportunities in the environment before to respond to external threats • requires greater resources (be more expensive and risky), • has high levels of organizational commitment (environmental corporate policy, top management, and employee involvement) • Long-term in orientation • Source of cost and differentiation advantage • allows firms to find new ways to cut operational costs, reduce consumption, re-use products and materials, or differentiate their image from that of their competitors. • drives industrial firms to achieve superior performance.
Similar concepts	related to the principle of *eco-efficiency*	related to the principle of *eco-effectiveness*

Source: Adapted from(Vaccaro, 2009), (Fraj et al., 2013).

2.4 Green marketing strategies perception according to business customers in a context of B to B

On the one hand, regarding the final customer behaviour (in a B to C context), (Garg, 2015) affirm that there is a positive influence of green marketing strategies on the customers' purchasing patterns. They are concerned about the product's environmental quality perception by the use of eco-labelling, recyclable packaging, and product claims such as eco-friendly, recyclable, biodegradable and ozone-friendly on product labels.

On the other hand, regarding the business customers (in a B to B context), (Sharma et al., 2010) **argue** that the business customer is concerned about the real product's environmental quality which are assessed through a standard reference model developed by each enterprise for suppliers selection. In the same way, they take into account the green practices and strategies communication related to environmental certifications, eco-labelling or eco-design used by the suppliers that are used as drivers to open new markets opportunities. (Fraj et al., 2013) explain that large companies can become more credible by emphasizing their environmental activities to their organizational customers and in the same way, business customers can be trustworthy in emphasizing environmentally-friendly policies in their transactions with other firms because they put pressure on organizations to be environmentally-conscious.

2.4.1 Green marketing strategies perception according to literature case studies

The literature review shows some case studies that explain how is perceived the green marketing strategies. (Garg, 2015) present four factors analysis showing perceptions of green marketing: (1) Environmental concern and green production for sustainable environment; (2) Green Marketing as a Promotional Tool; (3) Green Marketing for Building Customer Trust. (4) Green pricing. The results of the factor analysis show that:

- Companies from public and private-sector are concerned for the environment and they perceived the green production as a crucial factor.
- The perception of the business customer regarding its final customers is that customers are not willing to pay higher prices for green products.
- The companies with products with environmental quality will be able to remain in the marketplace.
- The lack of financial support from the government is perceived as one of the major limitations to adopting green marketing practices.

Here are some perspectives regarding the business customer perception about the green marketing strategies:

- In a context of B to B, Business customers should take into account that "*greening"* the supply chain must include intra-and inter-firm best environmental practices dissemination, environmental technology transfers, cooperation and partnership practices, and environmental performance measurement. Organizational buyers privilege formal partnerships with environmentally certificated sellers (Fraj et al., 2013).
- The adherence to an environmental norm is a requirement for accessing certain business customers that demand certified suppliers (Fraj et al., 2013)
- Green consumers are increasing and the companies which sell green products will be able to remain in the market and will be more successful (Saxena & Khandelwal, 2010).
- How business customers *perceive* the products' environmental quality must be distinguished from how *is performed* the environmental attributes evaluation by the manager (Garg, 2015)**.** Decision makers' background is reflected in their choices and sometimes determine the perception towards the environmental quality (Fraj et al., 2013)**,**.

3. Green supplier selection criteria on a B to B greenness perception

This section aims to understand the green demands in a Business to Business through the green supplier selection criteria definition. Studies on green supplier selection are characterized to define what environmental criteria are considered important by the industries to prefer one supplier over other. A categorization of the main environmental criteria and their sub-criteria is presented based on the related literature. The categorization is intended to provide an insight into the environmental criteria that influence the demand in a B to B context.

3.1 Green supplier selection importance

Increasingly industries have been integrated environmental issues in their strategic decisions (Handfield, 2002). Not only because they must follow governmental legislation to remain on market but also because, end-users are gaining more awareness and have become attracted to green industries that offer eco-responsible products (Ghadimi, Azadnia, Heavey, Dolgui, & Can, 2016).

This green attractiveness is not only perceived by the end-users but by the stakeholders, purchasing managers and policy-makers among others. Stakeholders are interested in investing in companies with green products rather than investing in classical manufacturing business (Ghadimi et al., 2016). Purchasing managers are requesting that their suppliers have certificates (i.e. ISO 14000) because they become responsible not only for the procurement of raw materials but also their disposal and end-life of the product (Handfield, 2002). In Europe, the ***extended producer responsibility*** policy can be defined as "*an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle*."[2] It is mandatory in European Union within the context of the WEEE, Batteries, and ELV Directives, which put the responsibility for the financing of collection, recycling and responsible end-of-life disposal of WEEE, batteries, accumulators and vehicles on producers. Policy-makers are concerned about the green practices implemented by the industries and how those strategies are perceived by the society (business-customer, end-user) whilst minimizing damage to the environment (Igarashi, De Boer, & Fet, 2013), (Ghadimi et al., 2016).

The environmental performance that can be assessed according to (Handfield, 2002), at two different levels. (1) Corporate level and can be perceived as an indicator of environmentally responsible and (2) Product or service level, known as product greenness. Therefore, (Jabbour & Jabbour, 2009) present three stages of the environmental management evolution:

1. Reactive: There is an environmental area geared to meet exclusively the environmental regulation and to meet legislation.
2. Preventive: There are other areas interested in the environment but it is not considered as a strategic topic.

[2] European Commission. 2015. Development of guidance on Extended Producer Responsibility (EPR). Available on http://ec.europa.eu/environment/archives/waste/eu_guidance/introduction.html

3. Proactive: The environmental area is viewed as an important competitive advantage for the enterprise regarding its competitors.

In this context, the business customers, stakeholder, and end-consumers may act as environmental performance drivers:

- Large customers (business customers) drive the suppliers to improve their performance regarding the environmental issues by selecting suppliers based on green criteria. They also act as a driver by promoting the implementation of environmentally friendly practices. (Ghadimi et al., 2016).
- Stakeholders are coming to realize that green purchasing could positively affect cost, operational and corporate performance along environmental dimensions (Handfield, 2002).
- End-consumers, they request green products and components, seeking for companies that can offer those products (Ghadimi et al., 2016).

Given the identified environmental aspects from the end-consumers, stakeholders and regarding their competitive advantage in the green market, a purchaser can start to translate those environmental demands into meaningful criteria for supplier selection (Igarashi et al., 2013), and integrating into the selection criteria proposed by Dickson (1966) such as quality, cost and delivery performance history, among others, several environmental criteria." (Jabbour & Jabbour, 2009).

The supply chain position of the customer driver and the power balance between buyers and supplier may influence the environmental criteria for the supplier selection (Igarashi et al., 2013),. Likewise, considering environmental criteria for supplier evaluation might not have direct impact on increasing the product demand of business customers but by selecting right suppliers, it can eventually be a driver for widening a company's profit margin, reduce purchasing cost, improve competitiveness and enhance end-user satisfaction among others (Ghadimi et al., 2016).

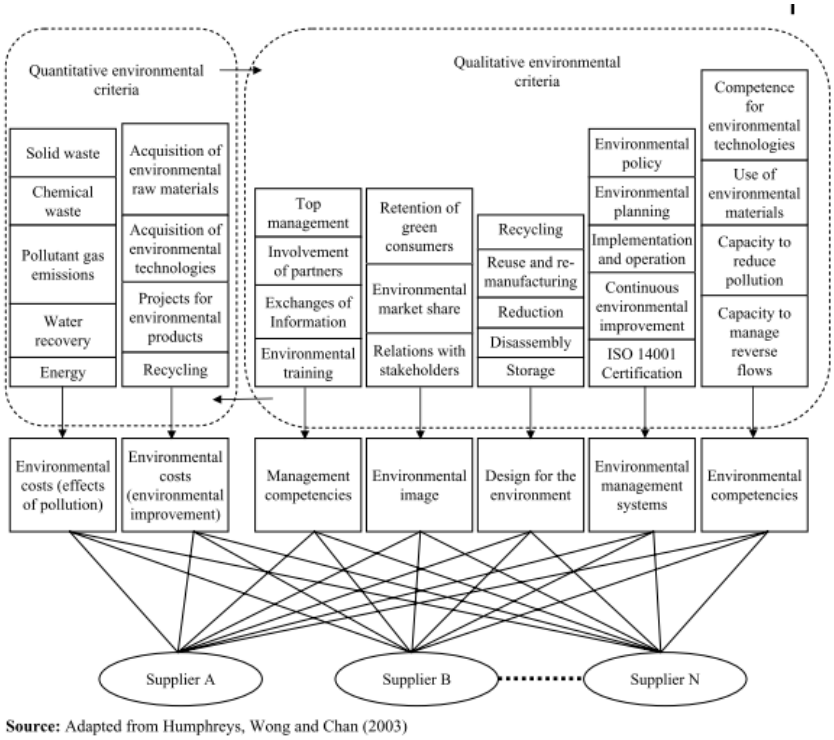
3.2 Environmental criteria

Many environmental criteria may be used to select suppliers. Those are proportional to the environmental demand of the end-consumers (Jabbour & Jabbour, 2009), and it is recognized that most of the criteria are used to measure environmental impact (Igarashi et al., 2013). Nevertheless, the classification of the criteria varies among studies.

3.2.1 Quantitative and qualitative categorization

(Jabbour & Jabbour, 2009) propose a framework of environmental criteria to take into account to select a supplier. They grouped these criteria according to two perspectives: (1) quantitative and (2) qualitative. The first group of criteria must be expressed in monetary value such as the cost generated to mitigate supplier pollution and cost generated to improve and support environmental management at suppliers. The second group of criteria refers to criteria linked

to the managerial practices such as management and environmental competencies, supplier green image, development of products with high environmental performance and environmental management system. They propose a subcategory of criteria presented in figure 11.



Source: Adapted from Humphreys, Wong and Chan (2003)

Figure 11 Green supplier selection criteria framework. Retrieved from (Jabbour & Jabbour, 2009)

3.2.2 Environmental sustainability dimensions' categorization

(Ghadimi et al., 2016) propose five main criteria regarding the environmental sustainability dimension. They establish a set of subcategories of criteria that can be used in a supplier selection evaluation in a qualitatively/quantitatively way. Table 10 shows the description and the subcategories of criteria.

Table 10 Environmental sustainability dimensions categorization. Adapted from (Ghadimi et al., 2016)

Criteria	Description	Sub-categories of criteria
Environmental performance	Supplier's performance regarding environmental policies, certificates and regular environmental quality audits implementation.	• Environment-related certificates • Internal control process • Green process planning • Continuous monitoring and regulatory compliance • Environmental protection plans

		• Environmental protection policies
Green image	Supplier's efforts to build an image of environmental friendly industry.	• Market reputation • Market share • Customer retention • Stakeholder's relationship • Staff environmental training
Pollution control	Supplier's pollution level, greenhouse, and Co2 emissions control, local and global legislation compliance.	• Air emissions • Water waste • Solid waste • Resources consumption • Use of harmful materials • Carbon footprint
Green competencies	Suppliers' competencies in green purchasing and manufacturing practices regarding the selections and use of green components and packaging to decrease environmental impact.	• Use of environmental-friendly materials • Flexibility • Responsiveness • Green packaging • Recycling capability • Green technology
Green design	Supplier's eco-design to obtain environmental friendly raw materials and product components.	• Recycle • Reuse • Refurbish • Remanufacture • Disassembly • Disposal

3.2.3 Product and organization related criteria

(Igarashi et al., 2013) explain that environmental criteria are structured in relation either to the product or to the supplier organization that provides the product. This is why they propose as the main point of departure two categorizations of environmental criteria for supplier selection product and organization related criteria. Table 11 shows the description of the criteria and the categorization.

Table 11 Product and organization related criteria. Adapted from (Igarashi et al., 2013)

Criteria	**Description**	**Sub-categories of criteria**
Product	It refers to the environmental request that must accomplish the product to be green. This includes raw material, product's components, and packaging.	• No use of toxic substances • Recycled raw materials • Environmental labelling • Packaging recycled

Organization	It refers to the set of supplier green practices to improve the greenness of the product.	• Certification of the environmental management system • Environmental policy • Compliance with regulations • Evaluation of the second tier suppliers' environmental performances

3.2.4 Environmental performance attributes criteria

(Handfield, 2002) define six environmental performance attributes as criteria for supplier selection. Table 12 shows the description.

Table 12 Product and organization related criteria. Adapted from (Handfield, 2002)

Criteria	**Description**	**Sub-categories of criteria**
Product attributes	To eliminate the level of toxic materials purchased and used in the product/process, it includes internal processes, re-design of existing products.	• Internal recycling • Control of toxic level • Control of hazardous materials
Waste management	These are primary outputs of the supplier's process.	• Gross annual solid waste tonnage that goes to landfill • Disposition of hazardous materials.
Labelling/certification	It is the supplier's processes certified by third parties (government or non-government).	• Voluntary participation in eco-labelling systems (Green Lights, Green Label, etc.). • Third-party certification of its environmental systems or activities such as ISO 14000 certification.
Packaging/reverse logistics	It refers to green reverse practices developed by the supplier.	• Remanufacturing/reuse, • Returnable or reduced packaging • Reverse logistics systems
Compliance with Government Regulations.	Those are the activities of the supplier are being carried out accomplishing the regulatory requirements.	• Air and water permits are up to date, • Number of violations have taken place.
Environmental	It refers to the presence	• Training programs

Programs at the supplier's facilities	of environmental systems within the supplier's management system.	• Internal reporting structures • Public disclosure statements • Internal mission statements relating to the environment • Supplier evaluation systems

3.3 Environmental criteria perspectives

3.3.1 Environmental criteria B to B perception

In the study developed by (Tseng, Tan, & Chiu, 2016), the environmental criteria ranked by managers as a top priority are:

- Environmental costs
- Strategic alliances
- Environmental audits of suppliers
- Environmental standards for suppliers
- Environmental audits of suppliers
- Standardized operational procedures and environmental department

From the (Ghadimi et al., 2016) categorization, environmental performance and pollution control is the criteria most cited and used by researchers. Likewise, (Handfield, 2002) add two indicators to the environmental performance criteria of the product, Biodegradable and compostable.

(Jabbour & Jabbour, 2009) define the top criteria selected by managers. Those criteria were the reduction of chemical and toxic material substances, the quantitative analysis of environmental impact, information database on supplier environmental performance, the ISO 14001 certification and the fact that a supplier has a corporate manual of environmental criteria, but it is without practical effect.

(Handfield, 2002), enlisted the top 10 criteria after Delphi group on its study. The managers that participated in that study, tend to rely largely on perceived measures of environmental performance. In the results of the study, the top ten criteria most important and the top 10 criteria that were perceived the most easily assessed by the managers are shown in Annex 2. Nevertheless, only four criteria are perceived as most important and easily assessed:

- Public disclosure of environmental record
- ISO 14000 certification
- EPA 17 hazardous material list
- Ozone-depleting substances

Finally, (Ghadimi et al., 2016) based on the number of papers that address to a specific industry, show that the three main industries involved in green purchasing practices and the definition of green supplier selection criteria as a strategy for the firm competitiveness are:

1. The automotive industry with ten papers.

2. The electrical/electronic industry with nine papers.
3. White good manufacturing with four papers.

3.3.2 Outcomes from green supplier selection performance

Regarding the increasing importance of green supplier selection as strategy, two main questions are addressed in the literature:

- *"How to translate supplier environmental performance into cost metrics?* (Handfield, 2002).
- *What are the actual outcomes that can be realized from the adoption of green supply chain initiatives."* (Eltayeb, Zailani, & Ramayah, 2011)

To answer these questions, (Eltayeb et al., 2011) propose four categories of performance outcomes explained in Figure 12.

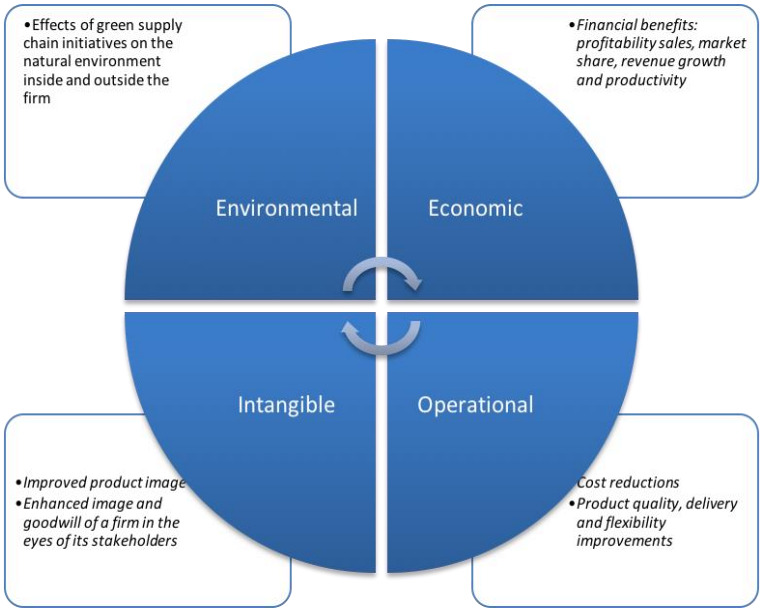


Figure 12 Outcomes from green supplier selection performance. Adapted from (Eltayeb et al., 2011)**.**

4. Categories for product's environmental quality criteria

4.1 Conceptual approach proposed

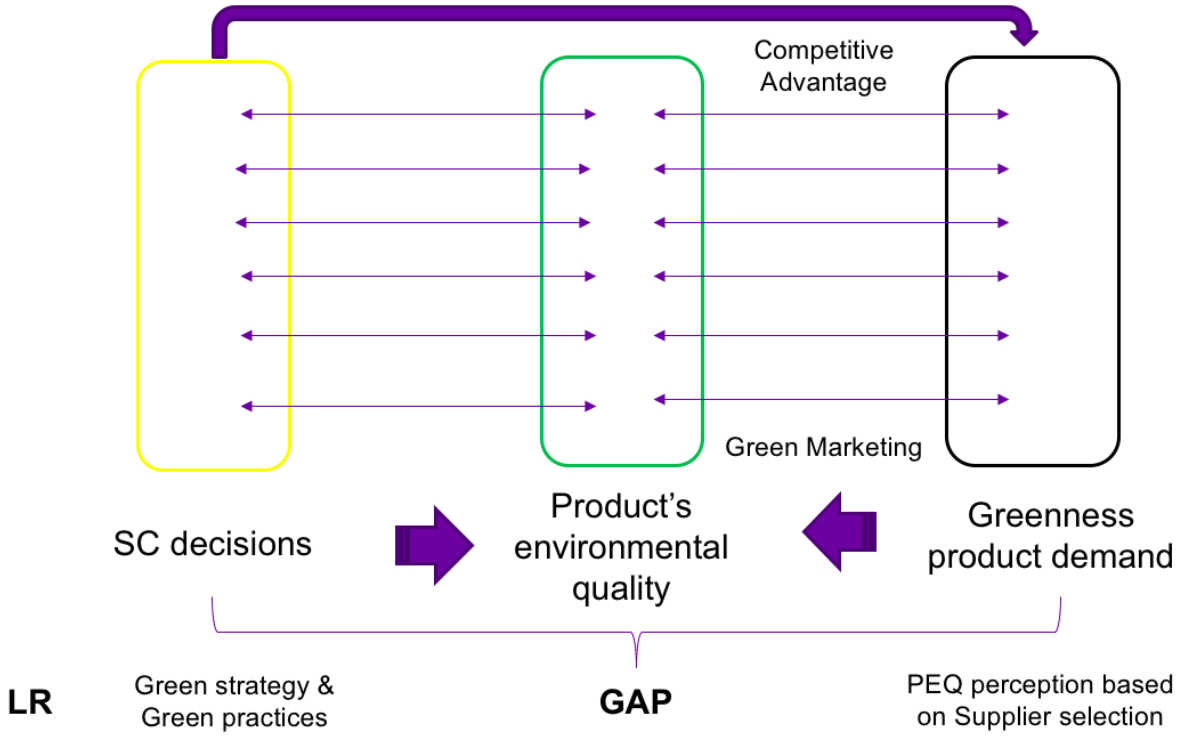


Figure 13 Conceptual approach proposed

In a Business to Business (BtoB) context, on the one hand, there are the green strategies and practices that aim to improve the environmental quality performance of the product. On the other hand, the environmental quality of the product is perceived by business customers when they perform the green supplier selection, influenced on the green marketing strategy of the supplier and based on its own competitive advantage.

4.2 Environmental criteria using the double coding method

Our objective was to categorize the environmental criteria preselected from the literature review and drawn from the bibliographical research. Two coders conducted this study by following the double-coding method, which is used in qualitative analyses. The results obtained facilitate the decision-making for the stakeholders since it defines more precisely the priorities.

The objective of the qualitative analysis was to develop a categorization of criteria influencing the environmental performance of a product. It was addressed according to two different phases: the first coder and the second coder analyses. The first step was to establish an inventory of environmental criteria as well as a study about the different methods of categorization.

The second phase of the categorization of the environmental criteria relied on the use of the double coding method. The principle was to code the same material and data by two researchers so as to discuss the similarities and most importantly their difficulties and difference of point of view. These disagreements and dissonance, according to (Miles & Huberman, 1984), mean that the definition is to be more in-depth developed or amended. The time spent on double-coding is no wastage since it allows researchers to reach a common vision of the categorization of the data. This method not only helps getting a clear idea on the issue tackled but also provides a good reliability check.

Double-coding can be divided into two steps: intra-coding and inter-coding according to (Miles & Huberman, 1984). The first treatment is to be conducted by the coder alone in order to ensure the consistency of his own work by reviewing his results regularly. As for the second treatment, the two results obtained by the two coders are confronted so as to come up ideally with a common resolution that does not negate the rich character of each contribution.

4.2.1 Results of double codage method

The following is the categorisation proposed by each coder:

Categories

The categories used by the two coders are the same:

- Supply
- Manufacturing
- Distribution
- Use
- Disposal
- Transversal

Subcategories

Regarding the subcategories, the first coder established 18 subcategories and the second coder established 20 subcategories.

- Supply category: 6 (1st Coder) vs 5 (2nd Coder)
- Manufacturing: both coder established two subcategories but different.
- Distribution: 4 (1st Coder) vs 3 (2nd Coder)
- Use: 2 (1st Coder) vs 3 (2nd Coder)
- Disposal: 1 (1st Coder) vs 2 (2nd Coder)
- Transversal: 3 (1st Coder) vs 5 (2nd Coder)

Table 13 details the subcategories proposed by each coder.

Table 13 Subcategories comparison between the coders.

Categories	Subcategories Coder 1	Subcategories Coder 2
Supply	Raw materials characteristics	Choice of materials and product's composition
	Product components	

	Product design	Design/Conception phase
	Purchasing practices	Procurement/Purchase management practices
	Packaging	Product's packaging practices
	Purchasing practices - suppliers	Suppliers relationship management
Manufacturing	Manufacturing management practices	Manufacturing management practices
	Manufacturing technologies	Manufacturing process
Distribution	Sales and marketing practices	Distribution methods and practices
	Warehouse decisions	Flow optimization
	Transport practices	Logistics' fleet
	Distribution technologies	
Use	Product use charasteristics	Product's characteristics during use
	Customer management practices	Consumer's involvement in the enhancement of the product's environmental quality
		Product's green image
Disposal	Reverse management practices	Waste disposal
		Reverse logistics practices
Transversal	Emission	Emission assessment
	SC actors environmental practices	Guideline of environmental practices
		Final product's intrinsic quality
	Ressources efficiency	Resource use
		Use of clean technology

Criteria

Then, each criterion was assigned to the appropriate category and subcategory. The first coder found 300 environmental criteria and the second coder found 265 environmental criteria.

The results of the intra-coding for the first coder are shown in table 13.

Table 14 Criteria established by the first coder.

Categories	Subcategories	Environmental criteria	Rate	Category rate
Supply	Raw materials characteristics	11	3,7%	27%
	Product components	24	8,0%	
	Product design	1	0,3%	
	Purchasing practices	22	7,3%	
	Packaging	12	4,0%	
	Purchasing practices - suppliers	11	3,7%	
Manufacturing	Manufacturing management practices	30	10,0%	12%
	Manufacturing technologies	6	2,0%	
Distribution	Sales and marketing practices	2	0,7%	18%
	Warehouse decisions	9	3,0%	
	Transport practices	36	12,0%	

	Distribution technologies	6	2,0%	
Use	Product use charasteristics	8	2,7%	6%
	Customer management practices	9	3,0%	
Disposal	Reverse management practices	32	10,7%	11%
Transversal	Emission	21	7,0%	27%
	SC actors environmental practices	41	13,7%	
	Ressources efficiency	19	6,3%	
	Total	300	100%	100%

The results of the intra-coding for the second coder are shown in Table 15.

Table 15 Criteria established by the second coder.

Categories	**Subcategories**	**Environmental criteria**	**Rate**	**Category rate**
Supply	Choice of materials and product's composition	22	8%	22%
	Design/Conception phase	6	2%	
	Procurement/Purchase management practices	9	3%	
	Product's packaging practices	11	4%	
	Suppliers relationship management	10	4%	
Manufacturing	Manufacturing management practices	18	7%	11%
	Manufacturing process	10	4%	
Distribution	Distribution methods and practices	32	12%	21%
	Flow optimization	19	7%	
	Logistics' fleet	4	2%	
Use	Product's characteristics during use	11	4%	6%
	Consumer's involvement in the enhancement of the product's environmental quality	2	1%	
	Product's green image	4	2%	
Disposal	Waste disposal	12	5%	12%
	Reverse logistics practices	20	8%	
Transversal	Emission assessment	4	2%	28%
	Guideline of environmental practices	38	14%	
	Final product's intrinsic quality	15	6%	
	Resource use	12	5%	
	Use of clean technology	6	2%	
Total		265	100%	100%

The result of the intra-coding is subject to the inter-coding which refers to the confrontation step with the results of the first and the second coder. Those results show similar proportion for each category and its rank with slight differences nonetheless. Qualitative wise, each coder developed its own classification in terms of subcategories. However, there are similarities in some cases but with different formulation, other subcategories are either split or grouped.

The double coding method used can be adopted in other qualitative analyses related to different projects. Besides, being able to provide an inventory of categorized environmental criteria impacting the demand is helpful for the organizations aiming at developing their green image since it facilitates the prioritization of the actions. This typology of criteria will also be used as a basis in the next phase of the project to structure the questionnaire for the quantitative survey that will endeavor to identify the relative weight of each type of criteria on the supplier selection decision.

Furthermore, the number of criteria that have been taken into account by the coders are different, for the first coder was 300 criteria and for the second coder 265. This difference is explained by different treatments to eliminate redundancy and classify each criterion in the appropriate category.

Nevertheless, regarding the results of the categorization developed by the coders, for each category unit, the subcategories scan the whole spectrum but with differences in numbers and titles. The distribution category expresses accurately the differences noticed. The first coder integrated the sales and marketing practices as subcategory whereas the second coder placed it in the use category and included it in the product's green image subcategory because its effect is noticed in the purchase trends of the users.

For the rest, the distribution methods can be divided into technology adopted, warehouse and transport practices as it is the case for the first coder who have seen from another perspective which is related to flow management and logistics fleet as it is the case for this present study.

Finally, we can conclude that the overall results are very similar. For the ***supply category*** rate, both coders categorized the criteria almost in the same percentage, between the 22% and 27%. For the ***manufacturing category,*** between the 11% and 12%. For the ***distribution category,*** between 18% and 21%. For the ***use category***, both coders obtain the same rate 6%. For ***disposal category*** between 11% and 12%. Finally for the ***transversal category*** between 27% and 28%.

4.3 Environmental criteria defined

The next step was to define the environmental criteria that characterize the product's environmental quality, for this we extracted from the literature review several criteria related to:

- Product characteristics
- Practices in the supply chain that improve the environmental quality of the product.

From the literature review, we observed heterogeneous groups of works and approaches, with different methodologies. In order to define the first unification criteria into a general framework to extract the different criteria and to propose a categorization for product's

environmental quality criteria we used meta-narrative analyses applied by (Gonzalez-Feliu, 2011, 2013; Greenhalgh, Russell, & Swinglehurst, 2005). According to (Greenhalgh et al., 2005), a meta-narrative comprises "a shared set of concepts, theories and preferred methods" and "is sited within a particular scientific discipline and should be regarded not as the unified voice of a community of scholars but as the unfolding of what they are currently discussing about". This means that the meta-narrative analyses are related not to words but to concepts.

Indeed, we found that researchers and scholars from similar research communities explain and describe the product's environmental criteria in different words but they address to the same concept. As a result, we obtained a set of environmental criteria reflected on product characteristics and practices that aim to take into account decisions on the product greenness and in consequence improve the product's environmental quality. Figure 14 shows the categories for product's environmental quality criteria.

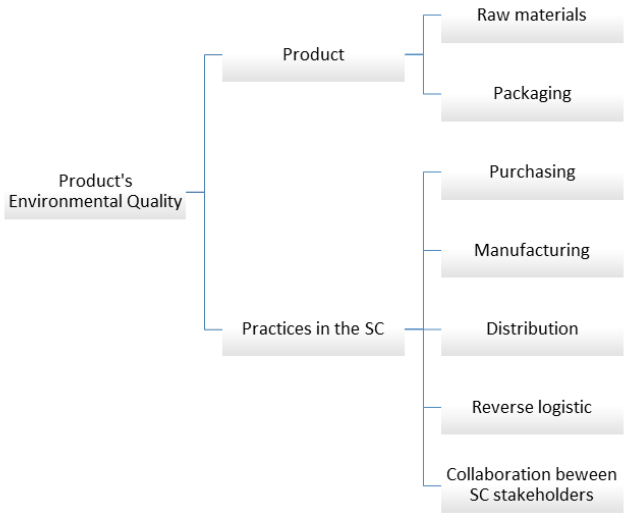


Figure 14 Categories for product's environmental quality criteria

We decided to present the product environmental criteria according to:

Product characteristics:

- *Raw materials:* this category includes the characteristics of the raw materials that improve the environmental quality of the product, such as environmentally certified raw materials, less or non-polluting/toxic materials, among others.
- *Packaging:* this category includes product's packaging characteristics such as recyclable, biodegradable, packaging's size and weight reduced, and environmental information on product's packaging, among others.

The supply chain practices that improve the product's environmental quality:

- *Purchasing:* this category includes criteria related to supplier's location, environmental impact of purchased materials, environmental practices performed by the supplier,

green purchasing guideline development, and environmental partnership with suppliers.

- *Manufacturing:* this category includes criteria related to location decision on manufacturing and warehouse, energy efficiency of production, eco-efficiency of production and greener production technology.
- *Distribution:* this category includes criteria related to location decision on distribution points, energy efficiency of distribution, eco-efficiency of distribution (related to the reduction of transportation emissions and pollution control).
- *Reverse logistics:* this category includes criteria related to the formal policy on reverse logistics of the product and packaging.
- *Collaboration between supply chain stakeholders:* this category includes criteria related to customer management practices, green network efficiency, product's environmental performance assessment in the entire supply chain and the implementation of the environmental management system (EMS).

4.4 Main contributions driving the development of the literature review

Regarding the set of papers selected to develop the literature review analysis, figure 15 shows the percentage of papers addressing each product's environmental quality criteria according to the categorization explained above.

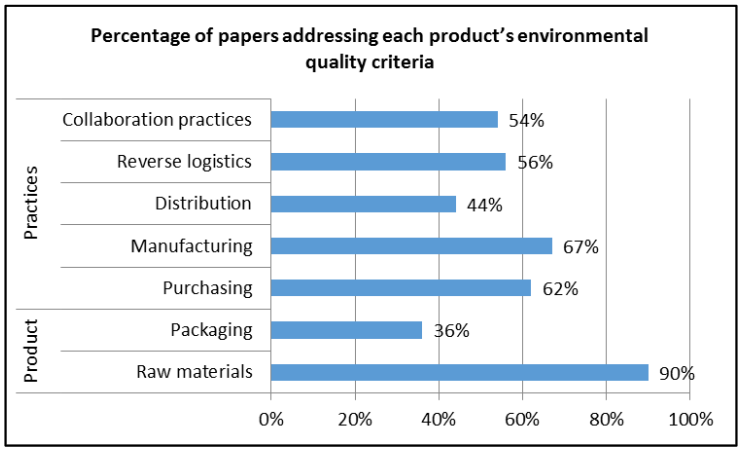


Figure 15 Categories for product's environmental quality criteria

On the one hand, the environmental criteria related to product characteristics are addressed by the 90% of the set of papers selected. In this set of criteria 90% of the papers selected mention the raw materials characteristics as an important factor that defines the environmental quality of the product. Only 36% of the papers address the packaging characteristics. On the other hand, 92% of the papers selected mention practices that influence the product's environmental quality. 67% bring up the fact that manufacturing practices can improve the environmental quality of the product, followed by purchasing practices with 62%.

In addition, taking into account the product's environmental criteria related to SCM and the meta-narrative analysis developed, we classified every criterion into each category proposed.

Table 16 shows the number and percentage of the total criteria that has been classified into the above categorization.

Table 16 Categories for product's environmental quality criteria results

Categories	Sub-categories	Environmental criteria	Rate (%)	Category Rate (%)
Product	Raw materials	36	12%	**16%**
	Packaging	12	4%	
Practices	Purchasing	41	14%	**84%**
	Manufacturing	56	19%	
	Distribution	71	24%	
	Reverse logistics	32	11%	
	Collaboration practices	52	17%	
	Total criteria	**300**	100.0%	

The product characteristics regarding product's environmental quality represent the 16% of the selected criteria, 12% in raw materials and 4% in packaging. Nevertheless, we found that the criteria related to supply chain decisions regarding environmental practices represent the 84% of the selected criteria. This means that in the researchers are most interested in analyse the practices that increase the environmental quality rather than analyse the intrinsic characteristics of the product.

Regarding the relationship between the first category and the second one, it explains the concept of greenness related to purchasing practices (14%) that have a great influence on the definition of the product's characteristics though the supplier selection process.

The manufacture practices are also relevant in the product's environmental quality with 19% of the selected criteria with practices that involve since warehouse location decisions until the use of greener technology to decrease the amount of emissions during the product production. The criteria related to distribution practices represent the 24% of the criteria selected. Among those criteria, we found several related to key decisions such as planning and optimization of transport to obtain an efficient transportation network to decrease unnecessary distance and in consequence obtain the reduction of emissions. Reverse logistic practices represent 11% of the selected criteria regarding the final disposal of product and packaging.

Finally, it is important to highlight the fact that collaboration practices represent 17% of the selected criteria. This means that the collaboration initiatives settled by the supply chain actors to develop a product qualified as a product with environmental quality are very important. This fact reveals the importance of the collaboration and joint practices through the supply chain.

4.4.1 Environmental criteria based on green practices and strategies

From the 300 criteria presented before and after deleting the criteria that were not relevant for the study (i.e. doubles, applied to specific cases or industries, etc..) we selected 92 criteria.

Then those criteria were categorized according to the literature review and redefined according to product and organizations criteria, we obtained 26 criteria:

- Regarding products characteristics: seven environmental criteria related to raw material and two related to packaging.
- Regarding organization green strategies and practices: five concerning green supply / green purchasing practices, four concerning green manufacturing practices, three concerning green distribution practices, one concerning green reverse logistics and four concerning transversal collaboration practices among the stakeholders.

The environmental criteria are described in detail in Annex 3 and Annex 4.

5. Conclusion: Research hypothesis from the conceptual framework

This literature review allowed us to propose several hypothesis that will be tested with a qualitative and a quantitative survey during the second phase of the CONCLUDE project.

5.1 General hypothesis

H: The environmental quality of the product impacts the product's demand (remains stable, decrease or increases the product's demand)

5.2 Regarding the business customer offer (product)

HP: The environmental characteristics of the product improve the environmental quality of the product

H (P1) The raw materials improve the environmental quality of the product.

H (P2) The product components improve the environmental quality of the product.

H (P3) The packaging improves the environmental quality of the product.

5.3 Regarding the business customer organizational practices

HO: The practices developed by the business customer improve the environmental quality of the product

H (O1) The purchasing practices improve the environmental quality of the product.

H (O2) The manufacturing practices improve the environmental quality of the product.

H (O3) The distribution practices improve the environmental quality of the product.

H (O4) The revers logistics improve the environmental quality of the product.

H (O5) The transversal practices improve the environmental quality of the product.

5.4 Regarding the business customer perception towards the supplier green practices

HS: The practices developed by the suppliers are perceived by the business customer as practices that improve the environmental quality of the product.

H (S1) The supplier's environmental practices that decrease the pollution performed are perceived as practices that improve the environmental quality of the product.

H (S2) The supplier's environmental practices that are communicated as practices that improve the environmental quality of the product are perceived as practices that improve the environmental quality of the product.

H (S3) The supplier's environmental management competencies are perceived as practices that improve the environmental quality of the product.

H (S4) The supplier's environmental image is perceived as a practice that improves the environmental quality of the product.

H (S5) The supplier's design for the environment practice is perceived as a practice that improves the environmental quality of the product.

H (S6) The supplier's environmental management system is perceived as a practice that improves the environmental quality of the product.

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Annex 1. Product eco-declaration (PED)

THE ECO DECLARATION

Product environmental attributes – THE ECO DECLARATION

The declaration may be published only when all rows and/or fields marked with an * are filled-in (n.a. for not applicable).
Additional information regarding each item may be found under P14.

Brand *	*Lenovo*	**Logo**
Company name *	*Lenovo*	
Contact information *	*Lenovo Global Environmental Affairs* *Alvin L Carter* *1009 Think Place* *Building 2 / 5F1* *Morrisville, North Carolina 27560* *alcarter@lenovo.com*	
Internet site *	*http://www.lenovo.com/social_responsibility/us/en/environment.html*	
Additional information	*The latest version of this document can be found at* *http://www.lenovo.com/social_responsibility/us/en/datasheets_notebooks.html*	

The company declares (based on product specification or test results based obtained from sample testing), that the product conforms to the statements given in this declaration.	
Type of product *	***Desktop***
Commercial name *	***ThinkCentre M900***
Model number *	***10FL 10FM 10FR 10FS 10ND 10NE 10NF 10NG***
Issue date *	*2016-09-20*
Intended market *	☒ Global ☐ Europe ☐ Asia, Pacific & Japan ☐ Americas ☐ Other
Additional information	*Tiny;ENERGY STAR® Qualified; GREENGUARD Certification;TUV Green Mark;ULE;EPEAT*

This is an uncontrolled copy when in printed form. Please refer to the contact information for the latest version.

Quality Control		Requirement met	
Item		Yes	No
QC1 *	The company enforces an internal quality control scheme to ensure the correctness of this eco declaration	☒	☐
QC2 *	The company is a member of an eco declaration system that enforces regular independent quality control such as organized by IT-Företagen (see www.itecodeclaration.org).	☒	☐

Model number *	**ThinkCentre M900** 10FL 10FM 10FR 10FS 10ND 10NE 10NF 10NG		
Issue date *	2016-09-20	Logo	Lenovo

Product environmental attributes - Legal requirements		Requirement met		
Item		Yes	No	n.a.
P1	**Hazardous substances and preparations**			
P1.1*	Products do not contain more than; 0.1% lead, 0.01% cadmium, 0.1% mercury, 0.1% hexavalent chromium, 0.1% polybrominated biphenyls (PBB) or 0.1% polybrominated diphenyl ethers (PBDE). (See legal reference and Note B1)	☒	☐	
P1.2*	Products do not contain Asbestos (see legal reference). Comment: Legal reference has no maximum concentration value.	☒	☐	
P1.3*	Products do not contain Ozone Depleting Substances: Chlorofluorocarbons (CFC), hydrobromofluorocarbons (HBFC), hydrochlorofluorcarbons (HCFC), Halons, carbontetrachloride, 1,1,1-trichloroethane, methyl bromide (see legal reference). Comment: Legal reference has no maximum concentration values.	☒	☐	
P1.4*	Products do not contain more than; 0.005% polychlorinated biphenyl (PCB), 0.005% polychlorinated terphenyl (PCT) in preparations (see legal reference).	☒	☐	
P1.5*	Products do not contain more than 0.1% short chain chloroparaffins (SCCP) with 10-13 carbon atoms in the chain containing at least 48% per mass of chlorine in the SCCP (see legal reference).	☒	☐	
P1.6*	Textile and leather parts with direct skin contact do not contain Tri-(2,3,-dibromopropyl)-phosphate (TRIS), Tris-(aziridinyl)-phosphineoxide (TEPA), polybrominated biphenyl (PBB) (see legal reference). Comment: Legal reference has no maximum concentration values.	☐	☐	☒
P1.7*	Textile and leather parts with direct skin contact do not contain more than 0.003% Azo colorants that split aromatic amines. (See legal reference and Note B1)	☐	☐	☒
P1.8*	Wooden parts do not contain arsenic and chromium as a wood preservation treatment as well as pentachlorophenol and derivatives (see legal reference). Comment: Legal reference has no maximum concentration values.	☐	☐	☒
P1.9*	Parts with direct and prolonged skin contact do not release nickel in concentrations above 0.5 microgram/cm^2/week (see legal reference). Comment: Max limit in legal reference when tested according to EN1811:1998.	☒	☐	☐
P1.10*	REACH Article 33 information about substances in articles is available at (add URL or mail contact): *http://www.lenovo.com/social_responsibility/us/en/materials.html*	☒	☐	☐
P2	**Batteries**			
P2.1*	If the product contains a battery or an accumulator, it is labeled with the disposal symbol and if it contains more than 0.0005% of mercury (for button cells only) by weight, or more than 0.004% of lead, it shall be marked with the chemical symbol for the metal concerned, Hg or Pb. Information on proper disposal is provided in user manual. (See legal reference)	☒	☐	☐
P2.2*	Button cells used in the product do not contain more than 2% by weight of mercury. Other batteries or accumulators do not contain more than 0.0005% of mercury or 0.002% of cadmium. (See legal reference)	☒	☐	☐
P2.3*	Batteries and accumulators are easily removable by either users or service providers (as dependent on the design of the product). Exception: Batteries that are permanently installed for safety, performance, medical or data integrity reasons do not have to be "easily removable". (See legal reference)	☒	☐	☐
P3	**Safety, EMC connection to the telephone network and labeling**			
P3.1*	The product complies with legally required safety standards as specified (see legal reference).	☒	☐	☐
P3.2*	The product complies with legally required standards for electromagnetic compatibility (see legal reference).	☒	☐	☐
P3.3*	If product is intended for connection to a public telecom network or contains a radio transmitter, it complies with legally required standards for radio and telecommunication devices (see legal reference).	☒	☐	☐
P3.4*	The product is labeled to show conformance with applicable legal requirements (see legal reference).	☒	☐	☐
P4	**Consumable materials**			
P4.1*	If a photo conductor (drum, belt etc.) is used in the product, it does not contain cadmium max 0.01% (see legal reference and Note B1).	☐	☐	☒
P4.2*	If ink/toner is used in the product, it does not contain cadmium max 0.1% by weight (see legal reference).	☐	☐	☒
P4.3*	If the ink/toner formulation/preparation is classified as hazardous according to applicable regulations, the product/packaging is adequately labeled and a Safety Data Sheet (SDS) in accordance with these requirements is available (see legal reference).	☐	☐	☒
P5	**Product packaging**			
P5.1*	Packaging and packaging components do not contain more than 0.01% lead, mercury, cadmium and hexavalent chromium by weight of these together.	☒	☐	
P5.2*	Plastic packaging material is marked according to ISO 11469 referring ISO 1043 (see legal reference).	☒	☐	☐
P5.3*	The product packaging material is free from ozone depleting substances as specified in the Montreal Protocol (see legal reference). Comment: Legal reference has no maximum concentration values.	☒	☐	☐

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Issue date *	*2016-09-20*	Logo	Lenovo

Product environmental attributes - Market requirements - Environmental conscious design		Requirement met		
Item	*=mandatory to fill in. Additional information regarding each item may be found under P14.	Yes	No	n.a.
P6	**Treatment information**			
P6.1*	Information for recyclers/treatment facilities is available (see legal reference).	☒	☐	☐
P7	**Design** **Disassembly, recycling**			
P7.1*	Parts that have to be treated separately are easily separable	☒	☐	☐
P7.2*	Plastic materials in covers/housing have no surface coating.	☐	☒	☐
P7.3*	Plastic parts >100g consist of one material or of easily separable materials.	☐	☐	☒
P7.4*	Plastic parts >25g have material codes according to ISO 11469 referring ISO 1043.	☐	☐	☒
P7.5	Plastic parts are free from metal inlays or have inlays that can be removed with commonly available tools.	☐	☐	☒
P7.6*	Labels are easily separable. (This requirement does not apply to safety/regulatory labels).	☒	☐	☐
	Product lifetime			
P7.7*	Upgrading can be done e.g. with processor, memory, cards or drives	☒	☐	☐
P7.8*	Upgrading can be done using commonly available tools	☒	☐	☐
P7.9.	Spare parts are available after end of production for: *5* years			☐
P7.10	Service is available after end of production for: *5* years			☐
	Material and substance requirements			
P7.11*	Product cover/housing material type: Material type: *ABS* Material type: *PC* Material type:			
P7.12	Electrical cable insulation materials of power cables are PVC free.	☐	☒	☐
P7.13	Electrical cable insulation materials of signal cables are PVC free	☐	☒	☐
P7.14	All cover/housing plastic parts >25g are free from chlorine and bromine.	☐	☐	☒
P7.15	All printed circuit boards (without components) >25g are halogen free. as defined in IEC61249-2-21. (See Note B2)	☐	☒	☐
P7.16	Flame retarded plastic parts >25g in covers / housings are marked according ISO 1043-4: Marking:	☐	☐	☒
P7.17	Alt. 1 Chemical specifications of flame retardants in printed circuit boards >25g (without components): TBBPA (additive) ☐, TBBPA (reactive) ☐, Other; chemical name: *Brominated Epoxy Resin*, CAS #: *26265-08-7* Alt. 2 Chemical specifications of flame retardants in printed circuit boards (without components) >25g according ISO 1043-4: *Brominated Epoxy Resin See P14*	☒ ☐	☐ ☒	☐ ☐
P7.18	Alt. 1 Flame retarded plastic parts >25g contain the following flame retardant substances/preparations in concentrations above 0.1%: Comment: No legal limits exist, this is a market requirement. 1. Chemical name: , CAS #: 2. Chemical name: , CAS #: 3. Chemical name: , CAS #: Alt. 2 Chemical specifications of flame retardants in plastic parts >25g according ISO 1043-4:	☐ ☐	☐ ☐	☒ ☒
P7.19	Plastic parts >25g are free from flame retardant substances/ preparations above 0.1% classified as R45, R40, R46, R48, R50, R51, R53, R60, R61 and any combination of these (See Note B3)	☐	☐	☒
P7.20	Of total plastic parts' weight >25g, recycled material content is *see P14*%.			☒
P7.21	Of total plastic parts' weight >25g, biobased material content is *0*%.			☒
P7.22	Light sources are free from mercury If mercury is used specify: Number of lamps: and max. mercury content per lamp: mg	☒	☐	☐
P8	**Batteries**			
P8.1*	Battery chemical composition: *Lithium manganese dioxide coin battery*			☐
P8.2	Batteries meet the requirements of the following voluntary program/s:			☐

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Issue date *	2016-09-20	Logo	Lenovo

Product environmental attributes - Market requirements (continued)					Requirement met Yes	No	n.a.
Item							
P9	**Energy consumption**						
9.1	For the product the following power levels or energy consumptions are reported: *See P14*						
Energy mode *	Power level at **100** V AC	Power level at **115** V AC	Power level at **230** V AC	Reference / Standard for energy modes and test method *			
Peak (On-max)	W	W	W	*Full load*			
Category I3							
Short Idle State - WOL Enabled	*12.94* W	*12.87* W	*13.23* W	*Use for ENERGY STAR V6 registration (P_{idle})*			
Long Idle State - WOL Enabled	*12.06* W	*12.07* W	*12.39* W	*Use for ENERGY STAR V6 registration (P_{idle})*			
Sleep (S3) - WOL Enabled	*2.28* W	*2.3* W	*2.37* W	*Use for ENERGY STAR V6 registration(P_{sleep})*			
Sleep (S3) - WOL Disabled	W	W	W	*Reference*			☒
Off (S5) - WOL Enabled	*1.28* W	*1.27* W	*1.33* W	*Use for ENERGY STAR V6 registration(P_{off})*			
Off (S5) - WOL Disabled	W	W	W	*Use for EuP*			☒
Category I1							
Short Idle State - WOL Enabled	*8.94* W	*8.86* W	*8.95* W	*Use for ENERGY STAR V6 registration(P_{idle})*			
Long Idle State - WOL Enabled	*8.94* W	*7.95* W	*8.2* W	*Use for ENERGY STAR V6 registration(P_{idle})*			
Sleep (S3) - WOL Enabled	*2.22* W	*2.22* W	*2.27* W	*Use for ENERGY STAR V6 registration (P_{sleep})*			
Sleep (S3) - WOL Disabled	W	W	W	*Reference*			
Off (S5) - WOL Enabled	*0.9* W	*0.9* W	*0.91* W	*Use for ENERGY STAR V6 registration(P_{off})*			
Off (S5) - WOL Disabled	W	W	W	*Use for EuP*			
Category I2							
Short Idle State - WOL Enabled	*9* W	*8.93* W	*9.18* W	*Use for ENERGY STAR V6 registration(P_{idle})*			
Long Idle State - WOL Enabled	*8.09* W	*8.11* W	*8.09* W	*Use for ENERGY STAR V6 registration(P_{idle})*			
Sleep (S3) - WOL Enabled	*2.22* W	*2.22* W	*2.27* W	*Use for ENERGY STAR V6 registration (P_{sleep})*			
Sleep (S3) - WOL Disabled	W	W	W	*Reference*			
Off (S5) - WOL Enabled	*0.9* W	*0.9* W	*0.90* W	*Use for ENERGY STAR V6 registration(P_{off})*			
Off (S5) - WOL Disabled	W	W	W	*Use for EuP*			
EPS No-load (External power supply / charger plugged in the wall outlet but disconnected from the product.)	W	W	W				
PTEC * Typical Energy Consumption	W	W	W				
TEC * Typical Energy Consumption	kWh/week	kWh/week	kWh/week				☒
ETEC * Annual Energy Consumption	*61.56* kWh/year *42.56* kWh/year *42.8* kWh/year	*61.31* kWh/year *42.14* kWh/year *42.6* kWh/year	*63.1* kWh/year *42.77* kWh/year *43.4* kWh/year	*E_{TEC} = (8760/1000) x (P_{off} x 0.45 + P_{sleep} x 0.05 + P_{long_Idle} x 0.15+ P_{short_Idle} x 0.35)*			
	P_{off}: Off Mode(S5) - WOL Enabled; P_{sleep}: Sleep Mode(S3) - WOL Enabled; P_{idle}: Idle State - WOL Enabled						
Display resolution* : Megapixels							☒

P9.3*	The product meets the energy requirements of the following voluntary program/s: ENERGY STAR® version: ***Version 6.1*** Tier: Product category: ***I1 I2 I3*** Others specify:					☒ ☐	☐ ☐ ☐ ☒
P10	**Emissions**						
	Noise emission – Declared according to ISO 9296						
P10.1	Mode	Mode description	Declared A-weighted sound power level L_{WAd} (B)	Declared A-weighted sound pressure level L_{pAm} (dB)			
				Operator position ☒ Desktop ☒ or Desk side ☐	Bystander positions ☐ (only if product is not operator attended)		
	Idle	* ***HDD:Idle***	* ***3.1***	***22***			☐
	Operation	* ***HDD: Operating***	* ***3.2***	***24***			☐
	Other mode						
	Measured according to: ☒ ISO7779 ☐ ECMA-74 ☐ Other (only if not covered by ECMA-74 with L_{pAm} measurement distance m)						
P10.2	The product meets the acoustic noise requirements of the following voluntary program/s:					☐	☐ ☐ ☒

Annex 2. Handfield's top ten criteria for supplier environmental performance

The top ten criteria most important and the top 10 criteria that were perceived the most easily assessed by the managers.

Top 10 criteria for supplier environmental performance

Top 10 – most important	Top 10 – most easily assessed
1. Public disclosure of environmental record	1. ISO 14000 certified
2. Second tier supplier environmental evaluation	2. Ozone depleting substances
3. Hazardous waste management	3. Recyclable content
4. Toxic waste pollution management	4. VOC content
5. On EPA 17 hazardous material list	5. On EPA 17 hazardous material list
6. ISO 14000 certified	6. Remanufacturing/reuse activity
7. Reverse logistics program	7. Returnable or reduced packaging
8. Environmentally friendly product packaging	8. Take back or reverse logistics
9. Ozone depleting substances	9. Participation in voluntary EPA programs
10. Hazardous air emissions management	10. Public disclosure of environmental record

Retrieved from (Handfield, 2002) p. 78

Annex 3. Criteria regarding product's characteristics

P1. Raw materials characteristics	
P 1.1	Energy efficient raw materia. Ex. thermal insulating materials
P 1.2	Raw materia allowing to extend lifecycle of other product. Ex. - Use of recycled material.
P 1.3	Raw materia with extended lifecycle/high durability.
P 1.4	Environmentally certified raw materials
P 1.5	Renewable raw materials: Ex. - Organic material - Raw material from reforestation - Biodegradable materials.
P 1.6	Raw materials not derived from threatened species or from threatened environments.
P 1.7	Less or non-polluting/toxic materials. Ex. - Materials not containing harmful or toxic substances for product

P3. Packaging	
P3.1	**Environmentally friendly packaging:** - Packaging partly made of recyclable or biodegradable materials. - Packaging that can be recycled with high-energy efficient processes. - Packaging's size reducted and weight, more compact packaging. - Packaging completely reusable, remanufacturable or recyclable.
P3.2	Environmental information on product available to customer.

Annex 4. Criteria regarding organization green strategies and green practices

O1. Purchasing practices	
O 1.1	**Suppliers location** - Give thought to keeping the circuits between the producer as short as possible. - Group the purchases with those suppliers who are closest - Seek out the closest competitive suppliers.
O 1.2	**Environmental impact of purchased materials (raw materials and packaging)** Ex. - Buy renewable materials for product and minimize the use of nonrenewable materials. - Increase the amount of recyclable materials. - Buy environmentally certified raw materials for product. - Buy of materials not containing harmful or toxic substances for product or packaging. - Do not buy materials derived from threatened species or from threatened environments.
O 1.3	**Environmental practices performed by the supplier:** - Supplier green image: Green marketing strategies are comunicated to the business customer. - Green certification because of the suppliers' environmentally friendly practices. - ISO certification of suppliers.
O 1.4	**Using green purchasing guideline:** - Greening procurement/ sourcing, substitute environmentally preferred buying processes. - Increase the size of your orders and your lots (group together and consolidate flows) - Communicating to third-suppliers environmental criteria for goods and services. - Providing design specification to suppliers that include environmental requirements for purchased item.
O 1.5	**Environmental partnership with suppliers:** - Arranging for funds to help suppliers to purchase equipment for pollution prevention, waste water recycling, etc. - Encouraging suppliers to take back packaging. - Working with suppliers to reduce and eliminate product environmental impact.

O 2. Manufacturing practices	
O 2.1	**Location decision on manufacturing and warehouse :** - Localized production near to the consumption bases and supplier bases. - Relocate distant production sites to closer sites. - Take account of all the cost variables of long-distance supply and production (prolonged transport times, increased stock inventories, delays, less predictability, more difficult monitoring and poorer quality, increased spending on business travel, more frequent use of transport or of breakdown repairers, etc.).
O 2.2	**Energy efficiency of production:** - Use of renewable energy sources in production processes. - Use of co-generation plants to provide electricityheatingand cooling in production processes. - Generating energy from exhaust hot gas/waste in production processes. - Use of more efficient energy generation systems in production processes. - Minimize energy and resource consumption in the production phase and transport.
O 2.3	**Eco-efficiency of production:** Causing no significant damage to the environment during manufacture. Ex: - Proper waste disposal (ex. transforming production waste in fuel). - Using standardized components to facilitate their reuse. - Internal recycling of materials within the production phase. - Formal policy on green warehouse, lend favor to new high environmental quality (HQE) platforms. - Water use efficiency: To assess water consumption and water use during the manufacturing phase. - Reduction of emissions due in production process : * Air emissions control: To assess Air emissions and Greenhouse gas emissions, global warming contribution per unit of net value added. Using filters and controls for emissions and discharges. * Pollution control: Non-polluting manufacture.
O 2.4	**Greener production technology** : Use of cleaner technology processes. Ex. - Invest in green technologies required for production of green products and that allow to make some savings in the ressources. - Training the employees to use environmental technologies in an efficiency way

O3. Distribution practices	
O 3.1	**Location decision on distribution points:** - Avoid a proliferation of hubs, platforms, shops and depots which increase the dispersity of cargos and detours on delivery rounds; or, conversely, too centralized platforms (national or continental) which increase delays and delivery times. - Use shared logistical platforms, use river ports and railway depots to consolidate incoming flows. - Create relay points to limit the number of vehicles and the mileage covered.
O 3.2	**Energy efficiency of distribution:** To perform the distribution by using environmentally friendly transportation. Ex. - Formal policy on the use of green vehicles: Support research and innovation in terms of clear CO2 and clean vehicles, favor newer vehicles, which are green and clean, which consume less or use renewable energies. - Use "soft" modes of transport (electric vehicles, electrically-assisted bicycles, etc.) for small urban distances. - Bio fuels use: The possibility of using biofuels, features that reduce CO2 emissions and also hybrid engine technology. - Use of flex-fuel technology (i.e. automobiles that run both on gasoline and ethanol). - Improve the vehicles in technical terms (restriction of engines, aerodynamic accessories, tires, automatic gearboxes, self-cooling engines, etc.).
O 3.3	**Eco-efficiency of distribution:** - Pollution control: Use modes of transport which are slower but more consolidated, more economic and less heavy emitters of CO2 (rail, river, sea) the opportunities of multimodal transport. - Reduction of emissions due to transportation : * Air emissions control: To assess Air emissions and Greenhouse gas emissions, global warming contribution per unit of net value added. Using filters and controls for emissions and discharges. * Train drivers in eco-driving and in behavior (switching off engines when stopped, use of air conditioning, etc.). * Planning vehicle routes for reduced environmental impacts (Avoid multiple deliveries to the same customer, weed out miles covered by empty vehicles. * Assess your itineraries as closely as possible (reduce the miles covered, avoid backlogs, equip your fleets with tracking devices). Give thought to keeping the circuits between the consumer as short as possible. * Increase the capacity of the transport units (e.g. layers one on top of another in a truck, or higher palettes). - Organize pooling (filling of trucks by multiple orders), multidrop (combination of small deliveries to nearby customers), multipick (concentration of deliveries from multiple suppliers), etc. to reduce the number of vehicles in circulation and with whom you can work to concentrate flows using shared means (transport, platforms).

O4. Reverse logistics	
O 4.1	**Formal policy on reverse logistics:** Post-consumer collection/disassembly system. - Recovery of company's end-of-life products and recycling. - Organize your reverse logistics (packaging, old products, repairs, exchanges, unsold stock, etc.).

O5. Transversal: Stakeholder collaboration practices	
O 2.1	**Customer management practices**: Cooperation with customer in the product eco-design. Ex - Working with customers to change product specifications. - Cooperation with customers for green packaging. - Customers return original packaging or pallet systems. - To asess the retention of green consumers
O 2.2	**The green network effeciency:** - Green strategies influence prices, qualities and market shares differently. - Collaborating with other companies and organisations for environmental initiatives. - Improving opportunities for reducing waste through cooperation with other actors. - Improve the quality of products so as to limit after-sales flows.
O 2.3	**Product's environmental performance assessment:** A practice to improve the environmental performance of products is taking into account the energy efficiency of the product. - To assess the environmental cost. - Develop Life cycle assessment (LCA) for every product . - To assess Revenues from "green" products. - To perform and environmental performance measurement according to the organizational processes (environmental accounting, audits, environmental reports). - To perform and environmental performance measurement according to the regulatory compliance (compliance with ISO, number of audits.). - Evaluating environmental disclosure in annual report with the material capital expenditures to reduce the hazardous emissions. - A nonfinancial ratio based on the level of pollution emissions released by the organization or the relative quantity of hazardous waste recycled, and they feel that it is important to qualify the measure of environmental disclosure and distinguish it from its more generic connotation. - To assess number of regulatory violations by type.
O 2.4	**Implementing environmental management system (EMS):** Integrating total quality environmental management (TQEM) into planning and operation processes. - To prepare and to obtain ISO 14000 certification (environmental management). - Environmental reporting should be reports on emissions trading schemes and include reporting greenhouse gas direct and indirect emissions, recycling or disposal waste and fuel combustion in boilers. - The environmental reporting must reflect to the emissions trading schemes and include reporting greenhouse gas direct and indirect emissions, recycling or disposal waste and fuel combustion in boilers. - Environmental compliance and auditing programs. - To apply Environmental policies and audits.