

*Implementing environmentally conscious product development in the
Canadian industries: an industrial design systemic perspective*

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By: Catherine Loriot
4648 rue Marquette
Montréal (QC)
H2J 3Y4 Canada
Tel: (+1) 514 523 9401
Catherine.Loriot.823@student.lu.se

Under the supervision
Of: Lena Sperling
Department of Design Sciences
Lund University
Tel: (+46) 46 222 7623
Lena.Sperling@design.lth.se



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Abstract

North American consumption patterns lead to extensive natural resources and energy consumption, affecting in return the environment and quality of life. Rethinking of our current consumption of products through the products themselves, could lead to more sustainable life styles and relief pressure on our environment. This research aims at understanding why there are so few environmentally conscious products developed in Canada. By elaborating and analysing a holistic model of the traditional product development system, it is possible to identify the drivers and barriers of ecodesign implementation, while meeting the demand and satisfying the corporate culture on the particular scene of Canadian industries of consumer goods. In order to support or negate the model, interviews with key actors of the field are performed to obtain correct disciplinary and organisational discourses. System analysis of discourses and variables helps assessing divergent perspectives and practices, explaining the misunderstanding of the need and opportunities associated with ecodesign and sustainability in general. The results demonstrate that the lack of economical benefits promotion and the poor ecodesign examples stock are challenges to the environmental product development stimulation in Canada. In addition, designers should promote their skills and particular position between users and corporations, in order to express what is possible to the society. The problem resides in the mandate given by corporate leaders and marketing professionals to industrial design, which is too narrow and not related to users needs. Further, many links are missing or not optimised when comparing the reality and the theoretical model of organisational structure of one business and its activities.

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List of Acronyms

ACID:	Association of Canadian Industrial Designers
AFF:	Alternative Function Fulfillment
CP:	Cleaner Production
DfE:	Design for Environment
EMS:	Environmental Management System
FAQDD:	Fonds d’Action Québécois pour le Développement Durable (Québec Fund for Sustainable Development)
ICSID:	International Council Societies of Industrial Design
LCA:	Life Cycle Assessment
NRTEE:	National Round Table on the Economy and the Environment
POEMS:	Product Oriented Environmental Management Systems
PSS:	Product and Services System
SME:	Small and Medium size Enterprises
TNC:	TransNational Corporations
TQM:	Total Quality Management
WBCSD:	World Business Council on Sustainable Development

1. Introduction

1.1 Sustainable consumption and production

Sustainable development is beautifully defined as the economical, social and environmental problematic synergy for meeting today's need and tomorrow's generations ones. In order to achieve such ambitious goals, the document Agenda 21 resulting from the Earth Summit held in Rio in 1992, addresses, in its 4th chapter, one important issue: Sustainable Production and Consumption. The suggested principles promote the considerations of production processes and consumption patterns in order to develop less harmful methods of need fulfillment, while promoting a better quality of life for everybody. That document has received major support in many countries, but in reality and in practice, real solutions and results from these principles application are seldom: absolute consumption is rising, and "total materials throughput and waste generation continue to grow" [103, p.29]. These impacts negatively affect our societies' health and quality of life. For a long time, the western "making" culture - conceiving or producing - has been marked by a will to change its environment, to dominate nature and hope for a better future. Today, many have realized that this culture cannot be continued indefinitely. Nature can maybe be manipulated locally, but can hardly be dominated globally [39]. What would define sustainable consumption and production in our western societies? The Wuppertal Institute proposed one definition, pointing at the important role of design in these life-cycle aspects:

"The use of services and related products which respond to basic needs and bring a better quality of life while minimizing the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardize the needs of further generations". [39, p.7]

The goals are clear in this definition and ways to reach them consist of various instruments: imposition of production processes standards and environmental taxes, products redesign, and promotional, educational campaigns for businesses, users and consumers. The most influential tools hence reside in the corporate sector initiatives. There seems to be a shift in our economies, towards more integrated measures that address products' whole life cycle, and that encompasses their design, production, consumption and end-of-life.

According to the World Business Council for Sustainable Development (WBCSD), many countries, including Canada, have performed growth while reducing material and energy use, therefore increasing industrial efficiency that in return increase competitiveness and reduce environmental liability. These advantages of sustainability are seen by many businesses that chose to participate in sustainable development. However, many others are still not addressing environmental issues. Choosing sustainability means firms address the environmental burden resulting from their growth and activities, while they acknowledge many opposing interests. This requires responsible leadership and vision, both very rare resources in the corporate sectors [9].

In North America, the U.S. Congress, already in 1992, recognised product development as an essential and focal point for reducing environmental impacts of production. Design consists of decision-making that affects directly and indirectly levels of materials use, therefore natural resources extractions and composition, and quantities of eventual waste [69]. The Congress hence supports designers in getting involved with environmental consideration when developing products. Such considerations could result in competitive implications and new markets opportunities. Unfortunately, the situation in Canada is more vague; environmental issues are still restricted to pollution prevention in the industry, and not tackled by product design.

"Industrials designers with their knowledge of industry and consumers, their intimacy with products and their ability to create and to visualise ideas, can play an important role (together with many other engaged professionals) in bringing about sustainable development" [2, p. 70]. Conversely, it is shown in

many studies, that designers seldom have the opportunity to exploit their skills to their full capacity. Our research will try to depict the whole product development system that affects Canadian end-consumer's choices and decisions, thus consumption, in order to understand roles, responsibilities and opportunities of industrial designer's in bringing environmental qualities in that system. In order to do so, we shall understand the decisions making processes, their causes and consequences during the first phases of production: innovation. Much of the literature views environmental product development as an evolution of traditional product development, but with new tools. The difficult challenge in eco-innovation is therefore to balance environmental qualities with usual products development criterias, such as costs, quality and functionality or performance.

The system consists, to take a metaphor used by the Wuppertal Institute and other authors, of actors, players and spectators in a product development scene [5, 39]. In order to understand what is ecodesign and how it is accomplished, we will first have an overview of the wide range of methods and tools available to the principal actors of ecodesign, which are designers and engineers. Other important actors however, such as business leaders and marketing people, are the ones that possess the decision-making power over the realisation of product development. We will try to appreciate and systemise the relationships between those participants. Besides, actors are subject to pressure from important players, such as consumers, shareholders and stakeholders and from spectators of this scene, such as governments, competitors, etc. This holistic view will permit us to have a better knowledge of drivers and barriers to the implementation of ecodesign in the product development scene. This research will focus on the production of goods, rather than look into consumption in general, even though sustainable consumption constitutes a relatively new field, full of opportunities and challenges. Both approaches, though, have the same goal of rethinking our current life styles in order to achieve sustainability.

1.2 Problems associated with consumption and production

Canada brings many wilderness, nature and peaceful images to mind when evoked. Very well considered in the 90s for its green efforts and consistent international involvement in environmental issues, the country is today in a far less glittering position. "Canadians are often cited as being among the leading per capita producers of solid waste in the world. Inefficient production processes, low durability of goods, and unsustainable consumption patterns lead to excessive waste generation that follows or exceeds trends in economic growth." [84]. Around the world, costs of dealing with waste, energy inefficiencies and pollution effects on healthcare are increasing enormously [8]. We know however that this fact has specific economic and geographical causes in Canada; for example, landfill costs in the province of Québec, by tons of waste, are the cheapest in all North America, and the country has plenty of space within its territory to accommodate for landfill. Waste is one problem, but resources depletion, high energy consumption and pollution are other harmful environmental impacts of our lifestyles. From the State of the Environment InfoBase, indicators measured by Environment Canada [84], the consumption of primary and secondary energy, consumed by final users, continues to rise, even if the part of energy efficiency, the amount of energy saved, is increasing since a decade. End-of-life measures, such as waste management, energy consumption reduction or pollution remediation are certainly the most studied and very successful ways to counter-balance unsustainable consumption patterns effects. In Canada, much effort has been made by governments, in partnerships with the private sectors, in the promotion of the "3Rs": Reduction-Reuse-Recycle, to reduce quantity of residual matter, usually known as "waste". Recycling programs in households are extremely successful; almost 47% of the total domestic residual matters is recycled [100].

In Québec, an important provincial government agency, Recyc-Québec, has the mandate to promote responsible consumption through the 3RVs, where “V” stands for *Valoriser*, to prise [100].



Figure 1: Recyc-Québec promotional campaign
"You bring back, we recycle!"
Source: www.pro-recyc.com

Their promotional campaigns, coupled with economic incentives, had great success and contributed to increase residual matter diversion, such as recycling or composting, returned deposited bottles augmentation, used tires conditioning, etc (see Figure 1). However, computability of such indicators is always made in weights, while problems in landfill are much related to volume of waste. Product design is said to represent the most important factor of increased products recyclability [1]. But producers, designers, manufacturers and the public, put maybe too much emphasis on this measure [8] as consumers might receive a distorted message from products possessing such qualities [11]. End-of-pipe measures do not reach the core of the problems, nor do they provide enough solutions; waste management, design for recyclability

or disassembly, educational campaigns, should not limit our creativity to effectively tackle environmental problems associated with production and consumption. It will always be better to prevent waste generation, pollution or over-consumption, than cure. In fact, the National Research Council of Canada estimates that “\$1 spent on prevention saves \$10 otherwise spent at end-of-pipe or \$100 expended on environmental remediation” [94]. Better products can thus be 100 times cheaper than harmful ones!

1.3 Sustainable production

Quantities of products are not dependent of an industry’s production capacity anymore; cheap and disposable products are widely available in our societies. Even if we long thought the expansion of consumption would augment chances to have a better quality of life around the globe, the results are however unequivocal: social instabilities, inequalities and environmental tribulations are direct consequences of this situation.

Basic needs are fulfilled in Canada, by products that possess good price for their quality, but the market of necessary products, products that fulfill primary needs, is saturated. Hence competitiveness is now installed in what Manzini calls “replacement products” markets. Ezio Manzini, Italian designer and renowned sustainable design author, argue these products are unnecessary, fashionable and sold because of marketing efforts and publicity [40], as the power of communication and spectacle is increasing and able to greatly influence consumption. Production activities and market shares competition are thus providing consumers with superfluous products that engender unsustainable consumption patterns, generate waste, and where products inherent qualities, such as aesthetic and design are no longer valued [40]. This has lead designers to rethink their role in the market economy, where innovation quality constantly reduces, and is “creating a constant technical, physical and aesthetic stress that puts a strain on companies without producing any substantial evolutionary refinement” [42, p.146]. Nowadays many authors, scientific communities, businesses and consumers agree that these problems reside in what products are consumed, the quantity that is produced, and their qualities.

The shift that is remarked within the corporate sector, from end-of-pipe solution toward prevention of environmental impacts, reflects the will of manufacturers to focus on the source of these impacts,

therefore on the products [27]. However, we should not keep a narrow perspective on products only. Products are objects, but also systems and services, but it is necessary to understand the needs underlying our products and production system [61] instead of conceiving products for the sake of the innovation process.

The state of the environment, cultural changes and unmet user needs should become sufficient reasons to base designer's thoughts on research activities that find and analyse major world issues, so they could participate in their solving. In order to do so, designers should be able to do research, and this paper is one contribution to the Canadian sustainability path. The perspective is in part inspired by Dewberry and Sherwin definition of what sustainability necessitates: "a more design-oriented approach to scenario and future thinking methodologies is required to frame possibilities and implement change in the form of concrete actions at the project, process and product-service level." [17, p. 126].

- **1.3.1 Industrial designers and sustainability**

It has been argued in many studies and researches since 20 years, and within the designer's community, that designers, makers of the artificial world we live in, are to blame for unsustainability. But their social, collective and environmental role in the design of the environment is part of the solution [2,11, 37, 40]. Sustainable design is a proposition to remediate to the unsustainable situation, while participating in the construction of a better future. There are many reasons designers should adopt environmental values while conceiving our artificial environment:

- 1) The necessity to preserve the physical environment equilibrium, for future generations and biodiversity
- 2) The need to preserve the richness of humans sensorial experiences, from which we can engage in a relationship with our environment
- 3) The opportunity to development human's capacity to act on its environment, as a creative activity, by inventing signs and symbols, necessary to "domesticate" its environment, its space appropriation [40, p.109].

Authors and many designers have proposed different paths to redirect meaningful innovation toward sustainability, such as minimalisation, durability, end-of-life valuing, re-use and biocompatibility [42]. It is a colossal change, from thinking and conceiving without limits, toward thinking and creating in a limited world [40]. One major challenge will be, for designers, not only to rethink their behavior in an ecological way, but also to propose realistic, attractive, and cultural sustainable scenarios.

Today we know that filling today's markets with better, less harmful designed products, both in terms of higher resources efficiency and reduced environmental impacts represent solutions to Canadian unsustainable production and consumption patterns. And industrial designers have an immense role in proposing these solutions. However facts speak for themselves: environmentally conscious products are very uncommon in Canada, on its markets and among its exportations. But then what are the causes of such low level of environmental qualities of products? One might wonder if the motivation amongst the design discipline and corporations is really present to participate in sustainability. Other paths will bring us to question the drivers and barriers of ecodesign projects within enterprises and the traditional product development that maybe does not permit environment to be included as design criteria. We will try to depict a holistic view of the product development field in a process that is always linked to change in businesses therefore, to innovation. Very few studies have been realised, and especially not in Canada, on the need to have a systemic view of the product development process for understanding how environmental qualities should be incorporated in it. The limitations and assumptions of this research will allow us to only focus on product development where industrial designers can play a role. The objectives and scope will be discussed in the next section. Further, the concept of innovation and

its application in Canada, its link with product development and design, as the “industrial design process is usually embedded in an overall innovation process”[2, p.29] will be addressed before exposing variables of the product development field. The world truly can be changed, and should not only be the continuation of present [17].

2. Objective and scope

2.1 Objective

This research aims at understanding how the current product development system is organised so that only very few ecodesigned products appear on the Canadian markets. We would also want to see how it could be changed for permitting more environmentally conscious products, while meeting end-users’ demand and satisfying corporate culture on the particular scene of Canadian industries of consumer goods, more specifically in the province of Québec. By looking first at the wide understanding of what is product development, its main actors, the players involved and spectators, it will be possible to see where, when and how environmental product innovation occurs, and why it is in such a weak level today. Assuming environmentally conscious product development is a necessary step to achieve sustainable production and thus consumption, we will try to understand if the conception of products with the environment in mind is possible in the current system. During discussions and in this paper, generalisations were not made to encompass all industries or the whole manufacturing sector. For this reasons, no case studies were performed in order to exemplify this research. Case studies are supposed to illustrate and confirm findings and theories. In this present paper, case studies would have exactly illustrated that theories cannot be generalised to all other sectors and businesses organisational structures.

2.2 Scope

Product development is a very diverse and wide discipline. We will limit our research on the development of end-consumer’s products, such as household consumption, where products are usually consumed because they provide a specific service for particular users. Therefore, business-to-business production is not considered in this exercise. Such limitation is relevant to illustrate how final consumers become very often, final users of products and services, and together form the end-consumer’s demand. Further, Canadian industrial designers are most of the time implicated in industrial or commercial products design that are computed within national households expenses, such as furniture, household operations, transportation, and other consumer products [101]. Industrial designers are also skilled to design industrial products targeted for industries and machinery. However, it is very difficult to draw conclusions on mass consumption of such products, as they are destined to industry-specific and very particular use and needs. Environmental impacts could be as much, if not more, important to address in that latter field, but this whole research tries to understand the product innovation process, not the process innovation one.

We shall note here, that some definitions of product development express the redesign of existing products on the markets. This research does not aim at limiting product development in the improvement of concepts of products, as we know them today. This would result in environmental performance gains of only Factor 2-3 [7]. Rather, we shall consider products as function fulfiller. Such products could be anything we do not know yet, but that respond to needs society might have. The main question that remains to be answered is how industrial designers are given the opportunity to rethink products, how they are produced, and why. Is it because the demand came from households’ members? Is it because a corporate leader decided to give an environmental flavour to one of his/her products? Or maybe is it because marketing and sales people analysed competition products and

evaluated the opportunity in one niche market? How to explain there are not much ecodesigned products in our markets? All these interrogations will be clearer after having analysing the product development process as it is in Canada. There should be also a careful distinction to make about products that are designed and manufactured in Canada and exported elsewhere, and products imported from other countries, where the demand specific to Québec for example, would not be traced here. Specialists in Canada are subject to products that are sold here; therefore their analysis might not reflect what is been designed and developed in other parts of the world. This paper will address many ecodesign products that were developed around the world, but the problematic is the poor development of such products both designed and manufactured in Canada.

- **2.2.1 Sector of the economy and production**

Another important limitation of this research is the economy sectors that will be observed. Because industrial designers are very rarely involved in the primary sectors of the economy, it will not be relevant to consider it during this research. Primary sectors include industries that exploit, extract and process primary resources, such as mining or forestry for example. The secondary sector is also called the manufacturing sector, which contains again two categories: the first is raw materials processing, and the second is consumer goods products. The latter is our main focus in considering our product development system. There is also a tertiary economic sector that consists of the service industries. Industrial designers are also often dealing with this sector, in developing packaging for products sold in the retail industries, and from an environmental point of view, in trying to combine products and services in an optimized system.

3. Methodology and material

- **3.1 Systemic approach**

A systemic approach to a problem implies an understanding effort to a complex situation. The understanding itself of one situation implies a perception of the reality that is proper to the person who is trying to grab the reality. In fact, a model is only valid from the choices made for its construction [50]. Therefore this present research, and particularly the model of the product development field system, have been realised from a designer's standpoint; the reality synthesis was captured from an industrial designer's rationality and mind.

- **3.1.1 Industrial design perspective**

Because a studied system will be influenced by one researcher's conceptual frame, and by its constructed understanding of the world, it is worth defining the perspective of constructing the reality through the eyes of one's understanding of the world. The specific perspective taken in this research can be explained by the author's profession: industrial design. Design methods and theories are very recent and still in their infant stages of consensus, amongst industrial designers themselves, and amongst other professions generally dealing with them. But the utilisation of a design "paradigm" is practical and compatible with a systemic approach to research, which is defined as looking not only at the totality of elements of one system, but also at all the links and interactions between them [16]. Moreover, systemic approach is based on the conception of models. Conception is the core activity of designers. The latter are experts in creating forms, optimising functions, relations and interdependences between elements. An interesting parallel is made by Ouellet in describing the action of model construction, in this case it will be the product development system, within a systemic paradigm, as opposed to a Cartesian, scientific one: for modelling, we have to unite form and function [50], hence the model

structure and components, and its mechanics. The systemic thinking is also intuitively present in design methods [2].

3.2 Literature review

The first phase of research consisted of the literature review of broad concepts such as ecodesign, sustainable production, industrial design and product development. The literature reviewed was generally recent, as there is a strong increase of ecodesign studies and publications at the beginning of the 90s [3]. It was found through electronic databases' browsing, amongst peer-reviewed papers, and also in journals and books on those subjects. This first exploratory phase permitted to determine the need to extend the landscape and include much more actors of the product development field, such as engineering methods, marketing, business strategies, corporate leadership and consumers' behaviours, all related to environmental concerns when it was possible. It was, at that moment, obvious there were many clashes between discourses relative to each discipline, about environmental issues but also within the product development process as such. In addition, as environmentally benign products literature in Canada is practically inexistent, we decided to focus on the reasons of this void by constructing a model that would encompass all decision makers and variables of the product development system, representative of the Canadian industry. It resulted in the elaboration of a theoretical product development model, illustrated in Figure 9. Such a work necessitated an extensive understanding of the field, which was provided by further literature review, and by interviews of important actors and facilitators of that domain.

3.3 Interviews

The author interviewed many people that were all relevant experts or elite in their own discipline, and had in common their deep understanding of drivers, barriers and current state of product development in the consumer goods industry in Canada. Elite interviews are one method of collecting data in qualitative studies in sciences. The large majority of interviewees were talking in the name of their organisation. However, a couple of participants did answer in their personal experiences and beliefs. Hence representative of professionals in all relevant fields of the product development domain were chosen and interviewed, in order to discuss the product development field in Canada, the challenges and opportunities it faces, and its implications with industrial design and the environment¹. Twenty semi-structured interviews were performed through personal visits, over the phone or through e-mail correspondence. Questions that helped directed conversations are showed in Annex II, as well as a graph illustrating product development professionals roles that provided bases for discussing about organisational structures, in Annex III.

It might be worth mentioning that interviews were based on the interviewee and industrial designer relationships. The author was presenting herself as an industrial designer doing research, and as a researcher doing interviews about industrial design. The bias might therefore be larger, and that is a weakness of this method. Literature review was further pursued during the whole research in order to find appropriate material, on specific issues, and to confirm or infirm links and relationships between variables of the model. The interviews results consist of empirical results that are compared with the theoretical background in order to find if the reality in Canada justly matches the model constructed.

¹ A complete list of interviewees and their respective disciplines is provided in Annex I.

4. Literature review results

4.1 Environmentally conscious product development

In the following parts of the text, ecodesign term will be used to illustrate wider design concepts, where environmental impacts of products and systems being conceived are reduced. We shall not confuse environmental design and design for the environment. Environmental design is usually recognised as the design of the environment; our natural and artificial surroundings, such as urban planning, landscape, physical buildings and architecture [11].

Lewis and Gertsakis did a review of ecodesign happening around the world. The “epicentre” of DfE is surely in Europe, particularly in Netherlands, Germany and U.K, also in Australia, with the Center for Sustainable Design². Ecodesign in Canada or Québec province is not much developed, nor very present in the industrial design profession, or within industries. This fact is widely accepted and denounced by actors of the product development field, even if very difficult to prove.

There were many ecodesign projects around the world, but the real outcomes and success stories are more seldom. A good project proposed on a national level is the EkoDesign project from the Swedish Industrial Design Foundation. Thirteen ecodesigned products were developed within Swedish enterprises with the help of specially trained industrial designers, and succeeded in a reduction of 50% the environmental impacts of the production of the original products. The report is convincing and includes numerous demonstrators products for stimulating further innovation in that field [102].

Baumann *et al.* did an extensive review of many ecodesign tools and methods and their use within businesses and in society [3]. They tried to assess the reasons behind the fact environmentally benign products are rather uncommon in our markets, even though the panoply of instruments, tools and methods of ecodesign is impressive. They analysed researches about products development processes as such, and the processes within different contexts, such as companies, supply chains and society. Their results help greatly documenting this research, and many important conclusions from their analysis are disseminated across the text. There are many definitions and small nuances between numerous methods and tools of ecodesign, Design for Environment (DfE) or sustainable design. We will try to understand some of them rapidly. However, they all represent processes of environmentally oriented product design, frameworks of implementation, where the ultimate goal is to design products whose environmental impacts, direct and indirect, will be minimised. In fact the aspiration is to design or develop solutions with the “environment in mind” [37].

● 4.1.1 Methods and tools for ecodesign

Table 1: Methodological environmental instruments proposed in the literature
Source: adapted from Millet *et al.*

Ecodesign
Green design
Eco-efficiency
Design for Environment
Design for Life-Cycle
Design for Sustainability
Design for Recycling
Design for Recovery
Design for Product Retirement
Design for Low energy Consumption
Environmentally conscious design
Pollution prevention by design
Eco-innovation
...

Some examples of methods and tools proposed in the literature, are presented by Millet *et al.* in Table 1. It reflects the wide range of expression and variety of ways for designers to contribute to sustainability [45]. They include vocabulary nuances but also differences between which professionals will perform them, and the environmental performance intensity resulting from others. They all help designers in trying to reduce environmental burden of artificial products. The benefits of ecodesign are numerous, both for businesses and for consumers and users. They consist of costs savings in terms of material use, energy consumption, waste generation and production process, and of course in better designed products.

² <http://www.cfd.rmit.edu.au/>

- **EcoDesign Strategy Wheel**

Elaborated in the Netherlands at Delft University, this is a graphical representation of the evaluation of strategies that could be used to reduce environmental impacts of one product throughout its lifecycle. Each category can be evaluated by a positive improvement (+) or a deterioration (-), beginning by 0) the product design review 1), the selection of materials, 2) the use of materials, 3) the production processes, 4) the distribution system, 5) the impacts during use, 6) the product life-time and 7) the end-of-life aspects. The 0), 1) 2) 6) and 7) strategies are said to be the most influenced by industrial designers [35].

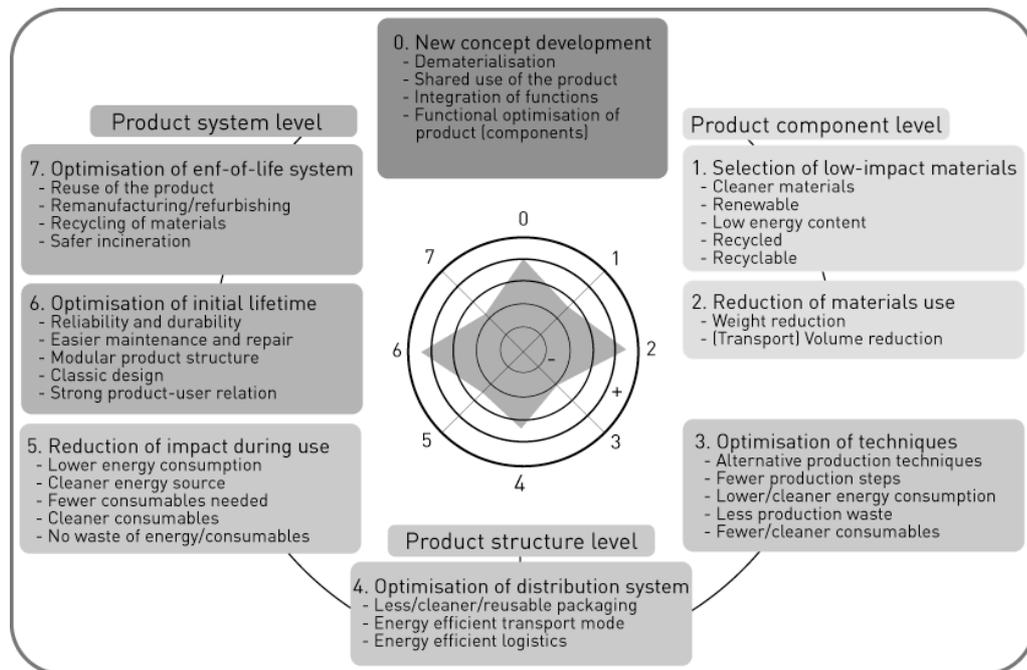


Figure 2: EcoDesign Strategy Wheel
Source: adapted from Delft University

- **Eco Indicators**

This method is in fact a “damaged-oriented” impact assessment method developed for designers, eco- or not, and the non-environmental specialist professionals. It forms the base for calculating impacts of materials use and their processes. Materials and industrial production processes have almost all been given points, per kg of matter use, transformed or processed that can be then computed by designers when choosing product design features. The more points accumulated for a single product, the more harmful it is for the environment. Designers can then reduce the weight of matter treated, chose different process, different materials or extend the product lifetime. The major reason to elaborate this method was to permit designers to design environmentally conscious product life cycles instead of simple products [97].

- **Factor X**

Factor 4 and 10 are creative concepts to reduce resource throughput or to increase resource productivity in our economies. It is often said that a reduction by half of the resources we use in the world, coupled with the doubling of the efficiency of these resources, resulting in Factor 4, are necessary for achieving sustainability within 50 years [72]. Or else, material intensity should be reduced by Factor 10 for attaining sustainable material turnover in the OECD countries. Examples of such opportunities and success are numerous. Fifty examples are presented in a very positive and constructive way in *Factor 4, Doubling Wealth Halving Resource Use* [72].

- **The Natural Step**

The Natural Step (TNS) is an international organisation that developed a framework, TNS framework, to help businesses embrace sustainability by looking at their organisational structure and the “strategic opportunities rather than unknown liability” [67, p.1]. The framework, based on serious scientific research and on a closed system perspective, which is the earth, proposes a methodology for companies to imagine what their activities should be in a sustainable future. In a sustainable society, “nature is not subject to systematically increasing:

- 1) Concentrations of substances extracted from the earth’s crust;
- 2) Concentrations of substances produced by society;
- 3) Degradation by physical means
- 4) and that in society... human needs are met worldwide” [67, p.8]

In the field of product development, the framework helps decisions-makers assess the sustainability considerations in many aspects such as the social context, raw materials use, energy, production, transport, etc.

- **Eco-labels**

Eco-labels constitute very good examples of stimulation of the demand for environmental products, by empowering customers that really want to make a difference, their voices being heard. Further, it might be “turning environmental investment into market advantage” [83]. The Environmental Choice™ logo, illustrated below, identifies products that succeeded complying with the environmental criteria established by the program. The number of eco-labeled products in Canada is surprisingly high. More



Figure 3:
Environmental Choice™

than 3000 different products are certified of this only program of labeling for manufactured products in Canada, as well as 169 companies. Eco-labeled products are typically primary and secondary sector products, like energy sources types, building materials, technologies for treating water, compost or chemicals, etc.³ As the promotional agency in charge of certifying products have directed their efforts until now toward corporate and governmental purchasers, products developed and submitted for certification are products suitable to government procurement (office supplies, systems and technologies, energy supply) and business-to-business purchases. Very few of

these products are end-consumers ones that could be intended for domestic use. Labelling comports certain inconvenient for businesses; criteria are sometimes arguable, while others would think they are not strict enough. Further, many businesses in Canada refrain from promoting environmental consciously developed products because they fear such label would transmit poor quality or low performance products image.

- **Life Cycle Assessment**

Sometimes referred to as cradle-to-grave analysis, LCA is a powerful tool for mapping any environmental impacts across one product’s life cycle. It is “a way of creating an overview of the total complexity of interaction between different processes in industrial society and the ecosystems” [55, p.252]. It includes the computability of the extraction of natural resources (primary matter, raw materials), the manufacturing of these materials and the product, the use phase and the end-of-life processes. LCA compiles also transportation impacts between all steps and locations of these phases. Interpretation of LCAs is also a critical phase that suggests the importance and rigour that must be

³ A complete list of certified products can be obtained from the Environmental Choice program website: www.environmentalchoice.com/index_main.cfm

demonstrate during the exercise for obtaining its full potential usefulness. However, because of its heavy methodology and questionable input data, the LCA appropriateness has been questioned by designers. Moreover, Robèrt argues that LCA does not help define how sustainability can be achieved and for what purpose it is necessary. For example, he asks if LCA results would be different from today and in the future, where our system conditions will necessarily be different [55]. LCA are heavy and time consuming within organisation, and of course also very expensive. Also, it is really interesting to note, “no examples were found of LCA being used by designers themselves” [60, p. 371]. Designers prefer to have LCA results or implications for their projects, from other specialists, such as environmental consultants, or another source of expertise [2, 60].

- **Design for Environment (DfE) and DfX**

In the most complete book about design and the environment, DfE is defined as a tool “that can substantially determine how a product is likely to interact with the environment and its users” [37]. DfE is in fact, an analogy to the DfX tools, where the X stands for many criterias that designers were provided with, in the mid 90s, for improving some aspects of their work through optimised processes and targeted clients’ methodologies [60]. Further, Design for Manufacturability, (DfM) or for Assembly (DfA), are integral parts of concurrent engineering, which will be discussed in a further section. It might worth saying though, that in many reputed universities and DfE specialist firms, industrial design is considered as a specialisation of engineering design. Examples of such programs exist in Netherlands, Germany and Denmark, where DfE is strong and well established amongst industrial development processes. However in Canada industrial design is a completely different profession and not linked to engineering.

Much of the DfE research and activities occur in Netherlands, Europe and Asia, in particular Japan, Canada has now adopted an eco-efficiency policy toward industries and some of its own Ministers. An outcome of this is the release of a tool guide: the *National Research Council DfE Guide*. The Canadian Government defines DfE as “the systematic integration of environmental considerations into product and process design” [94]. DfE aims at reducing the environmental load of a product or a system of product, mainly within its production cycle. DfE is more directed toward the production processes of a product, such as increased energy efficiency, decreased emissions from many operations, while optimising materials use instead of focusing on the product features in themselves [1]. For example, Eagan and Streckewald illustrated their experience in implementing DfE at AMP Inc, as a strictly engineering design process improvement [18]. Their approach was to ensure AMP was compliant with all environmental regulations and would be able to comply with future ones, on waste and emissions reductions occurring from production processes. They stressed the necessity to have corporate support in implementing these measures, in order to obtain successful and innovative results. The design of their electrical and electronical connectors is therefore not much changed [18].

While DfE is mainly used for end-of-life design and production processes improvements, ecodesign is concerned with a all environmental impacts embodied in one product development, from material choices to end-of-life, as we will see in the next section.

- **Ecodesign**

Ecodesign is usually defined as a much broader concept than DfE, “implying a balanced view of the whole product life cycle and design effort focused on reducing the major environmental impacts of a product or service” [60, p. 368]. Ecodesign can also mean “economically viable design”, and it is seen as one of the largest contributor to sustainable development, be it to promote resource productivity, and propose environmentally attractive and socially acceptable goods and services. Ecodesign should also be

an opportunity to augment environmental knowledge and information in order to stimulate other designers during the product development process [2].

The application of ecodesign occurs during a whole product development cycle, as opposed to other environmental management tools, such as EMS, cleaner production, pollution prevention, etc., as shown in the Figure 4, below.

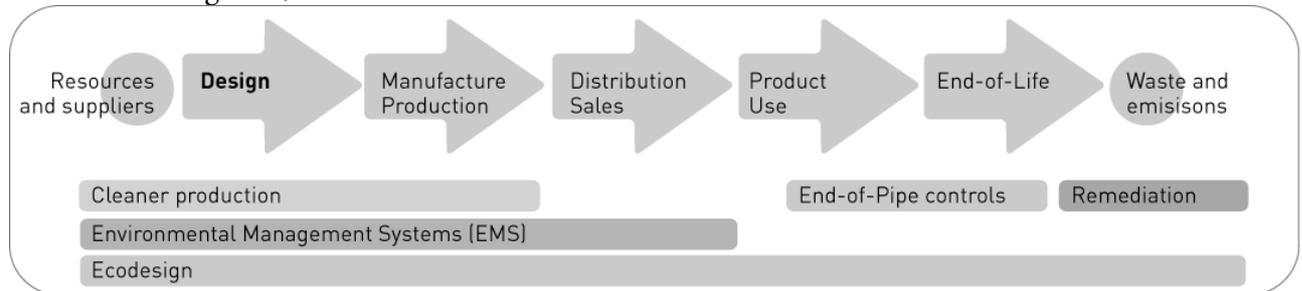


Figure 4 :Hierarchy and realm of application for CP, ecodesign EMS, etc.in the product development chain
Source: adapted from the "DfE Guide", from NRC

In some papers, however, ecodesign stands for a broader definition that includes functional innovation and Product and Services delivery Systems (PSS), therefore resulting in an expanded role of designers [21]. Fletcher and Goggin argue ecodesign is organised around three strategies: "product focus", "result focus" and "needs-oriented". The first strategy, the product focus, has been widely studied. It consists of increasing existing resources efficiency with the help of many tools and design methods, such as LCA and Factor 2, 4, etc. This approach mainly results in re-design of existing products. However, consumer acceptance of performing or environmentally conscious products sometimes constitutes barriers to new product development, as consumption of products is not only related to price, performance or environmental qualities; it is an "expression[s] of wealth, lifestyles and identity" [21, p.17]. The results focus strategy, tries to understand, analyse and assess all infrastructure associated with existing products and services, such as the distribution networks and use impacts. This focus has lead to product and services systems investigation, or product sharing, for example. However, it has been assessed that ownership, often the symbol of wealth and social standing, is not understood enough to predict and go further in establishing PSS. Finally, the needs focus orientation in ecodesign is concerned with the people element, searching new ways or modifying ways that human needs are fulfilled. The authors argue that "examples of needs focus in ecodesign are extremely limited, and yet it is here that the people-centred frame of reference for ecodesign activity has to be established"[21, p.24]. This focus must tackle cultural perception of one service or need fulfilment system within social values. Their categorisation is similar to the Figure 5, where ecodesign innovativeness degrees are represented in time.

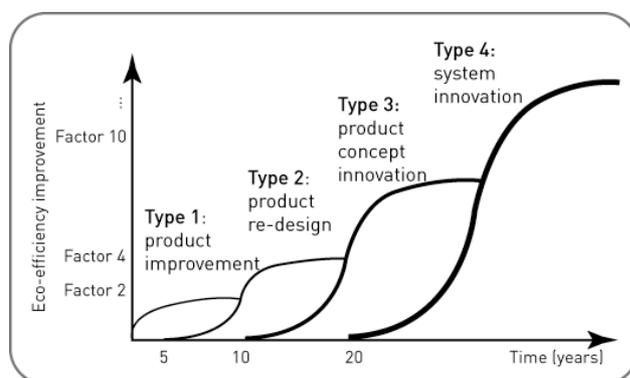


Figure 5: Types of ecodesign innovations
Source: adapted from Lofthouse et al.

- 1) **Product improvement:** The improvements of existing products with regards to pollution prevention and environmental care. Products are made compliant
- 2) **Product re-design:** Products stay the same but parts of the products are developed further or replaced by others. Typical aim being the increased reuse of spare parts and raw materials
- 3) **Product concept innovation:** (Function innovation). This involves changing the way in which the function is fulfilled. Examples include, a move from paper-based information exchange to e-mail, or from private cars to "call-a-car" systems.
- 4) **Systems innovations:** new products and services arise, requiring changes in the related infrastructure and organisations. A changeover in agriculture to industry-based food production, or in organisation, transportation and labour-based on information technology, belong to this type of innovation [38].

This graph represents chronological levels to reach sustainability through production first, and last, with the understanding of consumption, users and consumers, and their involvement. It is often said that product re-design (Type 1 and 2 innovations), permit achieving no more than Factor 2, while system innovation could reach Factor 20 and permit to achieve sustainability eventually.

The application of ecodesign has been experienced and described in a research, from Brezet *et al.* at the Design Department of Delft University. The period from 1990-1995 consisted of the “pioneer phase”, where ecodesign was corresponding to the redesign of existing products with less environmental impacts. Using simple, streamlined, LCA and guidelines for materials choices, Brezet *et al.* drew many useful conclusions: large reductions of environmental impacts were achieved with redesign, such as dematerialisation and reduced emissions and energy consumption. However, they remarked “successful ecodesign pilot projects are no guarantee that the approach is being integrated on a regular basis in normal business” [6, p. 605]. This phase permitted better product design, using the same traditional economical and corporate infrastructure, while not having much impact on the user or consumer behaviour. During a second phase, from 1995-99, the department tried to focus on the integration of ecodesign within corporate strategies by trying to promote costs savings and market share increase because of better design. This phase’s outcomes are less convincing: many actors of environmental product development had different opinions about what “green” was, and LCA was not a useful tool for rethinking design and innovate. However, Product Oriented Environmental Management System (POEMS) was seen as a promising approach to integrate, on a regular base, product innovation for the environment within a company [6].

- **Product Services System (PSS) and Alternative function Fulfilment (AFF)**

There is a common thought that services are less harmful than products consumed for the same use, in domains such as households, offices, tourism and leisure and mobility. Thinking in replacing products by the service they render is then a possibility for designers that could be choreographers of physical entities, such as products and associated services they can provide [74]. The concept of PSS seems to transmit the idea that products and services are different things. Products are artefacts that are purchased for eventual use, for service, while services are purchased and consumed immediately, hence having different “temporality”, but both should produce satisfaction, using infrastructure and artefacts [6]. Therefore maybe the differentiation between both terms is important for economical reasons, but it is less for designers.

It would require much change and more innovation, in terms not only of products, but also of infrastructure and the system already in place, as illustrated in Figure 5 above. The objects used for fulfilling a specific service purpose are rarely the essence of one user’s choice. Brezet *et al.* also discuss about the loss of humane autonomy that is linked with an increased dependence over services rather than individual purchases. But there are barriers and disadvantages to this shift toward a “service-based economy”. In that figure, Van der Zwan and Bhamra call Type 3: the Function Innovation step or better, the Alternative Function Fulfilment (AFF), on which they base their article [70]. As they say, literature has been much addressed to the first steps of ecodesign hierarchy and much less about AFF and system innovation. Their research was, therefore, to analyse the function or need of products, instead of the product design in itself. One way to arrive to this level of innovation is to increase the design space allowed to designers, in specifying, in the design brief, function that need to be fulfilled rather than product that need to be designed.

- **Sustainable Design**

Sustainable design is a larger, more general concept of what design should be in order to achieve sustainable production and consumption in our societies. It has been recently replacing, with wider scope, DfE and ecodesign, which are sometimes said to be, respectively, American and European terms for green design, a term used ten years ago. Sustainable design implies the consideration of needs, social equity, resource optimisation and productivity in the design process. It is a more systemic view of design, rather than solely one of product development; it aims at addressing global and regional environmental issues through production and consumption at a local level. It usually consists of well-reviewed concepts such as dematerialisation, products and services systems, Factor 4 to 20, etc., but where designers' role of "realising low-impact products that are culturally relevant, economically viable,

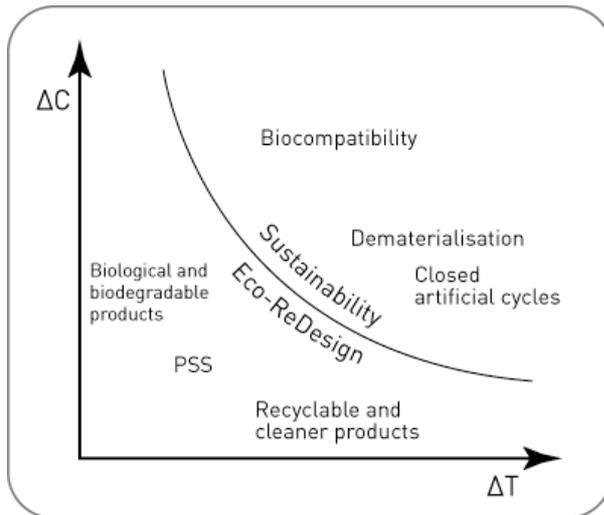


Figure 6: Paths towards sustainability
Source: adapted from Manzini & Vezzoli

technically innovative and ecologically compatible" [37, p. 18] is even more demanded. An interpretation and categorisation of all the ecodesign concepts is illustrated in the following figure, where Manzini and Vezzoli explain the different cultural (ΔC) and technological changes (ΔT) necessary for achieving sustainability. We can see from this figure that cultural acceptance of new concepts is a very important factor for reaching sustainability.

Designers must be aware and try to make new products or function fulfiller, as culturally relevant as possible, in order to guarantee their success. In addition, because imagination of what is possible does not define the ways and paths to get there, nor how to obtain desired results, we need to privilege

our creativity and find methods to process it, for example through foresighting, that aims at looking at the future with a reflective, inventive and process-oriented approach [6, 17]. "[W]hat is actually produced is only an incomplete manifestation of the imagination's capacity" [58, p.145]. Everybody has this capacity, but some people are, however, afraid of the instability and uncertainty associated with its results. The most successful way to stimulate imagination is to propose images, of possibles to the society [58]. As we know, very few images are available of ecodesign.

In summary of this rapid overview of what ecodesign means, implies and how it is performed, we can only remark the large quantity of methods and tools available for designers, engineers and corporate leaders for increasing environmental qualities of their products. However it has not brought the same number of ecological or sustainable products appearing on markets. This fact is often illustrated by the ecodesign literature and many book about ecological products that have an anecdotic character, rather than proposing a genuine multitude of examples [45]. Many tools, as we have seen before, are available and specifically constructed for designers, as they are the actors of ecodesign. But it is argued that until now many tools were directed towards engineering departments with the ultimate goal to find a perfect technological fix to environmental problems [40].

Further, although sustainable design is what societies might need and wish to achieve sustainability in consumption and production, ecodesign will be privileged in this research, as a short-term goal in Canada. In the continuing parts of this research, we will try to understand if it is possible, but first, we shall understand rapidly in what general framework ecodesign is initiated: the innovation process.

4.2 Innovation

Innovation is an important component of competitiveness, as it serves to increase one society's productivity. Product wise, innovation consists of changes, new ideas integration or modifications of an artefact, its production processes or the systems associated with it. In this research context, nevertheless, innovation will be limited to the Canadian government definition: "*Innovation is knowledge used to turn our best ideas into new opportunities. It is the driving force in economic growth and social development.*" [87] It is interesting here to note in that definition that innovation does not include an environmental dimension, although it might be included in social or economical development. Putting a lot of efforts and resources in promoting Canada as an innovative country, the Government of Canada decided to release a *Strategy of Innovation*⁴. This policy will eventually challenge expenditures on R&D in all sectors of the economy, in hope that this will increase our national productivity and competitiveness in a global market. One of the components consists of providing tools and resources to innovate in product development. While this could apply in many sectors, the most appropriate for our research is the manufacturing sector, where innovation is addressed and stimulated through increased R&D expenditures, product development incentives and tax credits to innovative projects. Reasons to initiate innovative projects are in fact the same than product development initiatives, such as the search for profits increase and competitiveness pressure. In this latter case, innovations objectives are, in 87% of the cases, the desire to surpass the product quality of competitors'. Other objectives most often mentioned are the production capacity enlargement and product assortment augmentation [54]. Hence innovative companies search for success over their competitors, market share gains, a greater capacity to respond to customers demand and the obtention of a benefit margin. Statistics Canada affirm that an enterprise' success is strongly proportional to its innovativeness level, explaining the fact that companies continuously improving their products or that release new ones are more competitive [63]. And as large companies have more access to investment than smaller companies, as well as more capital to invest in R&D, they are more innovative.

Even if environmental issues are rarely mentioned as innovation objectives, reduction in materials use, energy consumption of production processes and environmental impacts are mentioned in approximately 20% of innovative companies strategies. On the other hand, the same proportion of companies affirms these environmental concerns do not have any impact on their will to innovate. Obstacles to innovation consist of high costs associate with such projects and the lack of specialised and skilled workers.

● 4.2.1 Environmental innovation as a path towards sustainability

Environmental innovation is the "effects of the innovation on the environment", or "the intention of the innovator, to reduce the environmental impacts of processes or product" [44, p. 14]. An interesting study realized for the Swedish Agency for Innovation (VINNOVA), noted that there are very few materials and studies about environmental drivers of innovation in general, and this around the world [44]. While the need of environmental innovation is not to be questioned anymore, the importance should be put on understanding how to stimulate this type of innovation in our societies. The most important drivers of environmental innovation are without a doubt regulations and environmental policies [22, 44] and market related instruments [44]. However, there seems to be a strong bias over the policy instruments, rather than considering market related and other drivers. Policy instruments consist of command and control mechanisms, such as regulatory and economic instruments, or information tools, like education campaigns and "moral" persuasion [44]. On the other side, market based approach

⁴ For more information on this vast topic, please see Canada's Innovation Strategy: *Achieving Excellence- Investing in People, Knowledge and Opportunity*, 2001: <http://www.innovationstrategy.gc.ca/>

is directed toward consumers through taxes, tradable permits, etc. There is very little knowledge of the effects and impacts of market-based measures, because there is little knowledge on what customers and markets wish and demand about environmental performance and innovation. This type of consumers' information is very difficult to obtain, even in other cases than environmental ones. [44].

Other environmental drivers consist of competitiveness, growth, insurance, brand image, suppliers and environmental campaigns or pressure from those groups. North America is considered having mainly focused on costs advantages when wanting to increase competitiveness; therefore Markusson argues that they are more likely not to have included environmental preoccupations as a consideration. This statement might explain the poor level of environmental innovation in Canada.

It seems mature sectors of the economy are more resistant to change, therefore less prone to environmental innovation [22, 44]. This is because they have more power to negotiate and participate in policy building with the government; their organisational structure is often heavier and more complex than smaller, younger companies. But then how could we clarify that a considerable part of environmental innovation is emerging from large corporations? Markusson explains that large businesses are also more likely to respond to exterior and internal pressure, such as environmental groups and various stakeholders, and they have more human and financial resources to allocate to evolutionary concepts such as ecodesign. Smaller size companies have more difficulties in absorbing risks associated with proactive strategies, for example the environment [56].

Factors such as the innovative culture in businesses, the availability and allocation of resources, senior management commitment, new products strategy, etc., all have impacts over the performance of eco-innovation. Hence innovation drivers are important to understand, as they constitute of the core decisions related to product development strategies or greening activities within one enterprise. However we can already observe the differences between drivers of "traditional" innovation, that are mostly economical, and those of environmental ones, related to regulations and policies. Both types of innovation, however, can be stimulated by market-related pressure.

In the following sections, we will examine how innovation and environmental innovation are accomplished by different disciplines of product development. In this way, we will be able to identify the challenges and opportunities of implementing environmentally conscious product development in each of these fields.

4.3 Business strategies

For a long time, ecology and industrial development did not mean mutual integration. Environmental thinking was, until not so long ago, synonymous of constraints to progress, of legal and liability hassles and higher development costs. Stakeholders' pressure for a better environment, environmentalist denunciation, higher costs of pollution prevention, ethical considerations, corporate social responsibilities are all factors that contributed to convert the environmental constraints into new possibilities. Nowadays businesses are even considering themselves as "partners" of sustainable development and connect profitability and quality of the environment as not dissociable [23, 44]. Environmental concerns in business strategies seem to be profitable, but business are not all agreeing about directions to take, and the seriousness of these issues; the environment is not always seen as an important strategic concern for management decision-making [3].

However, Lanoie *et al.* affirm a new business paradigm is emerging in Canada, an ecocentric one [34, 37]. But some barriers prevent from confirming this shift. Structural barriers include the capitalist system where businesses are known to maximise profits, usually by reducing costs to the maximum. Operational barriers exist also, through commercial practices, and where business is not the best place for altruism, where promotional activities are extremely common and manipulating, if not creating, the

demand for consumption [34]. Many groups and authors claim businesses should try to change consumption patterns hence our societies' life styles, through consumer education or through management of their perception [5]. This of course is in contradiction with the traditional ways of doing business.

The greening of businesses activities is well documented but the case of SMEs has been less studied and might deserve much more research, specifically directed toward these types of organisations [44]. The potential of SMEs in addressing sustainability maybe even larger than the one of TNCs, as they are often located closer to consumers and have more flexibility in changing their activities. However, SMEs have difficulties in recognising correctly environmental impacts and opportunities. This situation would therefore explain the low environmental innovation in these enterprises [44].

Millet *et al.* propose in their research, a review of the differences between present corporations' behaviour and what degree of environmental consciousness is needed in businesses, if we suppose they are engaging in a real sustainable development proposal [45]. They use the concept of "environmental dimension", or dimension "E" to illustrate the degree of environmental consciousness within one business. This dimension varies greatly from one business to the other, and its definition usually gravitates around a vague sustainable development concept. Three scenarios serve the purpose to illustrate the difference between the states of environmental dimensions, and to illustrate their inherent coherence and stability, therefore their difficulty to be changed. The scenarios, illustrated in Table 2, consist each of three corporate components: corporate values about the environment, strategies of action, and results obtained from this state of corporate mindset.

Table 2: Corporate "E" Dimension scenarios
source: adapted from Millet et al.

Values	→ Strategies	→ Results
1. Infinite world Exploitable nature Trust in progress	Infinite world Exploitable nature Trust in progress	Products modification End-of-pipe measures
2. Finite world Environmental management	Continuous improvement Environment = management criteria	Eco-products Cleaner technologies
3. Sustainable development Environmental construction	Proactive Radical improvement Environment = value	Eco-innovation Industrial ecology

What we wish for a sustainable future is that corporation value the environment, as in the third scenario. This approach is proactive and based on dematerialisation, optimisation of matter, eco-innovation, and sustainable design [45]. It implies businesses consider the environment as a value, and not anymore as a constraint to their activities. Businesses are the key initiator of environmentally conscious product development project. In order to understand what would drive them to do

so, we will look at the most important concepts in the following sections.

● **4.3.1 Corporate leadership**

Because corporate leaders are one of the most important decision-makers in environmental development, what are the reasons that would lead them to encourage ecodesign development within their organisation? Gendron argues a possibility exists that many individuals and administrative persons, at a corporate level, could be personally touched by the environmental issues, and this fact could help improve the environmental and social performance of one corporation. However, she and the National Round Table on the Economy and the Environment (NRTEE), state that all studies conclude that corporate environmental sensitivity is a result of external pressures, especially from regulations and policies [23, 48]. Therefore there is a gap between the discourse of one company, and its realistic actions. Her doctoral thesis shed light over this issue in Québec [23]. By analysing many top corporations CEOs' visions and discourses, she discovered that leaders actually recognised

environmental degradation problems. Even if their speech might be partly an appropriation of the ecologists' discourses, corporate thinking has transformed it greatly in a more appropriate model of their reality, one that is related to their interests and their role in society. However one surprising affirmation is that they strongly tend to blame other tiers, such as governments, consumers and developing countries, with main focus on the overpopulation for these environmental and social problems. They affirm that competitiveness in a global market is the main obstacle to improve their environmental performance in Canada; Canadian businesses would lose if being progressive in environment, as they are facing developing countries with light regulations, and less pressure over these issues [23].

- **4.3.2 Regulations and environmental policies**

The main environmental focus of the Canadian government is the conservation and protection of natural resources: air, water, forests and biodiversity. These goals seem very promising toward achieving environmental sustainability, but in practice, policies and programs result in few incentives and thus, few realizations from the private sector. Regulations are known to be mainly associated to pollution: the *Environmental Act*, the only legal document over this issue prevents companies from exceeding certain pollution concentration levels, or emissions norms [34]. This curative image explains the negative and rather forcing framework denounced by businesses 20 years ago. Since some years however, and as mentioned before in this research, businesses start recognising benefits and opportunities associated with compliance to these regulations, or even by voluntarily doing progressive business. Changes in perception by the positive image transmitted to markets and customers when enterprises are not dealing with environmental suing [34] are encouraging this behaviour. In addition, complying companies have more opportunities to obtain funding and investments, together with superior competitiveness and new markets opening.

The work necessary for a real shift toward sustainable development by businesses remains of great size. A Québec study from Roy *et al.* aimed at understanding environmental commitment by linking it to strategic considerations and the proper social context. They found out there are several ways to evaluate a business concern about the environment; one of them is the presence of a business environmental policy. However, the experience has demonstrate that the existence of an environmental plan strategy or an environmental policy, is not a insurance that businesses that formulated them are really engaging in that cause [34, 56]. In a supporting survey, 87% of businesses admit having a particular sensitivity for the environmental question but only 49,1% of them elaborated an environmental policy [14]. Companies already having a TQM system, such as ISO 9000, tend to be more environmentally committed [56]. The most surprising result, though, is that companies possessing an environmental policy are not more innovative in R&D or new product development. The authors demonstrate the traditional win-win perspective, referring to the fact environmentally conscious activities increase profitability and competitiveness, can be better explained by the fact these enhanced performances are the results of modifications to management practices and optimised processes and procedures [15, 56]. "Therefore it is not so much the environmental management as the search for manufacturing excellence and the quality of managers themselves that would appear to be at the origin of the win-win logic" [56, p.265]. One interesting fact is that companies that are of European and American propriety are the most committed on the environmental level in Québec. In addition, companies that do export are much more committed than those that do not export any of their products. And finally, the most engaged sector of the economy, in environmental commitment, is the primary sector, followed by the secondary sector. The tertiary sector reflects the lowest level of commitment [15]. Indeed, a company which activities are based on natural resources extraction is directly dependent on the quality of

environment [22]. A tertiary sector company doesn't feel the closeness to the environment as much as a primary or secondary sector company, whose first activities are to modify this environment [22]. The author would argue that in fact the tertiary sectors industries are much responsible of user's behaviour of products, and as the use phase of many products result in 80% of the total environmental impacts of one product life cycle, their responsibility is greatly forgotten.

- **4.3.3 Economical considerations**

In Canada the usual characteristics that preoccupies business leaders when commercialising products are costs, prices, and performance [48]. Although there are many authors and even corporations that denounce sustainable development benefits derived from corporate environmental engagement, business leaders' analysis remain mainly economical. The NRTEE acknowledges there is a clash between common views that environmental performance mean increased competitiveness, performance and costs reduction; it does not make unanimity [48]. Not all businesses have realised the economical benefits and potential of an increased environmental performance of their products [4]. Further, businesses tend to take strategic decision based on forecasting of sales rather than forecasting of demand changes. This information being provided by marketing people, mainly using naïve judgmental methods [32]. And of course, the shorter the period of forecasting analysed, the smaller the error on previsions. This prevents leaders from seeing long-term opportunities and less tangible benefits, non-financial, of environmental commitment.

- **4.3.4 Stakeholders and pressure groups**

A large portion of corporate leaders in Québec recognise pressure groups as legitimate stakeholders and deserving dialogue [21]. Stakeholders, non-investors, have interests that are different from shareholders' in a corporate organisation; they include customers, suppliers in the supply chain, distributors of one business' products, educators, employees of that business, labour unions, local community, complementary services provider, and so on [64]. Environmentalists' pressure on one business can greatly influence its activities. Their pressure is increasing and can result in formidable results, with methods such as boycotts, lawsuits and negative public image [64]. Moreover, perceived environmental commitment from managers of companies is becoming a strong factor for strategic investment, illustrating good management practices and security for long-term actions [56].

- **4.3.5 Environmental commitment and Management Systems (EMS)**

In Québec, 20,4% of enterprises have an EMS, while almost a quarter (24,3%) do not have any environmental management activity within their businesses. EMS consists of a system to ensure environmental plan or policy will be managed in compliance within one enterprise's strategies. The procedure, that can be certified by the recognised International Standards Organisation (ISO 14001) in Canada, includes the documentation of the system and procedures, communication plan and continuity of implementation. Even if Bragd *et al.* affirm that research about Environmental Management Systems (EMS) have been carried out mainly on anecdotal successes stories, and mainly on multinational companies, EMS have received much interest and their implementation has been reviewed and analysed rather extensively.

The number of certifications such as ISO 14001 is increasing enormously around the world and also in Canada; these management systems are becoming a competitiveness issue in some sectors of the economy. As of December 2002, 1064 ISO 14001 certifications were awarded to companies, or their locations, compared to only 276 in 1999. These numbers are, however, relatively low compared to the certifications given in Europe or Japan [62]. The implementation of EMS in corporations could

constitute an ideal opportunity for implementing ecodesign, exploiting this change time in the organisation [60]; because EMS usually starts with environmental review of activities, including product development processes. However, companies that did not begin certification processes, and that do not intend to do so, suggest that these standards are very bureaucratic, time consuming and expensive, particularly for smaller companies [15]. Karlsson's literature review identified barriers to the incorporation of environmental issues in product development: they are low exterior incentives by customers or legislators, high costs issues associated with incorporation of DfE within EMS and a lack of expertise and available knowledge [3, 30].

- **4.3.6 Allocation of resources**

Allocation of research funds and human resources, in terms of financial, political or time support originating from corporate leaders is a strong factor of success of the product development process [27]. Corporate support also means the provision of strong environmental vision, and clear goals to the product orientation team. However it seems design resources are perceived as expensive: green projects are even more demanding in research time than ordinary design projects, probably because rethinking of proposed materials choices and development processes need to be achieved to obtain performing environmental product [1, 8]. On the other hand, designers are a relatively low-risk and inexpensive resource when considering that what they do has the potential to only add value and therefore improve market performance of one product, while reducing costs [8]. Åkermark concluded, after studying the role of design in implementing DfE, that time allocated is the most important factor in improvement of environmental qualities in new product development. And because corporate leaders did not see enough successful examples of green products, probably because there are not that many, they are reticent in showing confidence in sustainable design.

- **4.3.7 Extended Producer Responsibility (EPR)**

EPR consists of the most important and influential environmental policy in Europe for achieving sustainability in production [37]. The OECD defines EPR as the “principle that manufacturers and importers of products should bear a significant degree of responsibility for the environmental impacts of their products throughout the product life-cycle...” [85]. Functions of EPR include the transfer of externalities usually covered by governments for waste management or pollution remediation, to the producers. Therefore producers transfer those costs to reflect real production costs of their activities, in their products prices. Markets will reflect environmental impacts costs and help consumers in their choices. It should ultimately reduce waste amount and environmental impacts related to end-of-life measures resulting from consumption. Hence, EPR is said to help stimulate product innovation [37]. Unfortunately, the Canadian governments does not intend to instil any of those directives, but already, information programs have emerged in order to educate producers about EPR, when they want to export their products in countries where this will be in effect. A weaker strategy aims at encouraging product stewardship in Canadian electronic industries, in partnership with the USA, in order to share the responsibilities associated with harmful environmental impacts of products manufacturing, use and disposal amongst producers, governments and consumers. This could be accomplished by internalising costs of these effects in the products' price and provide incentives for cleaner production and sustainable management practices, as suggested by an American institute [99].

4.4 Market Research

Market research is the information collection and analysis, concerning consumers and markets, competitors, and marketing strategies effectiveness. Market sizes, buying decisions factors, consumers statistics, are all information collected by marketing people [12]. In addition, they try to understand needs and desires of their customers, try to meet the latter, and promote, with appropriate material and strategies, their products to potential targeted customer [76]. In the case of product development, marketing compares products with competitors', trends and products' stage of maturity, regulations, packaging, distribution, etc. [24]. Market innovation, defined by new markets identification and finding better ways to serve them, is said to be the most successful strategy for profitability and competitiveness [28]. Another task of marketing is the product testing, within focus groups or with other methods, such as surveys. As the Quebecer corporate culture encourages more action than planning; trials and errors methods are common. Even if they are very costly and time consuming [Q], testing permits developing business opportunities, while minimising the risks associated with a new product commercialisation [24].

Curiously, marketing research does not provide much tools or methods to assess needs and potential markets. The intuitive, naïve and experimental approach to market analysis is frequent. Intuition methods are not undesirable or negative. However they are based on the decision-maker experiences and values, cultural and societal context [58]. The method is hence risky and might explain the very large number of unsuccessful products developed in North America.

The current trend in marketing is to move from cost-based strategies, that forced marketers to propose always a higher consumption of mass produced products in order to optimise the technological improvements usually happening in the process innovation field, toward a more consumer-directed approach. Nowadays customers are more demanding, aware of the quality of products, brand and businesses that produce them. Marketing should then operate a shift toward customer focus strategies, and should not be subject to manufacturing constraints anymore [52].

Market research and consumption studies are greatly deficient, if existing at all, in the crucial understanding of what kind of consumption patterns would be suitable to achieve sustainability [21]. Charter goes further by claiming marketing people have considerable power in determining and driving the necessity of ecodesign within a corporate strategy of product development. And even if clients' demand, intern or external, for environmentally conscious product is present, it doesn't seem to reach designers because of market personnel, as they do not include such qualities in design briefs [10].

• 4.4 1 Marketing strategies

Marketing first concern is to assess the demand or potential demand of one product. The demand is purely defined by monetary or volume units, in terms of transactions operated to buy one product [12]. Geographic locations are major constraints when they compute the demand. Price range, product features variations, promotion and distribution are all factors that determine the demand elasticity, and hence that will influence consumers to buy a product. However, marketing can hardly test or survey markets without having an idea, or a future product in hand, something that hasn't been thought of yet, or something that simply does not exist. Zaccai argues marketing professionals should "[l]ook beyond the current assumptions of the market place and [...] not fall into the trap of simply projecting the past forward." [74, p. 7] The future could be provided by designers and people that can envision and create the unknown. Therefore designers need to obtain from marketing careful customers analysis of the physical, social and emotional needs of potential users, in order to provide appropriate and customised products, that could be tested, tried and presented to potential market [74].

- **4.4.2 Green marketing**

Typical marketing for the environment is often called “green” marketing, where it encompasses all efforts aiming at selling or commercialising ideas, services or products which contains environmental qualities, that would represent interest for buyer, user or a customer [34]. Communication plan is part of a marketing strategy and it consists of publicity preparation, promotional activities, public relations, labelling and distribution. The latter serves the purpose to seduce consumers, but could also be an information source about the utilisation of the product and its environmental impacts and performance [34]. Marketing strategies are maybe more and more aware and subject to a growing conscience from customers that want greener, cleaner and more durable products [34] but they are reticent to fulfil it. Even though there are no existing accepted definitions of green marketing, this strategy is usually utilised by companies who want to increase profits, or markets share, not because they wish to achieve sustainable advantage in itself [51]. And because pressure groups are alert to the release of environmental products, they are checking carefully marketing claims and labels associated with one product, in order to define if the performance matches the selling strategies. As regulations promise to be more coercive in the future, these factors are forcing businesses to be more responsible and to find ways to propagate this effort. Nevertheless, marketing personnel might decide not to promote green activities of environmental added qualities in one business’ activities. In Canada, many businesses are known to refrain from promoting their efforts toward the environment, arguing their image, or especially their product’s image, is diminished in the eyes of their customers. The most common example is the popular thought that recycled products are of less quality than ones that are obtained from virgin and raw materials. The extensive literature review on green marketing by Baumann *et al.* provided answers to why green marketing is not very present or increasing in our societies. Some answers relate to the fact green marketing has been largely untested and restricted to purchasing [3], but they remain vague and not convincing.

- **4.4.3 Publicity, demand manipulation**

Marketing state that contrary to the common thoughts, they do not “create” the demand [12]. Some essential needs are present in all societies and marketing serves the purpose to find, tackle and fulfil them with products. In the *Humane Village Journal* however, many authors denounced the demand manipulation and creation that play an extremely important role in the consumption patterns present today, arguing that demand theory are completely and unfortunately avoiding understanding needs fulfilment and psychology of satisfaction [25]. Authors denounce that advertisement, the public opinion and the consuming routine have replaced consumers’ judgment by the pressure to consume. Galbraith maintains that the actual production system is creating wants in order to sustain its own “raison d’être”. “[A]s a society becomes increasingly affluent, wants are increasingly created by the process by which they are satisfied” [J.K. Galbraith in 25, p. 44]. Many studies have been carried on this issue and an analysis of this subject would exceed the scope of this thesis. However, by looking at the model, Figure 9, we can see there are reinforcing causalities that are encouraged by the way new products are brought to markets and the image, fashion and pressure on consumers to buy them. Even the fact of introducing a new product renders obsolete the one already on the markets.

4.5 Product Development

Numbers speak by themselves in the commercialisation of new products field. Only 10% of product concepts produced by one company will be developed, and from these, 25 % will be commercialised. Finally, 67% of commercialised products will survive on markets [13]. These facts suggest great resources, ideas and energy losses. Development of products is defined by the “creation of new products

and the adaptation or redesign of existing products for new or existing markets [10, p.229]. Today, more than 50% of products sold on the market are new products, younger than five years of existence. Obviously, to sustain such product renewal, products life length has been reduced drastically since 50 years, of as much as 75% [13]. Competition is more aggressive than ever and consumers have plenty of choices on their markets. It is often said that 5% of total product development costs only are spent on the conceptual phase, while this phase, as we have seen before, results in more than 80% of total products costs [93].

In Québec, the Product Development Institute mission is to help SMEs and large corporation develop successful new products, faster than their competitors, and that better respond to their customer's needs. In order to educate their member companies, they suggest a method based on the Stage-Gate process, which results in costs reduction because of minimised errors and unproductive corrections to product development. This method is illustrated in the figure below.

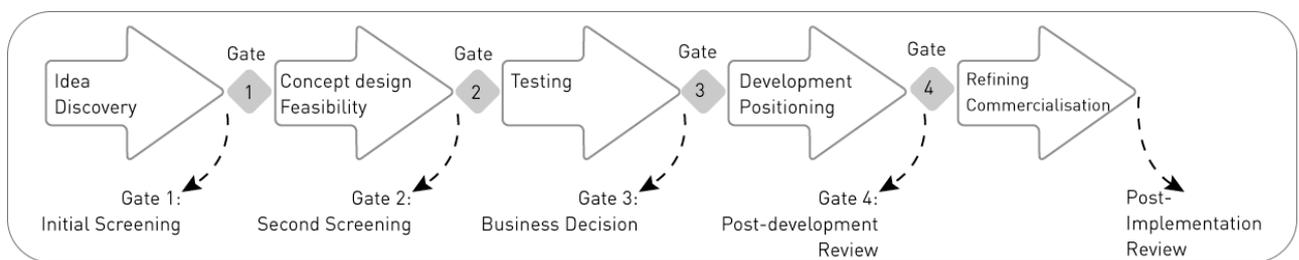


Figure 7 : The Stage-Gate™ process
Source: adapted from "The Stage-Gate process", www.stage-gate.com

The process makes great emphasis on the necessity to cross certain gates before addressing the following phase, in order to save resources and time if the outcome of one phase is not sufficiently convincing to go further. However, because the "purpose of product development is to transform a product definition into a product specification" [46, p. 739], models presented to illustrate product development processes, such as the one explained previously, are very linear [46]. Conception processes should move away from these mechanical, one-dimensional models of product development [40], as it exaggeratedly imitates the economic product development process "derived from the assembly line model of mass production" [46, p. 739]. In reality, the processes are iterative and many feedback loops information are generate during the development. Another process, concurrent engineering, is a less linear process. It is a systematic and cross-disciplinary approach that simultaneously integrates different phases of product development management and process, rather than consider the traditional sequential process separating disciplines and functions. It includes usually all phases of a product life cycle, from conception to its disposal [98]. This approach permits useful time gains for commercialization, of approximately 40%, result in costs reduction and resources optimization, and permits to bring profits faster. Concurrent engineering teams require many disciplines and designers are often managing such multidisciplinary teams [2].

In our research, it is extremely important to address the success or products that are developed, because if we want to understand how to include environmental concerns, we should understand factors of success of new products, so they commercialise successfully in order to bring much more examples on the market, stimulate competitiveness, and, in any case, respond to users' needs. Best practices in product innovation therefore are enumerated in Cooper study: top one is the presence of a dedicated multidisciplinary product orientation team, that has the support, in terms of financial and human resources, from the direction. Second essential condition is the understanding and assessment of customers needs, coupled with a corporate commitment to fulfil them [13]. Marketing departments are pointed out as a cause of bad results of commercialisation. They are usually not large and competent

enough to provide product development teams with quality and valid market studies. In addition, there are obvious lacks of users and consumers studies in those teams, thus resulting in products that are not appropriate for the targeted markets [13].

One of the only study on the product development process with a systemic organisational perspective result in finding that the front-end phase of development (phase that includes testing of new ideas, justification of its business opportunities, preceding design phases) is far more influential in the success of product, than the emphasis usually put on design and development phases [8, 31]. The authors also acknowledge the difficulty in managing front-end phases and suggest solutions reside in a better integration of the disciplines of R&D, marketing and production. We can see from the figure Khurana and Rosenthal propose, in Figure 8, that design briefs result from many decisions taken in the front-end phases. The authors also stress the importance of idea generation in the earliest phases of front-end steps, and often this link is one of the missing links where designers could participate and get involved. In support of this, designers argue it is better to act very early in the design process, at the product definition stage (strategic level), rather than being excellent in using guidelines and tools of ecodesign in order to achieve more environmentally conscious product development [2]. At this level only, can the environmental degree of awareness be discussed, assessed and accepted [60].

- **4.5.1 Industrial design**

Design knows best about the artificial environment. They possess various knowledge and skills about the human-made world. The official international definition of industrial design is given by the International Council of Societies of Industrial Design (ICSID):

“Design is a creative activity whose aim is to establish the multi-faceted qualities of objects, processes, services and their systems in whole life-cycles. Therefore, design is the central factor of innovative humanisation of technologies and the crucial factor of cultural and economic exchange.” [89]

The ICSID stresses designers’ tasks must include sustainability as one of their practice principles [89] Industrial design was previously defined, by the ICSID, as a purely “creative activity the aim of which is to determine the formal qualities of objects produced by industry...” [86]. This shift might illustrate the new sustainable mandate designers should accept when practicing. In Canada, industrial design is a relatively new field in the industry but the expertise is increasingly being recognised as an important driver of competitiveness, innovation and a factor of economic growth. “Through the application of sound design practices, design practitioners are able to increase the value of products, services, communications and physical spaces, while at the same time reduce costs, improve efficiency and increase productivity.” [101]

In his paper, Zaccai calls for the integration of the industrial design process in the Total Quality Management (TQM) process, to incorporate important use value of design, such as ergonomics, emotional value, etc. Design inclusion at the earliest possible stage of product development “results in products that are less expensive and easier to produce, assemble, inspect and service.” [74, p. 6]. The consequence of good design is therefore a lower cost of production, an increased demand for a good product and higher sales [74].

Often, industrial designers act as the link between marketing, engineering and manufacturing, by “augmenting traditional market research by observing consumer behaviour and identifying unmet customer needs and desires in a way that no marketing brief, alone, can.” [74, p.8]. In order to do this, designers join demands that have not been identified yet, with what could be possible from a technological point, and available at one point in time. This approach is different than how the usual “demand” is qualified by businesses and market researches. As these studies can only “photograph” the

reality at one time, without proposing what is not yet imagined, the designer's approach is to connect possible, and desirable [40]. Industrial designers have a "problem-oriented and synthesizing approach", therefore they provide solutions and they have these particular qualities in envisioning the future, intuitively taking a systems approach when considering many different factors and actors, or partners when conceiving, when making [49].

- **4.5.2 Industrial design and the environment**

Integrating environmental qualities within product development has been looked after by designers, engineers, marketing people, and many other professionals. Although many designers are enthusiastic and innovative in environmental development, many also feel refrained from their motivation of proposing environmental improvements or feel overwhelmed by corporate procedures and bureaucracy [DEEDS Project, in 60]. The prevalent project culture established in Canada permits industrial designers to give shape to products while introducing their own worldview on society and on consumers. There have been some studies analysing industrial designers behaviours, skills and motivation when confronted with ecodesign projects. Margolin considers the first major obstacle to environmental implementation within design is the will and self-motivation amongst designers, to believe in their role in ecodesign and in a less harmful practice [43]. Conversely, Van Hemel affirms that designer's personal commitment and values are not significant factors of sustainability. Rather, customers' demands and governmental policies are far more important drivers [71]. But again, Charter argues that individual motivation of employees seems to be very influential for ecodesign to expand within enterprises [10]. Designers can have a very influential position in the development of products, but their main priority should remain the functions and purposes of one product, while reducing lifecycle impacts and increase competitiveness [37]. But the debate is still on.

In that manner, however, designers are also creating needs and stimulating demand for new products, through their creativity and innovativeness [37]. Designers are part of the problem associated with consumption, and this has been widely denounced by many players of the ecodesign field in Canada. But designers should take responsibility in articulating environmentally designed products that have added value, and certainly not cliché image textures or forms related traditionally with "eco" products [37]. And because the product development phase determines up to 80% of a product environmental impacts during its whole life cycle [37, 69], industrial designers really have responsibility and role in conception. Environmental impacts are mostly locked in one product at its design stage, where materials and functions are chosen. Hence, the graph below represents the role of design and conception in determining the environmental burden of products.

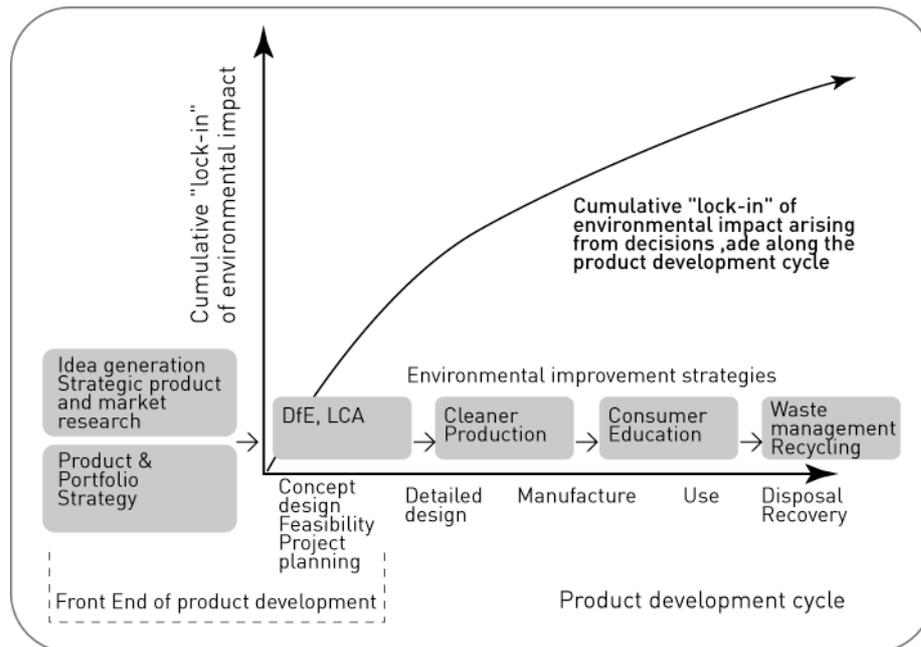


Figure 8: Conceptual representation of environmental "lock-in" over a product's development cycle
 Source: adapted from Khurana & Rosenthal, and Lewis & Gertsakis

Concretely, ecodesign requires a blend of industrial design, environmental knowledge within corporate culture, helped by design guidelines, softwares, and methods about environmental product development. And, certainly but not least, the cause needs real successful pilot-projects eco-designed products [37].

- **4.5.3 Designer's legal and ethical responsibilities**

Designers hence need to change somehow their attitude in front of product development, if environmental qualities are to be incorporated in the process. Burall affirms designers should approach product design through a stewardship approach. This attitude would make designers responsible with the whole life cycle, and therefore the environmental impacts of a products' life cycle phases, as opposed to simply intervene in a process already in place [8]. This concept is a logical extension of the notion of designer's responsibility in front of users, about health and safety of designed products. However, designers are not, in Canada, liable for poorly designed products or services. Engineers and architects for example, are liable to assure society's protection, its interest, and they each organised their profession in establishing a professional code. From a legal point of view in Canada, the profession is only defined by the Industrial Design Act, where design and industrial design "means features of shape, configuration, pattern or ornament and any combination of those features that, in a finished article, appeal to and are judged solely by the eye" [91] This law is to protect, by patented designs, designers, inventors or promoters that want to conserve their idea and right to exploitation of an object or a style. Nevertheless, the Canadian design professional association promotes the protection of the public and ethical design [75], but environmental considerations are not concretely addressed by these associations, contrarily to the USA, where the Industrial Designers Society of America (IDSA) approved officially principles of design for the environment [90].

Design has gone way too far in "giving form to products for mass production, it has been firmly embedded in consumer culture" [43]. In getting so good at "designing", designers have created reasons for users to become consumers, and pursued their research to have a place in the economy, in an industrially based manufacturing culture. Brezet *et al.* cite Jelsma, who has the same opinion: designer should better fill the gap between technology, user needs and sustainability [6]. Robert Campbell even

states that designers destroying our planet because they are encouraging the wrong ways of living [25]. Claiming they do not have much power within this corporate culture is a strong argument of the designers discourse when put in context of relationship with business decisions and marketing. Designers are often perceived as interventionist, incapable or not given the opportunity, to really participate in projects definitions. Therefore there is a call for designers to reinvent themselves, to take their “social responsibilities”, to provide solutions and participate in sustainability. Kenji Ekuan, a Japanese designer, advisor and former president of the ICSID, called for a new organisational structure for design, and their responsibility to propose societies with new lifestyles, less harmful for the environment and social structures [19]. Designer must not pursue client satisfaction, but essentially “the positive and significant contribution a design makes to the lives of people, above and beyond short term goals or unsound market appetites” [25, p.66]

Many authors referred to Victor Papanek as the first designer to have denounced this situation, with his book *Design for the Real World*, published in 1971. Papanek based his thinking on indigenous knowledge, innovation and creativity. Papanek wanted to promote a new role for designers around the world, a responsible designer’s role who would address and participate in solutions of the major world issues, such as natural resources depletion, pollution and low efficiency of production processes. In the follow-up book published in 1995, *The Green Imperative: Ecology and Ethics in Design and Architecture*, he acknowledges the efforts and progresses made in industries since the 70s, in order to address ecological issues and design. We can think of what is currently being developed in industries, by designers for the environment. In particular, Lewis and Gertsakis illustrate the example of the O2 network, with its fresh, positive, creative and constructive spirit, inspiring designers around the world about sustainable design⁵. Or the Eternally Yours foundation; the Dutch group is promoting the time dimension in product design, promoting products’ lifetime extensions; “it wants to find ways to help products age with dignity in cases where this is relevant for the environment” [82].

However, all these ethical concerns and environmental issues have not lead to any major “revolution” in the traditional definition of industrial designers until today, leaving many designers frustrated and desperate. Until now, designers have done very little in “this new culture of sustainability” [42]. Even if some efforts have been accomplished in creating and manufacturing greener products, the amount of improvement left to be made to achieve as low as Factor 4, for example, is tremendous.

- **4.5.4 Designer’s social responsibilities**

Designer’s role is not limited to conceive products and fulfil functional needs of potential users, nor is it only the creation and maintenance of the artificial. Some will argue that designer’s creations affect, if not result in, the quality of interaction between the environment, and between people, because good design enhances interface quality between environment, and people, and therefore between social interactions [20]. Besides, Findeli continues in claiming that designer have also a cultural responsibility toward society. Aesthetics emanating from designed artefacts “gives us a sense of connection to the object, the culture, and the activity at hand, whereas bad design tends to separate us” [20, p. 51].

⁵ For more information, many ideas, interviews and resources, see www.o2.org

- **4.5.5 Designers' designs**

The idea of sustainable development, of cleaner societies, did not produce, yet, any socially and culturally acceptable image, that would nourish collective memories and imagination. It has been often said in the literature, that a strong stimulative way to enhance environmental conscious design is to provide designers with good green design examples, and sustainable solutions [2, 27, 40,43]. However, examples are rare, especially in Canada, and case-by-case directed.

The materiality of our environment is completely different than traditional households; the number of things that furnishes our households today is enormous compared with 50 years ago: modern times were illustrated by solid and simple objects, things that represented modernity's essence. If the Modern movement did propose, not only references of the aesthetic of industrial products, but also a consumption democracy framework, the same should be developed in the name of the ecology of consumption and an aesthetic of the ecological project [40].

Nowadays, we live in a world that is far from simple. The time necessary to produce many objects have been so greatly reduced that people tend to not develop any material relationships with objects. The material presence of any disposable objects, for example, is the certainty that production facilities will provide these objects constantly, at very low price. Therefore the object in itself does not serve the purpose of its image, its materiality, but mainly provides the service.

Manzini, in his beautiful book "Toward a new ecology of the artificial", elaborates deeply on the responsibility of designers in the reduction of temporality of objects, of their loss of meaning to the eyes of many. He argues that our modern societies have lost their traditional relationship with things, with their artificial environment. Because manufacturers fight for markets and compete for sales, they innovate on the basis of adjustments to existing products, without truly changing the product in itself, that have very low value in the eyes of the users. Users become frustrated with the pace of these innovations and powerless in front of the fast succession of products resulting in obsolescence of the one they employ and in an accumulation of waste [43, 47]. One way to palliate to this situation is to close the cycle of the artificial, with higher conscience degree for technology and industrial qualities, imitating or inspired by the natural cycles [40]. But how to produce a new culture, based on the production and consumption circularity? The artificial environment will always be one that represents the time flying; it can only be degrading [40].

The problematic is the quality of our environment rather than the quantity of artefacts the world absorbs every year [40, 43]. "Twenty years ago, what was thought important was to look for beautiful images. Today all images are beautiful. What is needed is to find true images, images that tell a story." [43, p. 164]. Designers should respect the natural substrate by giving meaning to objects, to artefacts and to their performance; objects that would become the expression of the deep intelligence and creativity of the human wisdom [40]. A new products' generation, one that is durable, sustainable, that would get older with charm and memory supports should be introduced to compete with the disposable one.

In 1997, the ICSID held its Congress in Toronto, where the proposed theme was "The Humane Village". Beautiful ideas and embryos of new more humane and ecological design principles emerged, we can think of the *Humane Village Journal* [25]. But since then, low commitment and realisations came out of all this. Certainly, many different concepts have emerged on the international scene, such as DfE, LCA, DfX, but according to Margolin, these solutions are mere changes for a reform of the consumer culture rather than a genuine redefinition of the design profession and its designs [42].

In conclusion, it is very difficult to assess the stock of environmental product, or conscious product development process happening in Québec and Canada right now. But there seems to be a common idea that efforts are hesitant and in small proportion when compared to usual product development.

- **4.5.6 Industrial design education**

There are not many studies, in the literature, on the role of the education of industrial designers for design and the environment. One recent survey realised in North America by the Metropolis magazine reveal that industrial design and architecture education are not taking sustainability as a strong element within their courses. Sustainability related courses are often optional within a degree, and professors find it difficult to teach concepts such as sustainability and systemic thinking [66]. Some results are pretty alarming on this issue: only 14% of respondents agreed their school were developing programs to give sustainability formation to their staff, while only 25% of schools have specialist in environmental issues within their design faculty. However, a large majority of schools agree sustainability is relevant to the design curriculum [66]. Bisson affirms academia involvement in project definition and research, R&D and design would benefit companies. University research could be completing corporate research, as the latter focuses more on short term and immediate problems, and the former on sustainable production and consumption, lifestyles and sustainability in general [4].

- **4.5.7 Engineering perspective**

In reality, the engineering professionals and industrial designers cooperate fully in the product development. Thinking engineers simply perform process development while designers do product development, as illustrated in Figure 9, is a very vague generalisation, however helpful in this present research. Engineers can perform product design and designers sometimes help in process improvements, through better product design. Further, engineers have a longer history of tackling environmental issues, since cleaner production and pollution treatments are essential in industry. The engineering perspective on green product development is much related to the systemising of processes, tools development and methodologies. In the literature, more than 150 tools for product development process with environmental qualities were found by Baumann *et al.* However, tools are rather described as such, instead of being analysed in practice and how to are used; there are not much measuring and monitoring of the impacts of these tools use. They conclude that much of the engineering perspective is conceptual, related to product development as such, and few relate to the process links to society [3].

4.6 Customers and Users

- **4.6.1 Needs assessment**

The identification and fulfilment of needs of customers and users must be the focus of product development process [4, 13, 74]. It is one of the most important factors of successful product innovation [29]. However this step's impacts and implications has not been often empirically studied. Kärkkäinen and Elfvingen state "customer need assessment is understood broadly as the activities concerned with the recognition, gathering and clarification of customer needs and their importance to determine need specifications and objectives for new products" [29]. Their study result in finding need assessment and allocations of resources to perform it in business-to-business industry was one of the most lacking step of product development. These results are still in line with other consumer's studies in that field. Further, they raised the importance of coordination problems between departments of one organization in the development of new products. Obviously, the complexity of customers' needs assessment is also denounced [29].

Understanding consumers through ethnographic inquiry and dynamics of the green markets would increase successful products release [4]. Others claim that consumption can only be assessed and understood if analysts are participating in the understanding of consumers' behaviours, instead of relying on theories. An anthropologist himself, Marcoux controversially state that subjectivity should be

brought to the understanding of consumers, because subjectivity is present in all consumption intentions and habits. In fact, anthropologists study what consumers do, rather than relying on what they say they do or like to do! [P].

The ideal conversation between users, designers and manufacturers would not only consist of surveys and data collection of potential markets components. It would aim to include designers in the users assessment and manufacturers and conception team in observing consumers, users of the product [4, 57]. Consumers, on their side, have to be even more demanding about what they buy and use, and communicate to businesses their problems or ideas and comments. But Polonsky affirms this should be taken carefully, as consumers are not always right, nor demanding the right environmental improvement [51]. Further consumers might be afraid of change and do not always buy what they know is of best quality or suitable for them, they often just want to buy new things, “either because of the ingrained habit of trusting only the new, or the pressure of advertising that said new was better” [57, p.111] In addition, when trying to assess the market demand of environmentally conscious product, one might want to look at final consumers, but another way is to understand professional purchasers of consumable goods. Burall argues that professional purchasers are more aware of environmental issues when selecting products for retail or use within an organisation, than the general public, which is more diverse [8].

- **4.6.2 Customer information and education**

Many authors stressed the importance of educating customers in order to improve their environmental knowledge and certainly because environmental impacts occur often during the use phase. Designer’s role in making use transparent and available is one thing; product design might facilitate, for example, energy savings or recycling when a product is not useful anymore, or it can also be easily maintained or repaired, be converted into another use when put to a second life (remanufacturability), etc. Some of the desired environmental users and consumers’ behaviour are better habits of recycling, composting wastes and buying environmentally friendly products [65]. Many indirect methods of stimulating these behaviours, such as advertising, campaigns and educational brochures, have not resulted in a pronounced improvement [65]. When incentives are provided for changing behaviours, the “removal of antecedent conditions leads in the extinction of the reinforced behaviour” [65, p. 296]. The authors tested the hypothesis that the direct experience of the environment, through a natural activity such as hiking or exploration, has more effect on users behaviours than indirect methods mentioned previously. Their results are convincing. They also explained that consumers may behave in an unsustainable consumption way because of many factors that are exterior to what we usually think of for their remediation: time factor, energy, financial resources, convenience, effort to be made, etc. [65].

- **4.6.3 Consumers associations**

Lewis and Gertsakis affirm that in North America, Europe and Asia, the demand for cleaner or greener products is growing at an astonishing rate since consumers are more demanding towards environmentally conscious products [37]. Because a new generation of consumers, such as today’s informed and environmentally friendly youth will challenge the demand of ecodesigned products, businesses shall try to fulfil this demand. Consumer’s demand or will to buy green products is assessed and analysed in many surveys, as well in Canada. The gap, however, between the intention of potential consumers, and their real behavior is large; a saying related to the environment does not always translate in tangible action [8]. Canadian consumers associations are not especially sensitive to environmentally conscious products. Their main focus is directed towards products security, energy availability and affordability, and legal affairs relating to consumers and services and products providers. Retailers and

corporations interacting the closest with end consumers are more likely, according to Burall, to be sensitive to the environmental demand coming from conscious consumers. This effect is even more pronounced in the case of supermarkets, with organic food [8].

4.7 Product development system

From the overview of many variables of the product development previously, we can now elaborate the system, which is composed of four actors that have large responsibilities in product development. The process is always part of an innovation process which is initiated and performed by: the corporate level or business strategies (see on Figure 9), the marketing level which includes market research, the product development team comprising process developers, such as the engineering department, and the design of products as such, usually performed by industrial designers and finally, the consumers or users of the product. The model was constructed with the general knowledge of traditional product development methods and theories, in a capitalist system and in an industry of consumer goods in Canada. These limitations permit to explain the importance of sales, product price, costs and marketing strategies in the model.

Innovation is what drives change in a company, and it can be initiated by different factors: renewal of product line, regulations changes, stakeholders pressure, processes improvements, competitiveness, growth or reduced sales. It consists of changes in a product, resulting in added value, or in the way it is produced; the production processes innovation. Innovation is initiated mainly by business strategies, marketing research, and a little less by product development or Research and Development (R&D) teams directly. But innovation affects the latter considerably as it is performed by product development teams. It results in lower costs of production (in the case of production efficiency improvements or capacity), or added-value products in the case of products' improvement. Conversely, added value results in higher price goods and therefore might cause decreased demand. Businesses seem to overcome this effect with marketing strategies, such as publicity and promotional activities, but in general they might prefer to lower prices by improving production capacity and efficiency.

In a very general way, the industry is driven by the demand of consumers, which is measured in terms of sales of products. Sales can be measured in monetary value or in sold units number. Of course the principal aim of one business is to be profitable, therefore to make profits. Profits are achieved in two ways: by reducing costs of production or by increasing sales of units. If the product price is correctly set, usually by marketing and sales professionals, we have to remember here prices are one of the main incentive for consumption and businesses strategies, the profits margin will permit growth and expansion of one enterprise, pleasing shareholders and, in general, all people from one company and its suppliers. The actual state of business can survive only on growth, not on stagnation, hence in changes in products and stimulation of the demand for constantly new products. Another way to maintain the demand, therefore sales of a product, is to program, by design and quality, its obsolescence by reducing the useful life cycle, or by introducing new products that will render actual ones obsolete to the eyes of consumers. It is also interesting to note only businesses strategies and market research can influence the product development. In return, these variables are influenced by many factors and as we have seen in the literature, the regulations one might be the most powerful incentive to integrate environmental concerns. Market-related instruments however are more vague and difficult to assess. Need assessment should be carefully performed in order to successfully fulfil user's need. Need cannot really translate in pressure over one company, unless they are identified and correctly addressed (see Figure 9). The environmental impacts that we want to reduce are illustrated simply by "Harmful environmental impacts". We can see from the model that ways to reduce these impacts are straightforward: by increasing production efficiency (through Cleaner processes development that results in increased

5. Interviews results

The first question answers demonstrate the product development process was not very well known to all interviewees. For those who felt comfortable answering, the majority of answers about the drivers of product innovation were of financial matters [I, P, T]. Hence the need for an enterprise to reduce its operations costs associated with their products was seen as the strongest driver to innovate. Another important factor was competition-related issues, such as market shares and sensitive competitors dangers [F, I]. An innovative corporate culture, within an organisation is also seen as an important factor of product development effort [C, T]. Pressure from consumers, and the public opinion were also mentioned several times [F, Q]. Other answers related to market studies, as it is usually a tool to find opportunities for innovation [P], and governmental (usually economical) incentives, such as innovation tax credit, and the Canadian innovation strategy fund [F, I]. Further the large portion of SMEs forming the industrial and manufacturing sectors of Québec economy was seen as a factor of low environmental product development. Small companies tend to have less resource, lack investments and have a shorter-term strategy of product innovation; they tend to think in terms of “cash-flows” [P].

The answers to the concern of the author over the small quantity of environmental products in Canada can be illustrated by the very poor stock of products proposed in the answers. Environmental consumer goods were not easily enumerated by the interviewees. Many suggestions were made of companies taking care of the environment, but they were primary sectors companies, such as forestry, and agriculture, where industrial design is not present, or where only environmental management systems were implemented without product innovation-related strategies.

Answers to the second question were much more varied and concerned the drivers and barriers to environmentally conscious product development. Answers are partly similar to the traditional process, where costs are seen as the most influential for some respondents [E, F, N, S]. For others, factors of consumer’s pressure and demand were raised [C, H, B, D]. The importance of demonstrating economical benefits of ecological products, in order to incite innovation, was stressed [F]. An interviewee affirmed businesses having already an innovative culture, would it be technologically-driven or through product development, are more likely to embrace eco-innovations [J, T]. Another important barrier was the need of possessing knowledge and skills in order to implement environmental innovation [J, S]. The social values, our consumption habits and moral concerns were seen as not directed toward environmental protection [Q, E, L]. Hence, markets are perceived as not demanding it, and marketing studies would not assess it [P, Q]. Other factors were the environmental commitment of corporate leaders, their vision, will or motivation in sustainability [I]. Obviously, regulations pressure and anticipation of stricter environmental standards and policies are stimulating innovation [D, L, Q], but are not leading enough in Canada [K]. Another interviewee raised the lack of marketing skills in assessing the demand that was supposed to be present [P]. One person raised the poor recognition of ecodesigned products, the issue of ecolabels, and credibility of environmental claims as barriers to innovate further in that field [K]. Some businesses thus refrain from exposing environmental qualities about their products, because consumers perceive it in a negative way [R]. Self-motivation of many professionals is a factor of environmental innovation, and technological change an opportunity to shift toward sustainability [E]. Some proposed a threat or crisis would steer environmentally benign products [N, Q], by making consumers realise the earth is a closed-system, and their personal responsibilities over these issues [D].

Trends in environmentally conscious products are almost unanimously denounced: very few products are conceived with the environment in mind, and ecodesign is a discipline that is even less emerging. Only one person claimed ecodesign was very rich and promising in Canada, even lead by industrial designers [M]. The others argue environment protection and sustainable development is not a concern

in Canada, because of abundance of resources, publicity encouraging consumption patterns, etc. Weak regulations, command-and-control focus, is one reason companies are not proactive in an unnecessary issue for business. Lack of Canadian indicators and LCAs data is said to be a major cause of unsuccessful design for the environment [I]. Trends are emerging in LCAs' interest though, in Canada, thanks to academic research, the Kyoto Protocol and its associated publicity, international pressure, promotional efforts from the governments (providing guides, tools and methods) and funding, such as the provincial fund for sustainable development, FAQDD [I]. One person denounced marketing and corporate decisions in elaborating design briefs, not giving designers freedom and mandate to investigate increased efficiency of production and products [T]. Some businesses are said to be working on ecodesign issues, however confidentiality barriers prevent from telling their story and projects [K, L]. Hence, no statistics permit confirming these trends [R]. Another person said there was no tendency of increased environmental issue in product development [K]. Canada would need a crisis or threat for "awakening" people [Q, N].

The most often mentioned environmental qualities of innovative products were recyclable qualities, and increased contents of recycled materials. Energy efficiency and water optimisation during production processes were also mentioned twice [C, T]. Waste minimisation, concern over energy consumption during use phases, health and safety issues, ISO 14001 compliance, were indicated once.

Everybody interviewed did acknowledge the need for better designed, and environmentally conscious products to reach markets, in order to change our consumption patterns, and to be more friendly if not protecting our environment. Best ways to achieve this were discussed. Again, there was a difference in key paths: educating consumers so they stimulate the demand [S, H] or the costs benefits promotion path [K]. Some stressed the need to promote costs advantages of ecological design, rather than its environmental qualities; that language does not interest or stimulate corporations as much as the financial and business language [F]. There was a strong insistence over the need to change our social values of consumption, and our responsibilities in buying because of publicities and brands [R, K]. New ideas in LCAs becoming more and more available will help decision-makers choose environmentally friendly products development, especially if Canadian data is developed and reliable for the national situation [D, L, S, T]. The need to develop and spread much more tools and methods for ecodesign was raised, on top of forming and training people, with help of environmental and sustainability consultants, such as Five Winds Intl or The Natural Step [F, J]. Again, many interviewees raised the marketing issue, hoping they will not only become greener and proactive in assessing the present market demand of ecodesigned products, but also participate in changing consumer's behavior and perceptions of ecological products, and refrain from advertising diverted functions of one products (ex: cars vs transportation) [K, L, T]. Other solutions, that are mainly the extension of the present into the future, consist of higher governmental help, in terms of financial fund, tax credit or allocation to innovation [I], and official awards, in terms of contests in recognition to environmentally conscious developed products [N]. One person's view was to completely change the capitalist system and businesses essence [B], while a designer called for radical design solutions to some of our products [E]. Only one person saw stricter regulations as the most promising way of stimulating ecodesign [A].

Future of EPD in Canada discussion resulted in solution-driven comments, and only one negative, pessimist comment was given. No unanimous answers were provided, however. Market driven pressure will most likely stimulate businesses in becoming more active with environmentally driven innovation [F]. This is always linked to the sectors of the industry. Others claimed market research will assess the demand pulse [T], and marketing will enhance the push of green products [Q]. However others seemed to think demand is not a good source of pressure, rather, competition, because of globalisation, will push businesses to innovate responsibly [Q], or governmental incentives, campaigns to sensibilise, and

international initiatives (ex: UN) [D]. Negative future scenarios were related to the capitalist system, that pushes businesses to grow, pursue profits gains and market shares, and reduce their products useful life length to maintain the demand [B]. Almost all the participants mentioned the programmed obsolescence of products, and over-consumption of our societies as a major present, and future problem for the environment. Sustainable development might not be the way to promote environmental innovation, rather we should internalise costs, and speak in a business language. Some indicated there are not much pressures of resources or energy, as we already have renewable source of energy (hydro-electricity) in Quebec, and plenty of water [F]. Another person mentioned the need for collaboration between disciplines, between supply chains actors and academia, for working toward sustainable development and towards ecodesign [M]. Design was sometimes seen as a factor (part of the problem today) of solution provision and construction [N].

Perception of industrial designers in the EPD field was very different from one discipline to another. The majority of respondents see industrial design as essential, and having a large responsibility and a huge challenge in ecodesign [F, T]. However they called for a better communication within organisational structures of corporations performing product development [F], a more horizontal product management instead of traditional vertical scheme. Traditional product development processes are taught in business schools and in marketing disciplines, however designers seem to be more engaged with multidisciplinary work, with marketing, engineering and other design disciplines [O]. In reality, there are all kinds of product orientation teams in different companies, although each profession has its own discourse, language and beliefs. It is difficult to make generalisations. Designers themselves call for more freedom and strategic responsibilities in the product development cycle, to participate very early in the process [T]. However impacts of designers is said to be minor in the decision process, where they are partly responsible for the rapid obsolescence of products and subject to corporate culture of profits, and sales [B]. Further, ecodesign would not be considered, from a legal point of view an “innovation”, deserving tax credits and rewards [L]. This might be the result of the non-liability profession that is design [N]. There is a need to deepen the systemic thinking, within the designer’s community, and exploit their position between corporate interests in developing products, and user’s needs and concerns. They could even perform and propose needs assessment that is crucially lacking from the market research skills [N]. As green concerns are usually seated in beliefs and values, marketing is poorly skilled to provide solutions and market researches that respond to ecological products provision [G]. And last, designers they do not seem to design with the environment in mind, in the ecolabels certification process; never designers were interested in developing a product that could comply to receive the Environmental Choice™ label [H]. Another person thought it was wiser for designers to wait for stricter regulations in the environmental field, because designers, even if they are committed and fully creative, do not have enough power to change things [E].

6. Discussion

The implementation of ecodesign as a method for product development seems to be refrained by numerous barriers. Even if authors and interviewees could identify many opportunities and benefits of a change in the way we traditionally develop products, the barriers and ways to reach this goal are less consentient.

One main reason is that the traditional product development, which generally takes place in a more general frame of innovation, is not optimised yet in the Canadian industries. Hence it appears that adding environmental qualities in that process would represent a large risk in an already risky management activity. Many challenges already preoccupies actors of that system, such as business leaders and marketing departments in finding ways to successfully commercialise products on their

markets. In addition, they seem to understand mainly the economic language: as we have seen in researches that do not address environmental concerns, the main goals of innovation are an increase in profits and market shares, or a higher sales of products. This fact was strongly confirmed by empirical results. Unless environmental issues are proportional to a company's higher expenses, costs and liability issues, they for now only are referred to for demonstrating corporate responsibility on the base of a moral and ethical image improvements. Results of interviews are almost unanimous to this conclusion; designers should powerfully demonstrate costs benefits of any ecodesign project for making it accepted and obtain sufficient human and financial resources from an administration board. This implies designers are already prone to believe in ecodesign and perform it correctly. However it might not always be the case, as we will see a little later.

Competitiveness is also widely accepted to stimulate innovation. However, competition faces the same challenges in developing products and unless some initiatives are taken from governmental programs or extensive promotion of ecodesign, businesses in Canada do not feel the pressure from their competitors' products to engage in these kinds of projects. They might feel it from the exportation-directed countries, and foreign markets however. It could become a strategic issue, and a serious problem of competition in the long run, if Canadian businesses cannot reach the same level of commitment as its competitors, and if it cannot comply with stricter regulations from importations countries such as Europe and United States, or even with the procurement from Canadian governments.

Every person from the interviews realised for this research denounced the extremely low environmental qualities of product development in Quebec. Nevertheless, they recognised the difficulty of obtaining environmental information from the conception and production processes of products developed here. For obvious reasons of competitiveness, companies tend to hide their environmental innovation and development when developing new products, because their ingeniousness could be imitated by competitors and other companies. This is even truer for SME because small companies have fewer resources, in case of copyright or patent infraction, to take legal action against their competitors [K]. Therefore there is an obvious gap in statistics and documentation in Canada, when trying to assess environmental qualities and environmental efforts in product development within the industry.

Palliation to this lack of statistics would maybe provide more pressure over industries that still hesitate to engage with environmental issues.

While the need of multidisciplinary teams of product development or orientation is well recognised in companies, researches in policies' impacts, business perspectives and engineering one are rarely overlapping in the product development field. This reveals a lack of communication, if not of exchanges and common efforts towards environmental product development. Hopefully the EPR concept emergence might be an attempt to palliate to this systemic deficiency [3].

6.1 Barriers and drivers of ecodesign

The challenges of implementing ecodesign in the traditional product development are numerous and surprisingly diverse. In the theory, many barriers consisted in the high risks associated with such process, the short-term vision of corporations, the lack of skilled resources on this subject, the lack of exterior incentives such as governmental programs, marketing studies that rarely assess or stimulate green demand and the poor self-motivation of designers in acting in a more strategic role. While many factors are also important for traditional product development success, stronger focus on motivation and competence is essential for ecodesign [27]. However amongst interviews answers, barriers of ecodesign are very different. It seems the social values in Canada do not encourage businesses, designers or consumers to think environmentally. Canada has too much natural resource and no limitations in their use and exploitation. Weak regulations and policies, and narrow-minded marketing briefs were

also mentioned. Hence in reality, with answers from interviews, the activities and the constant reach for profitability and growth of businesses were not perceived as a cause of lack of ecodesign. The responsibilities in the poor environmental qualities of products and services provided on the markets rather fall on the social and national contexts shoulders.

Surprisingly, the drivers of ecodesign in the theory are not the removal of barriers; they mainly consist of wiser innovation strategies, which could consist of a good occasion to include environmental concerns. Interviewees, on the other side, thought that ways to stimulate ecodesign was rather similar to ones that stimulate traditional product development: costs advantages, appropriate knowledge and skills within an industry, and pressure from consumers, suppliers and clients. We can see from these flagrant clashes, that the literature and in general, designers, do not put enough emphasis on the economical arguments accompanying ecodesign projects in order to promote their acceptance. Environmentalists, designers, consumers even, should demonstrate costs savings and benefits that ALWAYS occur with re-design of products with the environment in mind. However, as said previously, there seem to be a common thought in Canada, that industrial design and ecodesign projects are expensive. This thought might also explain, or be the cause of, the low level of industrial designers involved in the manufacturing sector in Canada.

There are some solutions to overcome barriers to traditional and ecodesign in product development processes. The most important ones included multidisciplinary teams, best user's needs definitions, clear objectives and targets of products to develop, etc. [10]. Further, the motivation of players (internal or external), communication flows and quality amongst product development teams, life-cycle thinking of one product or service or system, chosen methods and tools of ecodesign, and market related effects of ecodesign all have positive effect on product development and ecodesign. It is also surprising to note the large number of researches that denounced marketing studies: the latter seems to not be performed adequately to sense environmental concerns on the markets. This is explained by the fact market research hardly can assess needs of users without proposing these potential consumers with what is possible, hence with what creative people can imagine and elaborate of a better future. Hence there seem to be a large problem with the idea that marketing should provide designers briefs of what they should design. Instead, the process should be less linear and designers should be able to totally, simultaneously propose ideas that marketing could then test and sense on their markets, unless market research becomes better at analysing needs and finding new markets, (this is an important missing link as we can see in Figure 9) maybe with more systematic methods, and an increased collaboration with sociologists, anthropologists and designers, as we can see in the next section.

6.2 Organisational structure

Many authors and interviewees addressed the professional skills differences and communication problems between designers, engineers, consumers, marketing and business administration people. One of the communication problems within an organisation when it comes to elaborate product development strategy is exactly the language, priorities and professional views of each of these disciplines, when put all together. Designers are known to be more arts-based, creative, intuition-driven, thus less incline to judge nocive emissions emanating from processes or materials choices, while engineering possess a more scientific and rigorous method, better able to analyse complex technical aspects involved in choices of environmental impacts reduction [8]. Marketing and businesses are usually on the same financial wavelength about goals and objectives of products development. This is crucially important when marketing or designers, for example, tries to persuade consumers to keep a product more, or less longer. But as we have seen in Figure 9, corporate strategies are all pointed towards a shorter products lifetime in order to sustain demand and sales.

An industrial design teacher and some authors have denounced that designers consider environmental concerns as constraints to their creativity and freedom of decision-making [N]. However the literature has made the point that ecological issues are surely catalysts for innovation, rather than inhibiting constraints. The environmentally conscious new markets emerging from concerned consumers are creating new opportunities for designers to develop new products, or redesign old ones. And often, rejuvenating or simple re-design of products, for example to increase energy efficiency, produce more savings than waiting for the replacement time of normal life cycle of those products. Hence redesign, or product innovation of Type 1 or 2 (see Figure 5) could present good starting projects to stimulate ecodesign further in Canada, even aiming at sustainable design in the long run.

There are few studies of organisational effects on product development and the environment in Canada. Specific research should be done to encompass this particular economical, social and business culture. It would provide precious hints on how to deal with industrial design discipline, working with marketing and engineering in North America. One of them however, analysed collaboration and traditional relationships between designers, businesses and clients [4]. It resulted that there is a clash between the recognised need for collaboration between professional disciplines and businesses partners, and the actual method to achieve such communication. Bisson argues that this subject as been vaguely and rarely addressed in the literature, while businesses claim such model of collaborative study would need to be unique in every industry, in order to receive acceptance, flexibility and corporate support toward sustainability. One solution to gaps between lacks of collaboration between players of the product development process was brought by her opportunity study; she suggests collaboration with new actors, that are usually left out of this field, such as sociologists, anthropologists, ecologists and economists, could add, with their expertise, to a project' careful strategic environmental product development [4]. This new collaboration would maybe greatly palliate to the lack of understanding of consumers and consumption patterns. It could as well become an occasion for dialogue between consumers and users' needs and what is proposed by businesses, but would increase considerably the complexity of this research's model of a product development system, without a clear methodology on how to accomplish such integration.

Although it is unclear if the usual habit of putting emphasis on sectoral studies and research is positive. Bragd *et al.* recommend there might be opportunities in developing common understanding and methods of cross-sectored approach to encourage dialogue [5]. Contrarily to the literature, it has been said in the interviews, that there is no need to develop more tools or methods of ecodesign, except data for the particular Canadian situation (in the case of LCA). Moreover, it seems tools are not sufficient for achieving an environmental shift within organisations. In fact, they might not be even necessary: management commitment, excellence and support is far more essential [36]. Even though multidisciplinary teams and collaboration between suppliers and companies have been developed and are aware of the immense quantity of information on ecodesign and sustainable design available, resources are limited in the industry, for product development, and this would consist in one of the main barriers of environmental product development. However, many of these solutions are minor when compared to what should be accomplished [45]. For example production processes improvements might help reduce emissions and therefore diminish pollution, however, these technologies do not constitute a real improvement because they instead concentrate pollution. The same applies for products modifications. It can contribute to environmental relief, but they only constitute a local intervention, rather than a rethinking of global impacts and issues.

The perspective taken also greatly gives colour to the recommendations proposed to palliate the lack of environmental concerns. Economists tend to promote economic measures, in order not to disturb competition laws, innovation researchers tend to recommend promotional campaigns and consumer

information, while engineers propose tools and solutions. These divergences might also be the result of the methodology used to collect results. Elite interviews' strengths reside in the fact these elites usually possess a lot of information, leadership, and even political power in their discipline [33]. They have a holistic view over one field and can better contextualise the components that are important for this study. Nonetheless, this method results in more difficult analysis, is difficult to reproduce, therefore to validate, and is less objective [33].

6.3 Business paradigm shift

The product development process is largely seen as the responsibility of the direction and corporate strategies. Hence in the case of ecodesign, business leaders should facilitate collective knowledge and learning about the environment. [45]. Millet *et al.* argue that product environmental performance improvements is a necessary condition but not a sufficient one to make evolve the environmental dimension within industrial activities. There is a need to get over unidirectional changes (bottom-up or top-down approaches) and operate a paradigm shift, from the environment as a constraint, to a development value (see Table 2). Respondents also acknowledge the necessity of having a more systemic view over product development, a less linear organisational structure, and a better environmental knowledge sharing between professionals. They therefore claim for businesses to genuinely change their activities not only for modifying the outputs (redesign of products, pollution prevention, emissions reduction, waste suppression, etc.), but also to change their organisational structure AND the values they cherishes in order to obtain a physiological change [45]. According to the authors, this shift can only be obtained from an iterative and reflexive process engaging all levels of an organisation, and all functions or professions, through action and experimentation. This process is similar to the Total Quality Management implementation process or the EMS one. This might also explain the fact companies having already such systems are more inclined to do ecodesign. In one of the rare solution proposed to palliate to the lack of businesses environmental commitment, Millet *et al.* claim for a collective generating learning, where knowledge is stimulated from a creative tension arousing from experiments and constraints, and that would help stimulate reflexion and idea generations inside one company [45]. This recommendation would also provide solution to the constant declaration from interviewees that businesses cannot find enough skilled professionals, or do not have enough resources to do so for environmentally benign design. Hence if professionals were already trained and motivated to perform in that way, it would be easier for an enterprise to exploit these skills, but if the skills are rare, an enterprise might as well want to train its professionals and generate its own specific environmental knowledge.

It is interesting to note that very few researches address the questions of how corporations assess and influence their markets. Studies should be done on “how consumers express their needs, to what extend they make use of environmentally related knowledge in expressing their needs and what sort of incentives they are receptive are highly relevant for studying whether and how organizations may influence civil society” [5, p.186]. Many attempts to modify consumption patterns have failed and these issues are not addressed to their just level [5].

Further, governments are moving towards a role of facilitator rather than regulator in environmental policies, leaving place to dialogue between businesses and society [5]. However many studies, maybe more recent, prove that voluntary measures of greening businesses are not working [73]. Therefore the government should not retrieve from this issue if we want to achieve sustainability, as regulations are known to be the most important driver.

6.4 Industrial designers' role

Studies and papers generally conclude that industrial designers, their skills and methods of creating and making, are all an excellent way of developing more environmental products. However interviewees demonstrated designers are always subject to a client or a "command" for designing, and not very often called when analysing markets and needs of society. Further, they are partly responsible of not including environmental concern with their own projects. Designers' usefulness in ecodesign is therefore optimised if they are performing on two levels: strategic (business vision and strategies in product development or orientation) and operational, where practicing the good intentions defined at the previous level [2].

It was mentioned several times that a strong senior and corporate commitment toward innovation and the environment are positive and necessary factors to engage in more conscious products development. Corporate leaders and marketing professional, as any individuals in society, can be influenced by their personal beliefs, social values, current environment concern state, and pressure from stakeholders or their suppliers. As very few environmental information is taught in business, marketing and to a less extend in design schools, we need to find ways to promote these considerations. And as their professional associations do not seem to promote ethical and social responsibilities either, industrial designers might be tempted to widely promote ecodesign benefits through promotional campaigns, association pressure on industry and by proposing actual ecodesign products examples. Because always the same examples of ecodesign and environmentally conscious products were described, BOTH during literature review and during interviews discussion, such as Teknion, in the case of office furniture, Interface, floor covering services, recycling qualities of certain products, GE, IBM, Electrolux, Philips efforts, they now serve illustration purposes, but many of these examples do not provide hints on how to implement this greener vision permanently within business strategies [3]. Usual and successful products should be proposed to nourish the collective imagination of what is possible.

For ecodesign, but also for all types and specialisations of industrial design, there is a need for a professional framework that would serve the purpose to be implemented in organisational structure and utilised by designers, with its language and jargon rather than environmentalists one. This would be easier to accomplish by independent industrial designers as they could participate to contests or simply voluntarily propose their ideas to the industry and potential promoters. For designers working internally in a company, they will need to educate their teams on these issues. There is already a precedent in designers wanting to educate manufacturers to understand their profession, to promote enterprises listen to their customers for trying to produce what users need instead of what they think consumers want. Therefore educating businesses to be environmentally sensitive in their activities should be less difficult [25]. Papanek, in the *Humane Village Journal*, simply calls for designers to refuse engaging in environmentally or socially degrading or harmful work. In reality, this statement is really too strong; designers need to obtain projects and gain notoriety by working and developing concrete examples of their work.

A research proposed the experience of the environment, rather than only make people aware of the its degradation, in order to stimulate appropriate environmentally conscious behaviour, such as consumers' purchases of ecodesigned products. Hence the experience of real environmental products could become a way to change consumers and businesses' mind over the negative image these products propose. Industrial designers could provide solutions by completely sidestepping problems, through re-inventing a product, or system but serving as well the environmental cause. In addition, as industrial designers are particularly able to work with the emotional, cultural and social acceptance aspects of new products, especially toward the use phase [8], they could propose radical solutions that could illustrate how people can act in this pursue of sustainable development. The same argument can be applied to the scale of

effect consumers can have over their environment quality. “Individual’s behaviour will tend to be influenced more by the personal consequences of the behavior, than the ecological consequences.” [65, p. 299] This path can be interesting for designers to conceive objects that could translate the effects of their use and consumption in individual consequences, to the scale of the user.

Further, it is interesting to remark that very little researches has been made over the role and impact of systemic approach to product development. However, companies having a holistic view over product strategy and corporate vision, by linking business strategies and products ones, are known to be developing more successful products [29]. This could become a strong argument when promoting environmental product development, which is a process that encompasses many levels of an organisation, even crossing enterprises’ boundaries.

7. Conclusion

If Canadian businesses wish to be competitive and sustainable in the future, there is a flagrant need they implement ecodesign in their traditional product development process. Ecodesign and its benefits are not widely understood by all the professionals that do perform innovation; the wide range of advantages need to be pushed in the industry. Designers should take this promotional responsibility, as they are already used to promote the forgotten user-value, and many other design criteria to the industry when they are participating in a project. Already there is a lack of a systemic view over the traditional product development in the industry, and this results in inappropriate, mainly curative, solutions provision to harmful products. Front-end product development, adequate market analysis and idea generation are crucially lacking in products proposals to potential markets. Further, real examples of what is ecodesign, its advantages for businesses, for the customers, for the social interaction and for the environment need to be proposed in Canada, in order to stimulate the collective imagination of what is possible.

Industrial designers are flexible and skilled enough to use different tools and methods and gather the available information in order to perform ecodesign. However they need to be given the proper role, the proper responsibilities and the good mandate for this cause, as they are usually intervening too late in the process of product development. Or else, the profession need to establish itself principles of design with social and environmental responsibilities as their core mission, in order to be able to promote, if not pressure, the environment in front of the industry.

The current business system in Canada continually aims at increasing profits by augmenting sales and stimulating the demand. It seems businesses tend to think ecodesign and industrial design in general are costly resources and result in expensive, added-value products that in return result in lower sales. Hence the industry is reticent to use strategic product development and this explains the low number of ecodesigned products on the Canadian markets. Obviously there are many levels of ecodesign intention in product development, but in order to achieve sustainability there is a common view that radical solutions and innovations of a much higher magnitude than the actual one are necessary.

“The future does not just happen. It is created by those who take responsibility for it today.”

[42, p. 155]

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9. Annex I – Interviews

Businesses strategies:

- [A] **Mr. Yvon Beauregard**, VP Occupational Health & Safety and Environment: Bombardier Inc.; Interview on June 26th, 2003 (phone)
- [B] **Mme Corinne Gendron, LL.B., MBA, Ph. D.**, Professor, Principal researcher: Chaire Économie et Humanisme, Université du Québec à Montréal, Corinne.gendron@uqam.ca; Interview on August 25th 2003
- [C] **Mrs. Yolande Labrie**, ISO 14001 responsible, IPL Plastics; Interview on September 8th 2003 (phone)
- [D] **Mr Daniel Normandin, M.Sc., MBA**, Director – Partnership Financing and Communications: CIRAI; Interuniversity Reference Center for the Life Cycle Assessment École Polytechnique de Montréal, Daniel.Normandin@polymtl.ca; Interview on August 8th 2003

Ecodesign:

- [E] **Mr. Jim Rollefson, PhD**, National Initiatives, Industrial Research Assistance Program, National Research Council Canada, Government of Canada Jim.Rollefson@nrc-cnrc.gc.ca; Interview on August 1st 2003
- [F] **Dr. Chris Sherwin**, EcoDesign & Sustainability Consultant, Philips Environmental Services, CFT, chris.sherwin@philips.com; Interview on September 1st 2003 (e-mail)
- [G] **Mr. Vincent Blouin, BDI**, Project manager- Ecodesign, Réseau Ressourceries du Québec (RRQ); Interview on September 3rd 2003 (phone)

Ecolabels:

- [H] **Mrs. Carolyn Miyazaki**, Communications Manager, TerraChoice Environmental Services Inc., cmiyazaki@terrachoice.com; Interview on August 21st 2003 (phone)

Engineering :

- [I] **Mr. Réjean Samson, Eng., Ph.D.**, Executive Director, CIRAI-Interuniversity Reference Center for the Life Cycle Assessment, Interpretation and Management of Products, Processes and Service, École Polytechnique de Montréal, Rejean.Samson@polymtl.ca; Interview on August 18th 2003

Governments:

- [J] **Mr. Gérard Croteau**, Ministère de l’Environnement du Québec, Direction du patrimoine écologique et du développement durable, Service du développement durable; Interview on August 13th 2003 (phone)
- [K] **Mrs Miheala Andronescu**, Environmental Protection, Environment Canada, mihaela.andronescu@ec.gc.ca; Interview on August 7th 2003 (phone)
- [L] **Mr. Richard Mercure, Eng.**, Industrial Technology Advisor, Centre d’expertise et de recherche en infrastructures urbaines (CÉRIU), NRC; Interview on August 26th 2003 (phone)

Industrial design:

- [M] **Mrs. Diane Bisson, Ph.D.**, Professor, École de Design Industriel, Faculté de l’Aménagement, Université de Montréal, diane.bisson@umontreal.ca; Interview on August 18th 2003
- [N] **Mr. Pierre de Coninck, Eng., Ph.D.**, Professor. École de Design Industriel, Faculté de l’Aménagement, Université de Montréal, pierre.de.coninck@UMontreal.CA; Interview on August 20th 2003
- [O] **Mrs. Marie-Hélène L’Heureux**, Institut Design Montréal; Interview on September 3rd 2003 (phone)

Marketing:

- [P] **Mr. Jean-Sébastien Marcoux, MBA, Ph.D.**, Professor of Marketing, École des Hautes Études Commerciales (HEC), jean-sebastien.marcoux@hec.ca; Interview on September 5th 2003

Product development:

- [Q] **Mr. Guy Belletête**, Executive Director, Institute for Product Development (IPD), guy.belletete@idp-ipd.com; Interview on September 5th 2003

Sustainability consultants:

- [R] **Mr. Pong Leung**, Sustainability Advisor, TNS Canada, pleung@naturalstep.ca; Interview on August 1st 2003
- [S] **Mr. Ralf R. Nielsen, B.Sc., M.E.Des**, Five Winds International, r.nielsen@fivewinds.com; Interview on August 11th 2003
- [T] **Mr. Marc Belley**, Stagiaire, Éco-conseiller, RECYC-QUÉBEC, m.belley@Recyc-Quebec.gouv.qc.ca; Interview on August 25th 2003 (phone)

Annex II: Question during the interviews

- What are the factors influencing product development in the Canadian industrial sector?
 - Innovation, competition
 - Competition
- What are the factors influencing *environmental* product development in the industrial sector?
 - Regulations, Standards, Extended Producer's Responsibility
 - Information, knowledge
 - Business culture, marketing
 - Public pressure, NGO's, Stakeholders, Supply chain
 - Competition (RE-action)
 - Corporate Responsibility (PRO-action)
- What are the trends in Environmental Products Development, in Canada?
 - Green Canadian products, Eco-designed, etc.
 - Certified Eco-labelled products (ex: Environmental Choice)
 - Product-Service Systems PSS (ex: Communauto)
- What are the common most environmental qualities of industrial products in Canada?
 - Recyclable, cleaner produced, etc.
- What is the best way of stimulating/increasing EPD in the Canadian business scene?
 - Education/Knowledge
 - Regulations, standards
 - Competition, Corporate responsibility
 - Customers Demand, Public opinion, NGOs
- What is the future of EPD in Canada?

Annex III: Graph presented for discussion

